# ASSESSMENT OF MINIBUS TAXI TRANSPORT SERVICE CHALLENGES AND PASSENGER FARE ESTABLISHEMENT
## A CASE STUDY ON FOUR SELECTED ROUTES OF HAWASSA CITY, ETHIOPIA

**MASTER OF SCIENCE THESIS**

**GETU BEKELE FEREJA**

**HAWASSA UNIVERSITY, HAWASSA, ETHIOPIA**

**JULY, 2021**

# ASSESSEMENT OF MINIBUS TAXI TRANSPORT SERVICE CHALLENGES AND PASSENGER FARE ESTABLISHEMENT
# A CASE STUDY ON FOUR SELECTED ROUTES OF HAWASSA CITY, ETHIOPIA

**GETU BEKELE FEREJA**

**A THESIS SUBMITTED TO THE**
**DEPARTMENT OF CIVIL ENGINEERING,**
**HAWASSA INSTITUTE OF TECHNOLOGY, SCHOOL OF GRADUATE STUDIES**
**HAWASSA UNIVERSITY**
**HAWASSA, ETHIOPIA**

**IN PARTIAL FULFILLMENT OF THE**
**REQUIREMENTS FOR THE**
**DEGREE OF**

**MASTER OF SCIENCE IN CIVIL ENGINEERING**
**(SPECIALIZATION: ROAD AND TRANSPORT ENGINEERING)**

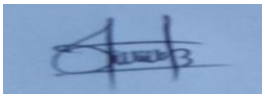
**JULY, 2021**

**ADVISORS' APPROVAL SHEET**

**SCHOOL OF GRADUATE STUDIES**

**HAWASSA UNIVERSITY**

This is to certify that the thesis entitled **"Assessment of minibus taxi transport service challenges and establishing passenger fare on case of Hawassa city four selected routes"** submitted in partial fulfilment of the requirements for the degree of **Master's** with specialization in **Road and Transport Engineering,** the Graduate Program of the **Department of Civil Engineering,** and has been carried out by **Getu Bekele** (ID No: **GPRoTrR/013/11)**, under our supervision. Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

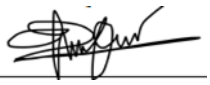
| | | |
|---|---|---|
| **Prof. Emer .T. Quezon,P.E.,M.ASCE,Dr-Ing(hc),Ph.D** |  | 19/06/2021 |
| Name of Major Advisor | Signature | Date |
| **Aschalew Mersha (MSc.)** |  | 21/06/2021 |
| Name of Co-Advisor | Signature | Date |

**EXAMINERS' APPROVAL SHEET**

**SCHOOL OF GRADUATE STUDIES**

**HAWASSA UNIVERSITY**

We, the undersigned, members of the Board of Examiners of the final thesis by **Getu Bekele** have read and evaluated his thesis entitled **"Assessment of minibus taxi transport service challenges and establishing passenger fare on case of Hawassa city four selected routes**", and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfilment of the requirements for the degree.

| | | |
|---|---|---|
| **Prof. Emer .T. Quezon,P.E.,M.ASCE,Dr-Ing(hc),Ph.D** |  | 19/06/2021 |
| Name of Major Advisor | Signature | Date |
| **Dr. Mihret Dananto (Phd)** | _____ | _____ |
| Name of Internal Examiner | Signature | Date |
| **Dr. Robam Solomon (Phd)** | _____ | _____ |
| Name of External Examiner | Signature | Date |
| **Mr. Tomas Bezabeh (Msc.)** | _____ | _____ |
| Name of the Chairperson | Signature | Date |
| _____ | _____ | _____ |
| SGS Approval | Signature | Date |

## DECLARATION

I hereby declare that this M.Sc. thesis entitled **"Assessment of minibus taxi transport service challenges and establishing passenger fare on case of Hawassa city four selected route"** is my original work and has not been presented for a degree in any other university and all sources of material used for this thesis have been duly acknowledged.

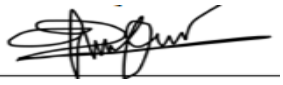
Name: **GETU BEKELE FEREJA**
Email: gechahawa@gmail.com
Phone: +251-916925270
Hawassa University, Ethiopia

Signature: _____

Date: _____

This M.Sc. thesis entitled "(**Assessment of minibus taxi transport service challenges and establishing passenger fare on case of Hawassa city four selected routes**)" has been submitted for examination with my approval as thesis advisor.

Name: **Prof. Emer T. Quezon, P.E., M.ASCE, Dr.-Ing(hc), Ph.D**

Signature: 

Place and Date of Submission: 19/06/2021 G.C

## ACKNOWLEDGEMENT

First and foremost, I would like to thanks the Almighty God and his Mother Saint Merry for giving me the required knowledge and good health during my studies. I would like to express my deepest gratitude to my Major advisor: Prof. Emer T. Quezon, P.E., M.ASCE, Dr.-Ing (hc), Ph.D and my Co-Advisor Mr. Ascahlew Mersha (M.Sc for their valuable guidance and consistent encouragement throughout the research process. Without their support and guidance throughout the journey, it would have been difficult to complete the work.

I express also my sincere gratitude to Dr. Alemayehu Ambo for constructive criticism and support on HDM-4 software analysis procedure and method.

Moreover, I am thankful for the sponsorship of Ethiopian Roads Authority (ERA) in providing the full funding of the program I have involved in and Hawassa University, Institute of Technology, department of Civil engineering for facilitating of the program and giving me this scholarship opportunity.

I would also like to extend my deepest gratitude to different organizations mainly, to the Hawassa road and transport office, Hawassa City municipality, Hawassa City Administration finance and economic development department, , especially to the staffs of the organizations for their cooperation in providing me the necessary data for my research.

Finally, I would like to express my deepest appreciation to my family, friends and to all the participants who directly or indirectly participated and have willingly shared their precious time and valuable support in completing this research.

## TABLE OF CONTENT

## ACRONYMS

| | |
|---|---|
| AADT | Average Annual Daily Traffic |
| ACBE | Anbessa City Buses Enterprise |
| CSA | Central Stastical Agency |
| ERA | Ethiopian Road Authority |
| HBO | Home Based Work trip |
| HBS | Home Based School |
| HBSHO | Home Based Shopping trip |
| HBW | Home Based work trip |
| HCM | Highway Capacity Manual |
| HDM-4 | Highway Development and Management tool |
| LOS | Level of Service |
| MT | Motorized Transport |
| NHB | Non Home Based Trip |
| NMT | None Motorized Transport |
| O-D | Origin destination |
| QOS | Quality of Service |
| RD | Road Deterioration |
| RTA | Road and Transport Authority |
| RUE | Road User Effect |
| SEE | Social and Environmental Effect |
| SNNPR | South Nation Nationality and People Region |
| SUE | Stochastic User Equilibrium |
| TAZ | Traffic Analysis Zone |
| TCRP | Transport Cooperative Research Program |
| TCQSM | Transit Capacity and Quality Service Manual |
| TRB | Transport Research Board |
| UE | User Equilibrium |

## LIST OF TABLE

## LIST OF FIGURE

## ABSTRACT

*In the developing cities like Hawassa an increase in size and number of population generate increased travel demand and triggered improved transport service. Among the public transport modes, the service provided by minibus taxi are unattractive due to the presence of a factors like providing service quality problem, mismatching of demand and supply of mini bus taxi and the transport fare system problem. This study aimed to evaluate the existing service quality, the distribution pattern and passenger fare establishment methods of mini bus taxis in the city and compared the current using taxi distribution and passenger fare with four stage demand modeling results and HDM-4 software based results respectively. Regarding with this, the data's like characteristics of vehicle, geometric characteristics of road, price of vehicle component, and various traffic data were collected through field survey, interview and questioner survey methods. The qualitative analysis which is subjective measures were used. For analysis of taxi distribution four stage demand modeling and other statistical analysis model which were fit to our data such as category analysis, gravity model and logit model were used and to establish the passenger fare HDM-4 multipurpose software were utilized. The finding of this study result revealed that more than half of transport users are dissatisfied on over all service provision of minibus taxi. Related to the result of taxi distribution The number of trip attraction and production for route of old bus station to mobil station of each purpose of trip home to work, home to school, home to shop and home to other purpose found to be 2657,3024,1602and1947respectively and for production trip purposes the number of trips were found to be 2018,1982,1919 and1784 respectively.. Concerning with result of passenger fare produced by HDM-4 software, the fare produced for one km road segment was about 1.35 Birr person; however the fare established by Hawassa city transport office was 0.75 cents per person. Finally, proper consideration of input parameters is required when setting passenger fare for each mode of transport and the transport bureau should studied further on demand and supply of mini bus taxi and service delivery in order to improve the operational system of minibus taxi in the city.*


***Keywords**:minibus,taxi,service,quality,fourstage,passengerfare*

# 1. INTRODUCTION

## 1.1. Background of the study

Transportation is one of the basic sectors supporting people's daily activities because without any movement it is impossible for them to fulfill their needs. People conduct activities in different places due to biological needs, social obligations, and personal desires (Vilhelmson, 2007). It is critical and undoubtedly essential that various forms of public transportation service adequately available in cities and urban areas so as to transport people from one place to another. The existences of a good transport service enable people to participate in wider variety of social and economic opportunities, to increase the mobility and improve their living standards. If transport service is poor, the mobility of people and the movements of goods are limited, social and economic opportunities curtailed, and living standards decline or rise only slowly (Hoyle, 1988).

According to the study of Hart (2012) stated as Public transport services are main aspects of the customer satisfaction system, because they are evaluated by travelers. Therefore, the quality of service provided in public transport industry will also be discussed in terms of customer/passenger satisfaction. So customer satisfaction with public transport is the degree to which an individual positively evaluates the overall quality of a public transport service delivered by a public transport operator and authority.

Urban mass transport is high priority social obligation of governments of cities in developing countries (Hensher, 2002). That is because private transport requires very extensive road capacity, which would induce more greenhouse gas emissions and congestion on the other hand public transport is adequate for mass mobility; it makes better use of urban space, reduces the dependence on more polluting modes of transport, and is likely to be an affordable means of transport for most residents in these cities (Vuchi,2005). However, existing public transport capacities in developing countries do not satisfy the demand for a number of reasons, such as the quality of travel on public transport is poor and the offered road network is inadequately managed (Hensher, 2002).

It is clearly observed that road transport is playing the dominating role in African cities including Ethiopia. The major modes of public transport in Africa including Ethiopia are taxis and buses. According to Addis Ababa Road Transport system, taxi service shares 20 % and bus service shares 35 % of public transportation service. For anyone without a car, one of the easiest and most reliable ways of transport is taking one of the many blue painted with a white roof and seating arrangement of 12 seats minibuses (or shared taxis) which speed up and down the streets of Addis all year round (Endale,2014).

According to the study of (Melaku, 2009) indicated that the transportation characteristics of urban residents are influenced by the supply of transport infrastructure, accessible and affordable means of transport and economic status of the urban residents, with this regard almost 53% of Hawassa city public transport user demands another alternative public transport system instead of existing public transport service which was dominated by Bajaj which can provided a reasonable fare of transport, improved service in terms of availability and safety to conduct their daily main tasks. That was because, the fare of minibus taxi and three wheelers was expensive and it was not broadly accessible to their destinations on the other hand it was due to fear of accident that commonly occurs in the city. As part of measure the city transport bureau then finally decided to buy 12 higher buses and induce the public transport service in high potential public traffic volume roots to accommodate 53% of public transport demand of the city by providing affordable service and fare.

This study systematically evaluates the service adequacy of taxi transport regarding with its service quality concept like reliability, affordability, time saving, comfort and, proper distribution to all direction and appropriate taxi fare system.

### 1.2. Statement of the problem

Suitable urban public transport needs to satisfy the demand of transport users. Since the demand of customers is always increasing, service providers should apply their ultimate potential to make their customers satisfied. However, in the absence of quality urban transport service and competition in the sector, customer's satisfaction is compromised. This would again affect the rights of customers' to get quality services they deem to get. To increase public transport service, the service should be designed and performed in a way it accommodates the levels of service sought by customers (Beirado and Cabral, 2007).

The demand for public transport services in urban centers has been growing at a rapid rate due to the expansion of cities and rise in population. As car ownership has not gone up corresponding to the population growth rate, public transport operations have a dominant role in urban mobility. Besides this according to World Bank (2002) report emphasized that efficient management of existing transport capacity, good traffic management, and efficient pricing and urban transport system is crucial for economic and social development of society. Among the public transport modes which are existed in Hawassa city, minibus taxi transport is the major one. Recognizing to this multiples challenges are faces to this mode among those: discomfort of taxi seat, overloading of the passenger beyond vehicle seat capacity, poor taxi transport controlling and management, mismatched supply and demand of transport service, over concentration of taxi on some specific route, passenger confusion on the same station of taxi but for different route and destination, and undetermined tariff of taxi due to the same origin of route but has different destination are commonly seen problems on minibus taxi transport service of the city.

According to Hawassa city transport office (2018) report for establishing the passenger fare for the city taxis some of the following item cost and considerations are included those are cost of new vehicle, fuel cost, spare part cost, vehicle maintenance cost, insurance related cost, new tire replacement cost, annual kilometer driven, profit and load factor of the vehicles are considered but those are not enough to establish passenger fare according to the finding of Wilson (2007). Concerning with this on this study HDM-4 software is used to establish reliable passenger fare through considering different essential parameters like general road network features, traffic composition of vehicles, environmental impact of the vehicle and

other parameters that are not considered in the transport office passenger fare establishment method of work. Thus using HDM-4 tool the researcher try to compare both fares those HDM-4 based fare with transport office established fare.

Some researchers conducted their study on public transport those are: Lulachew(2016), Kebisha(2019) and Robel (2017) conducted their study on city buses transport of Hawassa city. Tegegn (2018), Samson (2016) and Mulu(2015) conducted their study on Addis Ababa city buses, but none of them study on minibus taxi transport existed challenges regarding with providing service quality, distribution of taxi on the city and HDM-4 based passenger fare establishment of mini bus taxi transport. Those concepts was studied and covered here in this research.

From the gaps of this research with compared to other researches, for instance the study of (Tegegn,2018)deals about the service quality evaluation of Sheger bus enterprise, by using (TCQSM,2003) manual procedure his study evaluated the service quality of the buses based on objective measures of quantitative analysis, however this study used subjective measures of qualitative analysis based on (TCQSM,2003) which is recommended by former researcher to do on this method. The other related study is (Kebisha,2019) his study was aimed to assess the supply and demand of public transport in Hawassa city using four stage demand model and his study consider only home to work and home to school trip purpose and also during computation of modal chose analysis his study use cost function as major consideration. But according to this study , this study used four stage demand modeling and cover the rest trip purposes(uses four trip purpose) which is left by the former researcher besides this the study uses both cost and travel time for choosing modal choose.

Generally, this study is worth in that it emphasizes on filling the gap of Hawassa city minibus taxi problems related to the reliability, affordability, comfort ability and time saving in the service quality aspect, minibus taxi distribution problem and passenger fare establishment in other aspect with the help of four stage demand modeling and HDM-4 module respectively.

## 1.3. Objective of the study

### 1.3.1. General objective

The main objective of the study was to assess minibus taxi transport service challenges and to establish passenger fare in Hawassa city.

### 1.3.2. Specific objectives

- To evaluate the service quality measures of minibus taxi transport service based on customer satisfaction.
- To evaluate the existing minibus taxi distribution in the city and compare it with four stage demand modeling results
- To establish HDM-4 based passenger fare of minibus taxi transport and compare it with current taxi transport passenger fare established by the Hawassa city road and transport office.

## 1.4. Research questions

1. How much does the satisfaction level of taxi users on providing service quality attribute of qualitative measures?
2. What are the current taxi distributions in the city look like? How to distribute the mini bus taxi using scientific method along the selected routes?
3. How the transport office was established the currently using tariff of taxi transport and how much differ to HDM-4 based established fare results?

### 1.5. Significance of the study

A number of researcher's private or governmental organization will get a great deal of benefits from the outputs of his research. The main benefits include: insight provision of the level of satisfaction of minibus taxi users for service provided and how their dissatisfactions affect the market of taxi. The research also giving sound basis for transport planner and traffic management to indicate the methods for improving and to prepare the rule and regulation on taxi service requirement, distribution and passengers fare establishment, moreover the study giving a reliable basis for further scientific investigation by researchers and private or governmental organizations for future to study further.

### 1.6. Scope of the study

This study is aimed to evaluate the issues of minibus taxi transport providing service on Hawassa city more specifically deals about the quality service provision, distribution and passenger fare establishment methods. It include basic service quality measuring parameters those are very important for evaluating the quality of mini bus taxi and the study also concentrated on transport fare establishment using engineering software of HDM-4 in order to compare with the transport office established passenger fare. The study conducted on selected routes of the city which are mini bus taxi is dominantly operated routes. Therefore, keeping the nature of research problem in view, case study approach has been adopted.

### 1.7. Limitation of the study

Due to different reasons like limited research budget, unorganized data from government office and time constraint, this study was limited to among different mode of transport which is found in Hawassa city to only minibus taxi transportation system. And from different existed challenges of minibus taxi this study concentrated to three existed problems those service quality challenges, distribution of minibus taxi, passenger fare system problems of taxi users. And also from all different mini bus taxi operated route the researcher selected four minibus taxi dominantly operated route based on the study of (kebisha, 2019).

# 2. LITERATURE REVIEW

## 2.1. General introduction

Public transportation is a shared passenger transportation service which is available for use by public for the purpose of travelling from an origin to a destination. Developing countries are characterized by high population density, low income and lack of resources forcing them to depend on public transportation/transit systems, which can transport large number of people at low cost (Ranawana and Hewage, 2015).

Eboli and Mazzulla (2012) pointed out that public transportation is typically more energy efficient than private cars if running at reasonable occupancy rates, but offers less flexibility and typically longer travel times. The conventional bus is the most common public transportation mode in developing countries mainly due to its low running and initial cost, route flexibility and permeability into town and city centers.

In developing countries, the primary importance of public transportation is to move large number of passengers to meet mobility demand. However, existing public transportation supplies in developing countries do not satisfy the demand for a number of reasons. This includes: the quality of travel on public transportation is poor; roads are not properly maintained and so are managed; the safety and comfort of people using public transportation is low (Abate, 2007).

## 2.2. Methods of measuring quality service of Transportation

Service quality indicators deals with the relationship between service deliveries, customers expectations and degree of customer satisfaction. These indicators address the question; does the delivery of public transportation service meet or exceed customer expectations? (SPUTNIC,2012) Service quality has many dimensions and the importance of any single attribute differs from passenger to passenger.

According to (TCQSM,2003) manual service quality is also measured by two measuring methods those stated below:

### 2.2.1 Quantitative measures

Certain aspects of transit performance can be quantified that is, expressed as a number. Numerical values, by themselves, provide no information about how "good" or "bad" a particular result is, or whether one value is particularly different from another value, from a passenger's point of view. In order to provide this interpretation, performance results can be compared with a fixed standard or with past performance. Alternatively, the results can be expressed in a format that provides built-in interpretation (TCQSM,2003). These types of measures have used two dimensions for measuring or quantifying the results those are:

- **Levels of service**

According to the Highway Capacity Manual 2000 (HCM 2000) the concept of LOS was originally developed in the 1965 *Highway Capacity Manual*. Under this concept, the potential values for a particular performance measure are divided into six ranges, with each range assigned a letter grade ranging from "A" (highest quality) to "F" (lowest quality). Ideally, the threshold between each letter grade represents a point where the service quality becomes noticeably different to travelers, whether they are motorists or transit riders.

This (TCQSM,2003) manual also uses the LOS concept to describe passengers' perceptions of the quality of demand-responsive service. However, demand-responsive service has fundamental differences from fixed-route service, particularly in the manner of access, degree of trip spontaneity, and flexibility in choosing origins and destinations.

Xin *et al* (2005) also applied the TCQSM to evaluate the quality of service along a highway corridor. The author uses four LOS measures: service frequency, hour of service, service coverage and transit – auto travel time.

- **Indexes**

Performance measure users can quickly become overwhelmed as the number of performance measures being tracked and reported increases. One technique to minimize the number of measures reported, while maximizing the number of quality of service factors measured, is to develop a quality of service index. Such an index can incorporate several different performance measures, and each component can be assigned a weight reflecting its relative importance. Weights would be determined locally (e.g., from the results of a survey). The typical form of an index is as follows:

$I = C_n (w_1 p_1 + w_2 p_2 + \ldots\ldots\ldots\ldots + w_x p_x)$……Equation 2.1

Where:

i = index value;

cn = constant to normalize the maximum index value to a particular value;

wx = weight of performance measure x; and

px = value of performance measure x.

Although indexes are useful for developing an overall measure of service quality, the impact of changes in individual index components is hidden. A significant decline in one aspect of service quality, for example, could be offset by small gains in other aspects of service quality.

According to the study of (Eboli and Mazzulla, 2012) service quality of transports can be evaluated by subjective and objective measures. Subjective measures are evaluated based on passengers' perceptions, whereas objective measures are numerical values which are represented by disaggregate performance measures which must be compared with fixed standards or past performances. Definitively, both subjective and objective transit performance measures support the city taxi transport for monitoring, evaluating, and implementing improvements in service. Their study took quantitative measures of service quality as objectives measures and his study defined as objective performance measures are quantitative measures expressed as a numerical value that must be compared with a fixed standard or past performance. In order to evaluate and monitor service quality, performance standards should be established for each objective measure. Alternatively, the performance indicators can be expressed in a format that provides built-in interpretation.

### 2.2.2 Qualitative measures

Based on the manual of (TCQSM,2003) quantitative measures assess things that are directly observable about transit service. In contrast, qualitative measures assess passengers' perceptions. The latter measures' value lies in identifying aspects of service quality that is difficult or impossible to measure directly things such as security, tangibility of vehicles, value for the money, and so on. One commonly used, but indirect, method of identifying customer opinions is by tracking complaints and compliments that are made.

Two methods used by transit agencies to evaluate the service quality of transport vehicle problems those are generated from transport users as acomplain. Those methods are customer satisfaction surveys and passenger environment surveys, which are described below.

- **Customer satisfaction surveys**

Customer surveys help transit operators identify the quality of service factors of greatest importance to their customers. They can also be used to help prioritize future quality of service improvement initiatives, measure the degree of success of past initiatives, and track changes in service quality over time. Surveys can identify not only areas of existing passenger satisfaction or dissatisfaction, but the degree to which particular factors influence customer satisfaction. Thus, these surveys can help identify the quality of service factors of greatest importance to the riders of a particular transit system. And the factors evaluated through scale rated on 1 to 5 scales of likert scales (Kumar and Barrett, 2008).

The study of (Friman & Gärling,2001) indicated that likert scales qualitative technical measures rated through five commonly rated adjective words like very satisfied, satisfied, averagely satisfied, dissatisfied and very dissatisfied.

Subjective measures are evaluated based on customer satisfaction. Customer satisfaction represents a measure of company performance according to customer needs (Hill et al. 2003). In this case, customers express their opinions about the services provided.

The parameters or attributes those are (TCQSM,2003) manual recommended to evaluate the service quality of public transport qualitatively through the method of customer satisfaction survey are:

Table:2. 1.The TCQSM manual recommended service quality parameters

| Parameters or attributes of TCQSM recommendation | |
|---|---|
| Travel time saving | Smoothness of ride and stops |
| Reliability of the service | Physical condition of vehicle or station |
| Comfort of seat on the vehicle | Safety from crime on transport |
| Availability of public transport | Security of the vehicle or station |
| Cost effectiveness , affordability and value | Temperature and ventilation inside bus |
| Fairness/consistency of fare structure | Passenger loading condition |

| | |
|---|---|
| Cleanness of the vehicle and its station | Explanation of delays |

(Source: TCQSM,2003)

In the last few years, researchers showed great interest in customer satisfaction and service quality measurement. In this regard, Mekonnen M, (2010) conducted customer satisfaction to evaluate quality of service on ACBSE in Addis Ababa. Accordingly, he stated some customer dissatisfaction factors such as; low service frequency, schedule unreliability, excessive waiting time, long walking distance to get the service and overcrowding.

- **Passenger Environment Surveys**

Passenger environment surveys use a "secret shopper" technique, in which trained checkers travel through the transit system, rating a variety of trip attributes in order to provide a quantitative evaluation of factors that passengers would think of qualitatively (TCQSM,2003).

According to the study of (Kumar and Barrett, 2008) among the parameters evaluated by MTA-New York City Transit for buses and rail vehicles based on passenger environment surveys includes cleanness, appearance ,customer information and operators. Having took those parameters the transport officer or transit agents secretly evaluated the public transport and forwarded the improvement methods.

### 2.2.3 Parameters recommended for qualitative service measures

A review of literature on transit performance reveals that different authors use different service quality attributes or parameters to assess customer satisfaction of different transport mode; for example, Friman & Gärling (2001) classified service quality attributes for evaluating mini bus taxi transport into four broad categories which include; reliability of the system, tangibility of the transport, safety and security, and tariff structure.

Researches were conducted regarding customer satisfaction on mini bus taxi with an aim to identify unattractive and substandard factors. For instance, Edvarsson (1998) also found that travel time saving nature of the modes, lack of punctuality, security and cost affordability were important factors causing dissatisfaction.

Based on the above literatures review and the manual recommendation four basic parameters or attributes are selected and discussed below:

**Service reliability**

Basically the parameter service reliability related to availability of public transport, travel time saving and ability to perform the promised service dependably and accurately. Several performance metrics can be used to assess the reliability of transit system. These include on-time arrivals, travel-time adherence, run-time adherence, and customer satisfaction. (Arhin, 2013). In addition, Reliability affects the waiting time of passengers at a stop for a bus to arrive. Reliability also affects total trip time of a passenger. As stated by Chang (1988), effective scheduling and utilization of vehicle capacity increase the reliability of service and provide significant benefits to transit agencies and passengers alike. Similarly Beirao and Cabral (2007), stated that the lack of control due to the uncertainty of the vehicle arrival makes the service unreliable. A study proposed by Eboli and Mazzulla (2012) confirmed that service reliability is one of the most important service aspect for the users.

**Tangibility of minibus vehicle**

According to the study of (Degewale *etal*, 2018),during analyzing the degree of passengers' satisfaction with urban public transport service, focus was made on different variables of tangibility. These variables of public transport tangibility constitute the overall physical conditions of vehicles and individuals' hygiene of vehicle from them: comfort of the vehicles, loading corresponds to Seats, cleanness of the vehicles, enough space is there for leg and ventilation inside the vehicles are evaluated under this parameter.

**Safety and security**

Safety and security indicates the degree of safety from crime or accidents and the feeling of security resulting from psychological factors; therefore, this aspect refers not only to safety from crimes while riding or at bus stops and from accidents, but also to safety related to the behavior of other persons and to the bus operation.(Eboli and Mazzulla,2012).

**Passenger fare structure**

The service aspect regarding fare includes characteristics of the monetary cost of the journey by bus, like the cost of a one-way ride, the cost of a transfer, the availability of discounted

fares (e.g.For students),the availability of volume discounts (e.g. for monthly passes), the cost of parking at bus stops (Eboli and Mazzulla,2012). Fare structure is the system set up to determine how much is to be paid by various passengers using a transit vehicle at any given time. The fare paid is a contribution to the operational costs of the transport system involved, either partial, as is frequently the case with publicly supported systems, or total. The rules regarding how and when fares are to be paid, for how long they remain valid are many and varied. Where the fare can be generally predicted in advance such as fixed fare systems, fare is usually collected in advance; this is the usual practice of rail and bus systems, which usually require the payment of fares on or before boarding (Tegegn, 2018).

### 2.2.4 Evaluation Criteria of public transport quality measures parameters

As presented in the Best Practices Guidebook (BPG) by Litman, (2015), provide guidance on evaluating and measuring public transport service quality parameters from various perspectives, the following criteria is used to measure some of parameters of service quality.

Table:2. 2 .Evaluation criteria of selected quality evaluating parameters

| No | Parameters | Evaluation criteria |
|---|---|---|
| 1 | Reliability | How frequently service follows publish schedules. |
| 2 | User comfort and security | including riding on, walking to, and waiting for transit |
| 3 | Availability | when and where transit service is available), and coverage (the portion of a Geographic area, or the portion of common destinations in a community, located within reasonable distance of transit service; |
| 4 | Affordability | User costs relative to their income and other travel options. |
| 5 | Travel speed | absolute and relative to automobile travel |

Source :( Litman, 2015) study

## 2.3. Transport planning and modeling

Transport planning and modeling is afield involved with the evaluation, assessment, design and siting of transport facilities. The transportation planning function covers a diverse set of activities that focuses on different transportation modes and system, time frames, geographic scale, policy issues and stake holder groups. It is critical to gather inputs from abroad cross section of stake holders on types of policy consideration and modal analysis that need to be accounted for in the travel demand model prior to its development (Samuli,2008).In addition to this transportation planning process plays a fundamental role in the state, region or community's future vision by providing a comprehensive consideration of possible strategies. The process is designed to involve all community users and the general public through public participation and engagement. The process include a number of steps , including the monitoring of existing condition ,forecasting future population and employment growth, determining future transportation requirements, developing long range and short range plans to address the needs and estimate the impact on environment and community(Assaye,2016).

According to (Robert,2006) study trip is defined as outward and return journey often for a specific purpose their purpose trips classified in to the following trip purposes

- **Home-Based Work (HBW):** This category includes To/From Work or Work-Related Business trips (Samiul,2008).
- **Home-Based School (HBShc)** - This category includes trips to school, college or university for classes, or to school-related meetings (Robert,2006).
- **Home-Based Shopping (HBSho)** – One end of trip is shopping activities.
- **Home-Based Other (HBO):** As pointed by (Assaye,2016**)** this category includes family and personal business trips such as banking, haircuts, visiting friends and relatives, other Social or Recreational trips taken for entertainment and recreation, and for trips that do not fit any of the other categories.
- **Non-home Based trips (NHB)** – This category includes trips that do not start or end at home (Samiul,2008) .

### 2.3.1 Types of Travel Demand Models

There is a number of travel demands modeling techniques used in the transportation planning. Four stage demand modeling, strategic planning model and elasticity demand modeling techniques are the very commons (Myer, 2004).

- **Strategic planning models**

According to the study of (Khan,2007) strategic-planning models are often narrow in scope but incorporate significant detail in specific areas of analysis. These models often are used when there is a desire to analyze many scenarios quickly and implemented using basic software and hardware tools; these models are less expensive to develop and apply. Strategic-planning models are useful for testing a wide range of large-scale policy and investment alternatives but may be less appropriate for analyzing detailed project alternatives.

- **Elasticity models**

The definition of elasticity modeling is the ratio of percentage change in one variable to the percentage change in another variable. Trip demand forecasts have traditionally been prepared using an incremental elasticity-based modeling approach. In this modeling approach, historic evidence is used to determine a statistical relationship between the observed demands for travel (in the case of public transport services) and a range of variables representing those factors that affect public transport passenger demand (Assaye ,2016).

- **Four stage travel demand modeling (FSM)**

Four stage travel models (trip based models) have evolved over many decades ago. As their name suggests, these models use the individual person trip as the fundamental unit of analysis. Four stage models are widely used in practice to support regional, sub-regional, and project-level transportation analysis and decision making (Wardrop,1952) . As pointed by (Assaye,2016) the first trip generation components estimate the numbers of trips produced by and attracted to each zone (these zones collectively represent the geography of the modeled area). The second trip distribution step connects where trips are produced and where they are attracted to. The third mode choice step determines the travel mode, such as automobile or

transit, used for each trip, while the fourth assignment step predicts the specific network facilities or routes used for each trip.

The structure of the four-stage model has changed little since the 1960s, although within that framework there have been considerable advances in Modelling techniques, not least as a result of significant increases in available computing power (Ortuzar & Wilumsen, 2011).

As the explanation of (John & Russels, 2010) the outset the transport system is simplified into a series of links (representing the various available networks) and zones (where trips begin and end). The general definition and purpose of each step is as follows:

**Trip generation**

According to the explanation of (Ortuzar & Wilumsen, 2011) the aim of trip generation is to predict or estimate the number of trips that are generated by and attracted to each zone in a study area. In trip generation, methods are applied to predict productions and attractions or origins and destinations. The zones that contain the home end of home based trips or the origin end of non-home based trips are considered to have produced the trip while the destination zone where an out of home activity will be undertaken is considered to have attracted the trip. Trip making is highly varied reflecting the diverse activities pursued by people in their work and non-work activities.

People engage in activities, these activities are the "purpose" of the trip. Major activities are home, work, shop, and school, eating out, socializing, recreating, and serving passengers (picking up and dropping off). There are numerous other activities that people engage on a less than daily or even weekly basis, such as going to the doctor, banking, etc. Often less frequent categories are dropped and lumped into the catchall "Other". Every trip has two ends, an origin and a destination. Trips are categorized by purposes, the activity undertaken at a destination location. (Khan, 2007).

Based on different trip intentions, productions and attractions consist of absolute counts, denoting the number of trips that depart from and arrive in each zone. Regarding with this these numbers of trips are calculated by the two common methods: growth rate factor and linear regression analysis (Edvarsson, 1998).

**Growth factor model**

According to the book of (Ortuzar & Wilumsen, 2011) considerations during analysis of growth factor are trip type ,the minimum age to be include in the trip analysis (i.e. three and above), households and income of the house hold.

The basic equation for growth rate factor is:

$Ti = Fi\ ti$ ……Equation 2.2

Where Ti future trips in zone i

ti current trips in zone i

Fi growth factor

**Regression analysis**

According to the view of (John & Russels, 2010) a model for forecasting trip numbers would include a number of explanatory variables: for example, the number of trips from a zone may be proportional to the zone population. Statistical techniques, in particular linear regression, are used in the development of such models. However, implicit in this approach is the assumption that forecasts are available for any explanatory variable. For example, if trip numbers today depend on today's population, it is necessary to know the future population in order to forecast future trips.

The most common a linear regression function is,

$Ti = ao + a1x1 + a2x2 \ldots + akxk + e$.....Equation 2.3

where, $ao\ a1 \ldots ak$ are coefficients of linear regression equation

$Ti$ is dependent output variable

$x1, x2 \ldots . xk$ are independent input variables

e is the error in estimating the output variable

**Trip distribution**

Trip distribution is the second step performed in four step modeling. Trip distribution uses the zonal productions and attractions output from trip generation, and assigns each production to a destination and each attraction to an origin for all possible zones in the study area. In trip distribution, these two known sets of trip ends are connected together, without specifying the actual route and sometimes without reference to travel mode, to form a trip matrix between known origins and destinations. Historically, trip distribution has been the

least developed component of the transportation planning model.(juan de dios Ortuzar and Luis G.Willumsen,2004).

In general trip distributions methods in travel demand modeling methods lies in two categories; Growth factor methods, and gravity methods.

**Growth factor methods:**

According to the (Ortuzar & Wilumsen, 2011) if the only information available is about a general growth rate $\tau$ for the whole of the study area, then we can only assume that it will apply to each cell in the matrix:

$$Tij = \tau . tij$$ .....Equation 2.4

Where, Tij is the future number of trips from zone i to zone j

tij is the present number of trips from zone i to zone j

$\tau$ is the constant factor

According to the explanation of (Michael,2003) the advantages of growth factor method are easy to apply, flexible, can be used to distribute trips by purpose, mode and time of day, by defining different growth factors for each zone. When applied to areas where conditions are stable over the study period, the result have been satisfactory. But, when applied to a study with significant changes in land use, such as proposal of new transportation facilities, and where travel costs change with time, this method gives unreliable estimates of future trips.

**Gravity method**

Distribution models of a different kind have been developed to assist in the forecasting future trip patterns when important changes in the network take place. These models make assumptions about group trip making behavior and the way this is influenced by external factors such as total trip ends and distance travelled. The most widely used of these models is the gravity model. This model estimates trips for each cell in the matrix without directly using the observed trip pattern (Ortuzar & Wilumsen, 2011)

$$Tij = Ai\ Oi\ Bj\ Dj\ f(cij) \quad \text{Equation 2.5}$$

Where

Oi and Dj are total trip ends

Ai and Bj sets of balancing factors

fcij is a generalized function of the travel costs

**Modal split analysis**

According to the explanation of (Khan,2007) the issue of selecting the most appropriate travelling mode has always been a critical issue in travel behavioral modeling, since it tells an individual about the most efficient travelling mode available. Therefore, it is vital to develop and use models that are receptive to those attributes of travel that influence a certain individual's choice of mode.

So, the most important classic models in transport planning are choice of transport mode. Therefore modal split is a means of choosing different types of modes that should be helpful for distribution of trips. The modal split models can reflect a range of performance variables and trip-maker characteristics, but, they produce disaggregate results that must then be aggregated to the zonal level prior to traffic assignment.

There are two commonly used methods for analysis of modal split analysis those are:

**Logit methods**

As explained by (Khan, 2007) the logit method is the most commonly used modal split method in the area of transportation planning, since they possess the ability to model complex travel behavior of any population with simple mathematical technics.

The most commonly used discrete choice analysis method in travel forecasting. The basic idea underlying modern approaches to travel demand modeling is that travel is the result of choices made by individuals or collective decision-making units such as households.

This logit method may be binary logit deals with two modes or multinomial logit deals with more than modes (Babay,2016) .

We have governed equation to get the generalized cost for each mode when the trip maker is goes from origin to the destination. That is the generalized formula is

$$Cij = a1tij^{v} + a2tij^{w} + a3tij^{t} + a4fij \quad \text{Equation 2.6}$$

Where: $i$ and $j$ are origins and destination

$tij^{v}$ - Vehicle travel time

$tij^{w}$ - Waking time

$tij^{t}$ - Waiting time

fij - Monetary charge

The equation of probability of an individual $i$ selecting a mode m, out of N number of total Available modes are given by:

$$P_{ij}^{mode} = \frac{(e^{-\beta * Cij\ mode})}{(\Sigma e^{-\beta * Cij\ modes})} \quad \text{.....Equation 2.7}$$

Where;

$pij\ mode$-- Probability of using mode

$c\ ij\ mode$-- Generalized value of mode

β -- Parameter for calibration

**Probit method**

The probit method is based on the random utility theory, representing the utility function as the sum of the systematic component and an error component. Which is,

$Ui$ = V (xi, $s$) + $ei$.....Equation 2.8

Where, Ui the utility alternative i;

V the observed (systematic) component of the utility function;

xi the vector of observed attributes of alternative i;

s the vectors observed characteristics of the individual of the study area

e the error component of the utility function.

As it indicates in the above equation the probit method has a complex estimation algorithm.

**Traffic assignment**

As the study of (Babey,2016)trip assignment is the last step of the four stage model and it is a process of the allocation of a given set of trip interchanges to a specific transportation network or system. The fundamental aim of the traffic assignment process is to reproduce congestion on the transportation system, the pattern of vehicular movements which would be observed when the travel demand represented by the trip matrix, or matrices, to be assigned is satisfied.

According to the analysis of (Ramos & Bazzab, 2015) traffic assignment represents an important step towards modeling and simulating transportation system. Specifically, the traffic assignment problem addresses how to efficiently connect the physical infrastructure (supply) and the vehicles that are going to use it.

In order to solve these mentioned traffic network problems, different types of traffic assignment models are developed and most commons are; All-or-nothing assignment, STOCH assignment, incremental assignment, capacity restraint assignment, User equilibrium assignment (UE) and Stochastic user equilibrium assignment (SUE).

- **All-or-nothing assignment**: as stated by(Babey,2016) in this method the trips from any origin place to any destination place are loaded onto a single, minimum cost, path between them. It assigns without consideration of whether or not there is adequate capacity or heavy congestion; travel time is a fixed input and does not vary depending on the congestion on a link.
- **STOCH assignment:** distributes trips between zones of origin – distribution pairs among multiple alternative paths that connect the pairs. The proportion of trips that is assigned to a particular path equals the choice probability for that path, which is calculated by a logit route choice model. Generally speaking, the smaller the travel time of a path, compared with the travel times of the other paths, the higher its choice probability would be (Assaye,2016)
- **Incremental assignment** is a process in which fractions of traffic volumes are assigned in steps. In each step, a fixed proportion of total demand is assigned, based on all-or-nothing assignment. The study of(Babey,2016) indicated that after each step, link travel times are recalculated based on link volumes. When there are many

increments used, the flows may resemble an equilibrium assignment; however, this method does not yield an equilibrium solution.

- **Capacity restraint assignment:** According to the study of (Assaye,2016**)** attempts to approximate an equilibrium solution by iterating between all or-nothing traffic loadings and recalculating link travel times based on a congestion function that reflects link capacity. Unfortunately, this method does not converge and can flip-flop back and forth in loadings on some links.
- **The User Equilibrium assignment** is based on Wardrop's first principle (Wardrop, 1952), which states that no driver can unilaterally reduce his travel costs by shifting to another route. If it is assumed that drivers have perfect knowledge about travel costs on a network and choose the best route according to Wardrop's first principle, this behavioral assumption leads to deterministic user equilibrium. This problem is equivalent to nonlinear mathematical optimization program.

### 2.3.2 Hawassa city transportation system

As studied by (Melaku, 2009) the most common transportation means of transportation to move to and within the city is automobile. There are a number of buses and mini-buses that serve as the means of public transportation from different cities in the country. The road is among the first rank in the country in almost all gates of the city. There are also a number of transportation service providers in the city. Those include:

- **City buses:** the city administration started city bus service in September 2012 G.C. There was four buses to begin with mainly used to give transport service the cities longest routes and the nearby areas this vehicle bus number further increased to 12 (one double bus which has a personal capacity of 49 passengers on seat and 60 standees, eight medium bus which has a total of 60 passengers 39 on seat and 21 standees capacity and 5 small bus 25 on seat and 17 standees passenger capacity (Kebisha,2019).
- **Minibus taxi transport**: According to the study of (yeshitela,2019) ,Hawassa city has more than three thousand taxi providing vehicles within the city among those about 2750 are Bajaj and 578 mini bus and 112 Damas and Tata taxi mode of the

transportation. Currently in Hawassa city major arteries of asphalt road is served by minibuses also known as "taxis". They provide about 16.80 percent of the public transport journeys despite their fares being up to two or three times more expensive than the bus fares. Basically, they are blue and white painted minibuses with a white roof and with a seating arrangement of 11 seats. They travel very fast from one part of the city to another. Besides minibuses taxi, about 112 Damas and Tata taxi-cars with the same blue and white colors are available to provide service. The minibuses are mainly used by Hawassa city residents to reach their work place, and tend to represent a better quality of service than the conventional buses (Endris,2019).

- **Motor Bike**- As indicated by (yeshtila,2019) now a day's motor bikes are becoming popular means of transportations for residents. Most residents with upper middle level income are becoming more and more users of motor bike transportation system. The suitability of the roads, relatively lower priced than private car, motor bikes availability and the growing need for faster transportation are contributing for the greater degree of assimilation in motor bikes.
- **Pedal Bicycle** – before some years pedal bicycle was one of the most popular private transportation system. But now a day it is mainly used by some high school students and some elderly people in the city. The former dominant private transportation role of pedal bicycle is over taken by motor bikes and Bajaj taxi (Melaku,2009).
- **Traditional cart or in Amharic "Gari**" – this means of transportation was common in Hawassa before some years when there was not asphalt road and the village were relatively clustered. However now a days the coverage of asphalt road is increased, the service is now limited to the areas where formal taxi are not available and in the rear by rural areas(Tsegaye,2020).
- **Boat Trip on the lake**—(Degewale *etal,2018 )* study said that, there are a number of boat trip service providers on the lake.these service providers can be found in Gudumale/ Amora gedel, Lewi resort, Haile resort and around Tikur wuha area. The lakes have different carrying capacity, and system. Some have motor system while the others are soley or partially operated by human labour.

- **Air transport service**—Hawassa has no local nor international standardized airport. However there is some undertaking to improve the level of air field to accommodate air transport. Some air private flight service providers available to provide air service in case of emergencies and for special needs (yeshitela,2019).

### 2.4. Methods of passenger fare establishment by Hawassa city transport bureau

The amount of payment that the passengers need to be charged for the service is set by the responsible body of the transportation. According to (Melaku,2009) study road and transport authority is the responsible organization for doing so in Ethiopia. Though the responsibility that the organization has, it does not decide the fare for each transportation services. Focusing on the intercity bus services, the Federal road and transport Authority sets the passenger fare only for the long distance buses. The passenger fare for the intra city taxis transport, small buses and medium buses is established on the basis of zonal boundary. The fare is calculated by the zonal transport authority based on a common ground that is primarily set by the Road and Transport Authority. There are many factors which should be included or considered to establish and set transportation fare. Currently in Ethiopia, the Road and Transport Authority (RTA) consider different factors to decide the passenger fare on transportation services. Those passenger fare components are used as the basic fare decision guidelines for public transportation. In Ethiopia, price of fuel is the main criteria to revise and establish transport passenger fare. When the fuel price is considerably increasing or decreasing in the world's market, then the fare will be revised accordingly (Samson, 2016).

According to Hawassa city road and transport report of 2018 for establishing the passenger fare for public transports the following consideration were used:

Table:2. 3.Considering parameters for passenger fare establishment

| Input components for establishing passenger fare | |
|---|---|
| New vehicle cost and tire replacement cost | Average annual Km driven |
| Fuel cost, oil cost | Insurance payment, Interest and depreciation |
| spare part cost | Profit margin for transport operators |
| Maintenance cost and direct labour cost | Passenger load factor (load factor |
| loading/unloading workers cost | Number of passenger seat |
| security guards cost | |

Through consideration of the above listed parameters the transport office prepared the questioner paper for collecting information and cost of the above parameters from the following different individual and groups (Hawassa city road and transport office, 2018)

- Vehicle sellers company and Guarages
- Representative of taxi owners
- Spare part sellers
- From fuel and oil distributor
- Insurance company
- Association of taxi drivers
- Technical evaluators institution
- Ethiopian road fund and internal revenue collectors

After collecting all the necessary information from respective body by questioner paper the transport office will establish the passenger fare for all public transport using formula given below

Passenger fare per km = $\frac{sum\ of\ all\ expense + profit\ margin\ in\ percentage}{annual\ km\ driven * number\ seat\ vehicle * load\ factor}$ ……..Equation 2.9

Generally, Hawassa city road and transport office (2018) report announced that the previous passenger fare of the city transport is altered due to the increase of the Benzene from the 18.07 cents to 18.90 cents in 2018 G.C. in the case the passenger fare for the minibus , ladas and Bajaj taxi is 0.75cents /km, 0.75 cents /km and 1.25 cents/km respectively. Therefore the decided passenger fare for the different length of km of each mode of transportation is given as follow in table below:

Table:2. 4.Fare structure for minibus taxi and Bajaj taxi

| Distance (KM) | Passenger fare of minibus | Passenger fare of Bajaj |
|---|---|---|
| 1 | 0.75 | 1.25 |
| 2 | 1.50 | 2.50 |
| 3 | 2.25 | 3.75 |
| 4 | 3 | 5.0 |
| 5 | 3.75 | 6.25 |
| 6 | 4.50 | 7.50 |

### 2.4.1 Application of HDM-4 software

The highway management process is considered as a cycle of activities that are undertaken within each of the management functions of planning, programming, preparation and operations. Upon considering HDM-4 application, it is advantageous to view the highway management process in terms of Strategic analysis, Program analysis and Project analysis (Hana,2017).

- **Strategy analysis**

Based on the study of (Samson,2016)Strategy analysis may be used to analyze a chosen network as a whole, to prepare medium to long range planning estimates of expenditure needs for road development and conservation under different budget scenarios. In order to predict the medium to long term requirements of an entire road network or sub-network, HDM-4 applies the concept of a road network matrix comprising categories of the road network defined according to the key attributes that most influence pavement performance and road user costs. Road user costs, per see, comprise:

- Vehicle operation costs (fuel, tyres, oil, spare parts, vehicle depreciation, utilization, etc.);
- Costs of travel time - for both passengers and cargo, due to road condition and traffic congestion (Hoban 1987); and
- Costs to the economy of road accidents (i.e., loss of life, injury to road users, damage to vehicles and other roadside objects.

- **Program Analysis**

This deals primarily with the prioritization of a defined long list of candidate road projects into a one-year or multi-year work program under defined budget constraints. It is essential to note that here; may deal with a long list of candidate road projects selected as discrete segments of a road network. Generally, program analysis deals with individual links and sections that are unique physical units identifiable from the road network throughout the analysis, but in strategy analysis, the road system essentially loses its individual link and section characteristics by grouping all road segments with similar characteristics into the road network matrix categories (Hana,2017).

- **Project analysis**

It is concerned with evaluation of one or more road projects or investment options. The application analyses a road by link or by section with user-selected treatments, with associated costs and benefits, projected annually over the analysis period. (R. Bennett,2000) study stated that economic indicators are determined for the different investment options. Moreover, it allows users to assess the physical, functional and economic feasibility of specified project alternatives by comparison against a base case, or without project alternative.

The study of (Samson,2016) indicate that project analysis estimates the economic or engineering viability of road investment projects by considering the following issues:

- The structural performance of road pavements
- Life-cycle predictions of road deterioration, road works effects and costs
- Road user costs and benefits
- Economic comparisons of project alternatives

Among the above listed road projects, this paper focuses on road user costs section this section comprise the vehicle operating cost of each vehicle those vehicle which had more than and equal to four wheels since our case is focusing on establishing the passenger fare for mini bus taxi transport, the researcher select four paved road routes in the city those having dominant mini bus taxi operation , particularly on the arterial roads that starts from

Tigest Hotel to Mobile, Old bus station to New bus station ,Millinium hall to Referral Hospital and from Tigest Hotel to Piassa adare Hospital .

### 2.4.2 Previous study related works

Actually different research had been conducted on public transport system on different mode of public transport from them (sheth *et al*, 2007) assessed the provision of bus services along different routes that comprises a public transport network. The authours expanded the existing approaches of the network model and goal programming in data envelopment analysis to capture the relationship among the operator and the user of the transportation service as well as the externalities (e.g. emissions, noise pollution, etc) related to the transportation investment.

Tegegn (2018) study also focused on evaluating the quality of service provided by Sheger Mass Transport Enterprise in Addis ababa using Highway Capacity Manual 2000 (HCM 2000) and Transit Capacity and Quality of Service Manual (TCQSM, 2003). HCM provides four LOS measures for service frequency, hour of service, passenger load and service reliability. Moreover,( lulachew,2016) has carried his study by using GIS analysis tool and based on the procedures in transit cooperative research program(TCRP) incorporate the evaluation of spatial and temporal analysis of public transport service and offered service quality jointly with the available passenger capacity to meet the demand of public transport in Hawassa city.

However all of the studiers ( sheth *etal*,2007) ,(Tegegn, 2018) and (Lulachew,2016) studies uses quantitative analysis for service quality evaluation of public buses,but this study is focused on qualitaive analysis of minibus taxi transport.

Related to transport planning and modeling researches (Kebisha,2019) did his Masters research entitled “Assessment of public transport demand of Hawassa city using four stage demand modeling ” The Author used four stage demand modeling and two trip purpose approach of the four step travel demand modeling technique. In addition, he adopted cost function as major chose for modal split analysis. Even though he did the best in forecasting future transportation demand and supply of Hawassa city, but the research data were only

limited to two trip purposes those work related trip and school related trip, thus this is not leading to know the exact supply and demand of the city public transport. Having taken that, this study consider four trip purposes work related, school related, shopping related and other purpose related trips.

The other study on transport planning is (Babey, 2016) did his Masters research entitled "Analysis of Passenger Demand Forecasting Models within the Context of AALRT" during 2015 -2016. The objective of the research was to show that high growth rate of population and economic activity of Addis Ababa increases traffic flow resulting in high traffic congestion and imbalance between the demand and mode of transport. In the research, the three major rail passenger transportation demand forecasting mechanisms were compared and the four step travel demand modeling was also used; but the research data for travel demand modeling were represented by six sample households in Kirkos sub city. This results for host generalization on travel demand model of Addis Ababa, since it can't represent the populations of Addis Ababa by six Kirkos sub city residents.

Concerning transportation tariff of passengers, proper attention should be given to establish tariff by studying the actual vehicle operating costs of vehicles. According to (Hawassa city road and transport office, 2018) report, for establishing the tariff some necessary component of VOC were missed. However, the practical industry situation of VOC should be seriously taken into considerations. For the transport operators to continue in the service provision, they should be profitable. Therefore, it is important to establish tariff by considering the industry practice.

Generally, this research was incorporate to deal the service quality of taxi using the method of subjective measure rather using objective measure. Tegegn(2018) and Lulachew(2016) was used objective measure to evaluate the service quality of public transport. Transport planning concern was done on four stage demand modeling and using four different trip purposes. Besides this the passenger fare established by transport bureau not used some essential parameters but this study use to set the passenger fare through scientific tool which is HDM-4 software.

### 2.4.3 Summary of literature review

The general overview of the study literature greatly deals about three major minibus transport existed problems of Hawassa city with their respective scientific methods in detail. When starts from service quality concern different researcher tried to study on performance evaluation of service quality of public transport through using quantitative approach, now here in this study both quantitative and qualitative approach are reviewed detail, since this study uses qualitative approach moreover described the qualitative approach with its selected attribute those reliability, availability, tangibility, safety, security and travel fare aspects. During transport planning and modeling concern, According to (Meyer,2004) studies three transport demand modeling were assessed those strategic planning models, elasticity planning model and four stage demand modeling. From those models with regard to data type four stage demand model had used here and review inside included models for analysis gravity model, growth factor method, logit model and others are assessed. Trip generation, trip distribution, modal split and traffic assignment sequential demand analysis steps are followed and based on the study of (Robert,2006) four trip purposes were selected like home to work, home to school , home to shopping and home to other purpose trip were selected for analysis. With regard to passenger fare establishment concern, the study review both transport authority fare establishment method and HDM-4 based establishment method. HDM-4 is a software tool that is used to appraise the technical and economic aspects of road investment projects. It consists of different sections for determining necessary parameters. Road User Effect (RUE) is one of the outputs obtained from the model. This comprises vehicle operating cost (VOC) and travel time cost (TTC) for both motorized transport (MT) and non-motorized transport (NMT), and Accident cost.thus having taking the VOC of our concern minibus taxi vehicle ,the passenger fare for all selected four route per segment was established.

Finally, this study on filling the gap of Hawassa city minibus taxi problems related to the reliability, affordability, comfort ability and time saving in the service quality aspect, minibus taxi distribution problem and passenger fare establishment in other aspect with the help of four stage demand modeling and HDM-4 module respectively

# 3. MATERIALS AND METHODS

## 3.1. Description of study area

Hawassa was founded in1952 E.C during the period of Emperor Haileselasie I and it is a young old city with a master plan. The city is located 273km south of Addis Ababa, with a latitude and longitude ofcoordinates:$7^0$05'North and $38^0$29'East respectively. The main rainy season generally extends from June to October and the town has relatively flat topography in the rift valley region with an average elevation about 1,697m.a.s.l. Besides this the total surface area of Hawassa City is 157.2 square kilometers (Hawassa city municipality, 2020). The figure 3.2 shows over all road network of Hawassa city with their respective road types.

### 3.1.1. Description of selected route

**I. Route one from Old bus station (around Tigest Hotel) to Mobil gas station**

This selected route its origin is from Menahariya subcity infront of Tigest Hotel and its destination at Mobil gas station. It is about 2.7 Km long route. The route has more than two corridor reaching to the destination (Mobil gas station) but the researcher selected the corridor along Megenagna intersection. Its origin (Tigest Hotel) located at coordinate of $7.048^0$N latitude and $38.488^0$E longitude its destination (Mobile gas station) located at coordinate of its latitude $7.065^0$N and longitudinal location is $38.481^0$E.

**II. Route two from Old bus station to New bus station**

Most part of selected route is found in Tabour subcity, However its origin is found in Menahariya subcity.it has a length of 4.1km and the route has different corridors the researcher select along weldeamanuel roundabout route. The route connect two bus station thier location of coordinate are Old bus station the latitudinal location is $7.048^0$N and the longitudinal location of $38.486^0$E and the location of New bus station is its latitude is $7.022^0$N and its longitudes is $38.500^0$E.

### III. Route three from Old bus station to Piassa Adare Hospital

This route has about 2.1Km length and the route passes through commercial purpose land use area and it has high traffic volume happened especially in Monday and Thursday of week days. The corridor selected in this route is along St. Gebriel church the coordinate of its origin is located at latitude of $7.048^0$Nand its longitudeis$38.489^0$E its destination located at latitude of $7.052^0$N and the longitude of $38.473^0$E.

### IV. Route four from Old bus station (around Millinium Hall ) to Referral Hospital

The route started from around old bus station area infront of Millinium Hall. It is about 4.1Km long the route passes through different commercial, college, and church purpose land use area along trufat intersection corridor is used for study. The origin coordinate is the latitude at $7.049^0$N and the longitude at $38.484^0$Eand the destination coordinate is the latitude at $7.027^0$N and longitude $38.465^0$E.

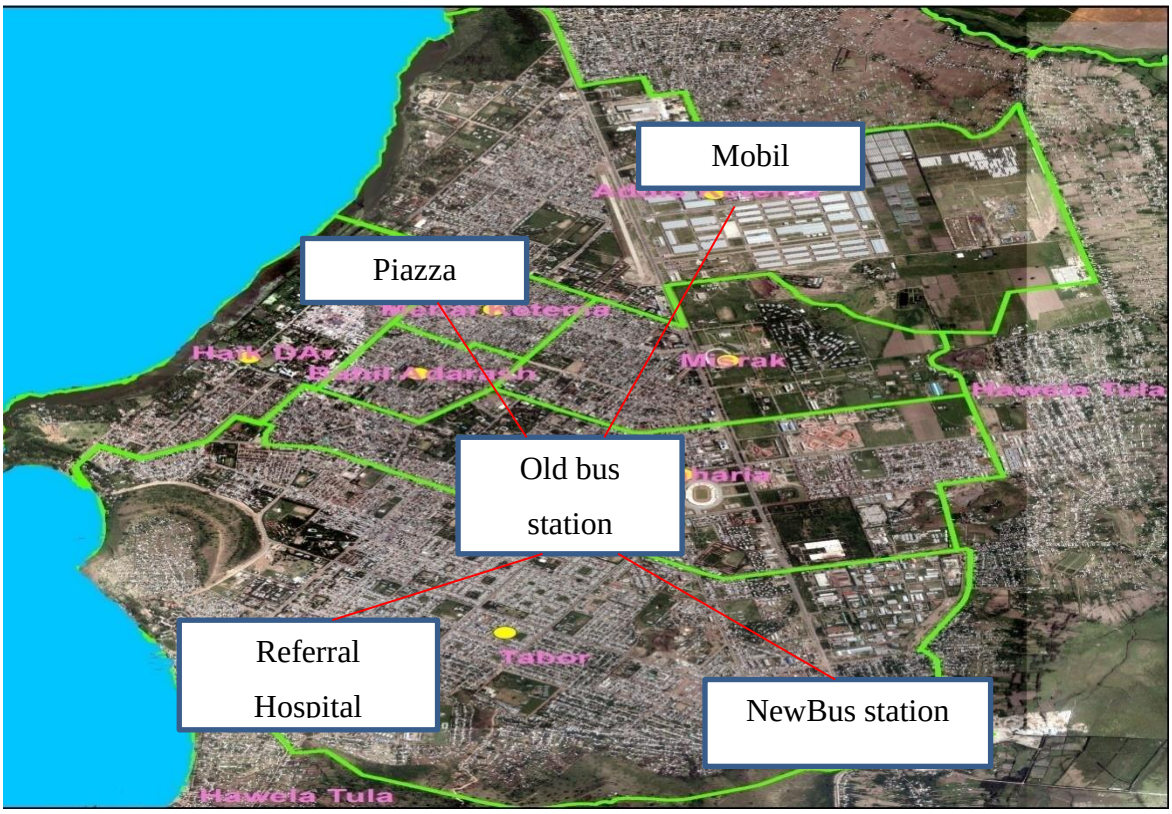



Figure:3. 1.The selected four routes direction and position

### 3.1.2. Route selection criteria

According to the gathered data for this study using interview survey attached at(annex-A3). There are about 43 minibus taxi operated route in the city. From those 43 routes there is also routes only mini bus taxi and bus transport operated route that the routes three wheelers are not allowed to operate route in the city among them like route of shell intersection to Piassa Adare Hospital route. Concerning with this the researcher selected four minibus taxi dominantly operated route. The selection criteria of the routes were based on two references; those are the study of (Kebisha, 2019) and data obtained from interview survey attached in the (annex) from transport officers. According to the result of (Kebisha, 2019) under the modal split stage the most preferable public transport mode in each sub cities was determined and the type of preferable transport mode in each sub cities of Hawassa city is different for instance when we take zone 3(Menahariya subcities) the dominant or preferable mode of transport is mini bus taxi rather than city bus and Auto rick Shaw. That means the demand of mini bus taxi in zone 3 is very high. Since Menahriya subcity is found at the center of the city the routes are highly congested on vehicles to reduce the congestion the transport bureau decided the Bajaj vehicle not allowed to operate on some selected route of the city and this prohibited most part of the routes are existed in Menahriya subcity. Due to this reason the demand of mini bus taxi in this sub city is high.

The following (Kebisha,2019) study result present the required number of minibus taxi (demand) vehicle in existed eight sub cities of Hawassa city:

Table:3. 1.Required number of transport mode type in Hawassa city

| Zones | Number of mode of vehicle required per day | | |
|---|---|---|---|
| | City bus | Mini bus taxi | Auto rick Shaw |
| Zone 1 | 346 | 593 | 845 |
| Zone 2 | 105 | 434 | 834 |
| Zone 3 | 104 | **1156** | 956 |
| Zone 4 | 387 | 479 | 816 |
| Zone 5 | 401 | 585 | 924 |

| | | | |
|---|---|---|---|
| Zone 6 | 303 | 465 | 795 |
| Zone 7 | 201 | 502 | 904 |
| Zone 8 | 365 | 432 | 320 |

Source :( Kebisha, 2019) study

Beside the previous study the data obtained from Hawassa city road and transport bureau through interview survey was confirmed the above information from all 43 minibus taxi operated route. The demand of minibus taxi is high on the following respective order of routes in the city

- Old bus station to Piassa adare Hospital
- Old bus station to New bus station
- Old bus station to Mobil gas station
- Atote taxi station to piassa Adare Hospital
- Old bus station to Referral Hospital
- Old bus station to old market
- Atote taxi station to new bus station
- New bus station to Ayer marefya
- TTC college to piassa city center

Due to time and budget constraint the researcher selected four the busy route on demand of minibus taxi transport. The selected route to carried out the study are:

- Route one: from old bus station (Tigest Hotel) to Mobil gas station
- Route two: from Old bus station to New bus station
- Route three: from old bus station (Tigest Hotel) to Piassa Adare Hospital
- Route four : from old bud station (Millinium hall) to Referral Hospital

### 3.1.3. Population density of the city

The population of the city is increasing from time to time rapidly. The total population of the city according to successive population surveys and estimates was 3600 in 1962& 10740 in 1970, According to Ethiopian Central Statistical Agency (CSA, 2015), gives the estimated

population of Hawassa for 2015 as 251,469, with an annual population growth rate of just over 4%.The population is relatively young, with 65% under 25 years of age and around 5.5% over 50 years of age (Hawassa city municipality, 2019).

Table:3. 2.Demography of Hawassa city based on sex

| No | Name of Sub City | Hawassa city population based on sex category | | |
|---|---|---|---|---|
| | | Male | Female | Total |
| 1 | Addis ketema | 15,878 | 15,874 | 31,752 |
| 2 | Hayek dar | 15,949 | 15,009 | 30,958 |
| 3 | Mehal ketema | 13,247 | 12,833 | 26,080 |
| 4 | Bahil adarash | 13,278 | 13,172 | 26,450 |
| 5 | Misrak | 21,688 | 19,637 | 41,325 |
| 6 | Menehariya | 22,330 | 21,315 | 43,645 |
| 7 | Tabor | 40,865 | 36,748 | 77,613 |
| 8 | Tulla 01 | 676 | 625 | 1,301 |
| Total urban | | 143,911 | 135,213 | 279,124 |

Source: (Hawassa city municipality,2020)

### 3.1.4. Traffic nature of the city

Public transportation system of Hawassa city had faces multiples challenges stemming from a mismatch between the supplies of public transport services and growing public transport demand, The frequency of loading unloading; poor integration of different sized vehicle; safety, security and comfort ability as well as over concentration of public transport system to a specific route are some of them. The high transit demand has been attributed to rapid and uncontrolled urbanization outstripping the capacity of public transport supply. This in turn has contributed to the insufficiency of public transport services and it is very problematic in terms of forecasting the public transport demand of the city due to the conditions mentioned above.

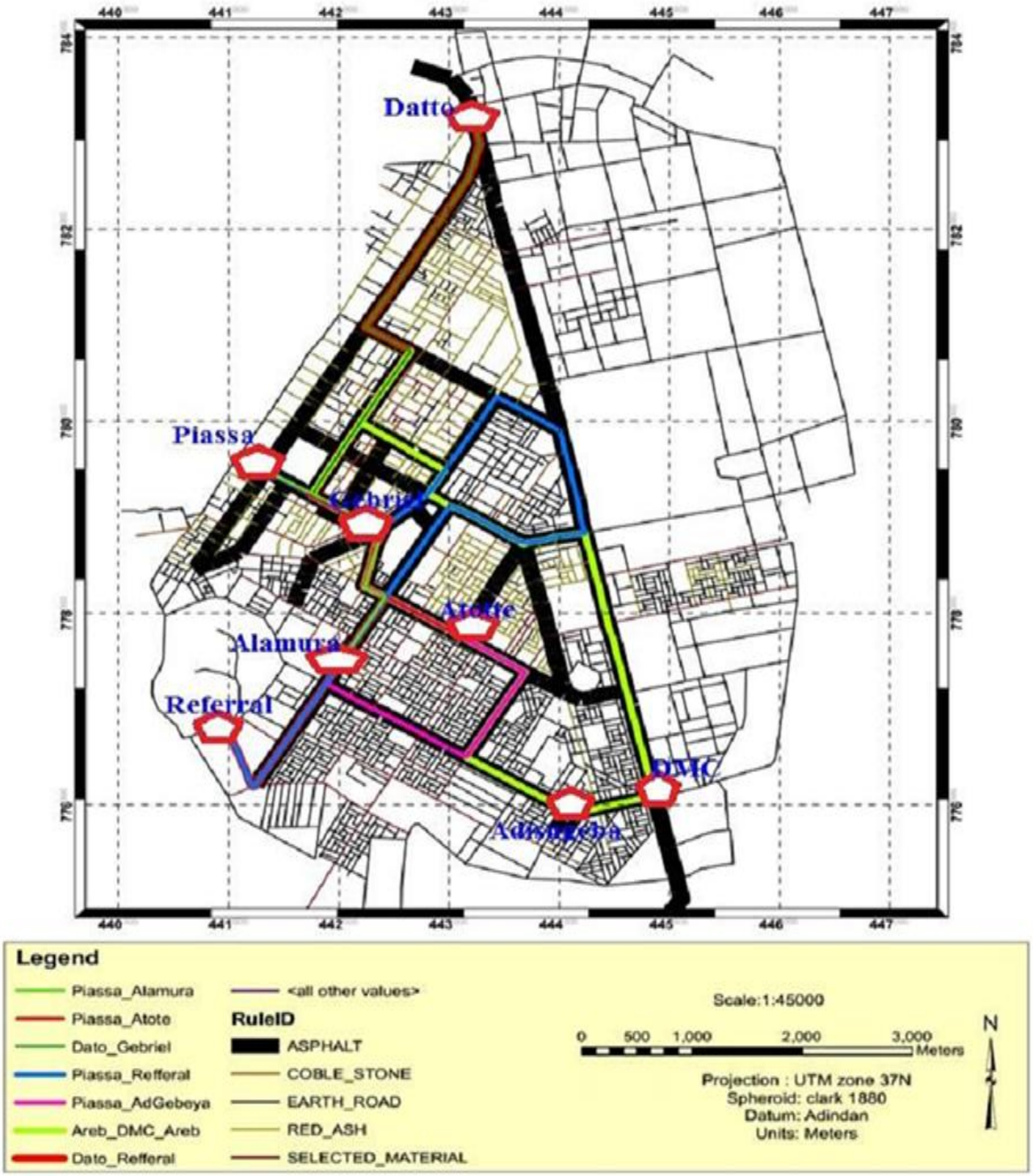



Figure:3.2.Hawassa city road network

### 3.2. Method of Data collection

The target population and area for the study were Hawassa city major roads, minibus taxi stations, minibus users ,Bajaj users, public bus users, road users and government office like Hawassa city Municipality, Hawassa city Administration and Hawassa city road and transport bureau and road department. The People movement is characterized by its nature of mobility from one place to another making their destination at different locations of Hawassa city like educational institutions, work places, recreational areas, holy places and market places, etc. The population took into consideration were the variety of individual with their differences concerning age, sex, educational level, income, occupation and others.

#### 3.2.1 Sampling techniques and sample sizes

According to Hawassa city Road and transport office (2018) report, there were a total of 131,543 populations use public transport. Out of this 46,436 people were use minibus or dolphin taxi and 56,107 passengers also were uses Bajaj taxi transport and about 31,000 transport users were used public transport. And according to (Lulachew,2016) study there are about 16,191registerd motor vehicles in Hawassa city.

##### 3.2.1.1 Sample size determination for service quality evaluation

Probability sampling or random sampling was used for sample selection of minibus taxi service quality evaluation purpose. This means, every member of the population has a chance of inclusion in the sample. This sampling method has been used for taxi users passenger.
The formula that used to determine the sample size was developed by Cochran (1963) which is used for large population

$$n = \frac{z^2 pq}{e^2}$$ .....Equation 3.1

Where, n = Sample size

Z = the standard normal deviation at the required confidence level.

P = the proportion in the targeted population estimated to have characteristics

q = 1-p and e = the level of statistical significant set (margin of error).

Then, p = 50% =0.5 and q = 1-p = 0.5 (Possible to take the value of p = 50% in statistics).

Z statistic is 1.96 and e desire accuracy at 0.1levels. (94% confidence level and 5% error).

$$n = \frac{z^2 pq}{e^2}$$

Therefore, the minimum sample size is

$$= \frac{(1.96)^2 x(0.5)x(0.5)}{(0.05)^2} \quad = \quad \underline{\mathbf{384}}$$

Hence the minimum sample size for service quality evaluation was proposed to be 384 Samples; however, for simplicity customer satisfaction of minibus taxi users was analyzed on this study by taking 400 sample customers (100 from each of four selected route the study area) which were selected using random sampling technique.

#### 3.2.1.2 Sample size determination for taxi distribution evaluation purpose

For the purpose of determination of number of representative household size sample in the study of demand and supply analysis the targeted population public transport users should have to be stratified based on different categories like population per Kebele,traffic analysis zone, grouped based on sex, grouped based on age and based on trip purpose, thus among different sampling methods Stratified sampling method is chosen for this purpose.

And to determine the size of sample Aczel (1999) equation is used below

$$n = \frac{N}{1+N(\alpha)^2} \quad \text{.....Equation 3.2}$$

$$N = \frac{Po}{HH\ av} \quad \text{.....Equation 3.3}$$

Where n is number sample house hold size

Po is the number of population in the study area

$HH_{av}$ is the average people per households

α is confidence level and assume 95%

α = (1-0.95) = 0.05

N = 43,645/6.2 = 7040 HHs in the study area

$$n = \frac{7040}{1+7040(0.05)2} = 378.5 = 380$$ House hold sample

Since the sample was drawn from the household population of Menahariya sub city its stratified over the Kebele's level. Then, the samples were selected from each of the Kebeles with the respected sample size based on their population number.

Table:3.3.Summarized drawn sample size of Menahariya sub city

| No | Kebeles | Population per each kebele | Sample size |
|---|---|---|---|
| 1 | Guwe stadium | 10,326 | 90 |
| 2 | Millinium adebabay | 18,820 | 163 |
| 3 | Piassa | 14,499 | 127 |
| Total | | 43,645 | 380 |

### 3.2.2 Data collection method of Service quality evaluation of minibus taxi

The data's those collected under this was used to evaluate how much the minibus taxi users are satisfied and how much gap is there in between the taxi users and the operators based on the service provided in the city minibus taxi transport. For this condition of evaluation the

researcher used only primary data source which is questioner. Beside this the researcher tried to observe the minibus taxi provided service and capture some picture related to providing service quality defects.

**Questionnaire**:- It was prepared for passengers of minibus taxi. For passengers, all the questions were multiple choice or closed-ended questions. The passenger was selecting the satisfaction level for each minibus taxi service attributes evaluation questions based on the Satisfaction evaluation dimensions those very dissatisfied, dissatisfied, neutral, satisfied and very satisfied scales.

After collecting the satisfaction level of taxi users per each selected attribute those like reliability, availability, tangibility, safety and security of minibus taxi by using questionnaire paper inserting to Microsoft excel software and through using bar chart method of analysis the output of Microsoft excel is displayed in the form of bar chart and the researcher tried to discuss on the displayed result of excel.

**Observation:** since, the observation helps by providing visible information and strengthens the data collected by the other methods**;** the researcher did travel survey in the city captured photos and gathered information about the existing service of minibus taxi**.**

Figure:3.3.minibus taxi internal chair defect and appearance

### 3.2.3 Data collection methodology for minibus taxi distribution concern

#### 3.2.3.1 Method of Data collection of travel demand

First the researcher had been started the data collection process of this targeted objective by selecting the study area which is minibus taxi is dominantly operated area and Old bus station area of taxi station is selected for the study and four route of mini bus taxi operated links were selected their starting origin is Old bus station taxi loading area those are route one from Old bus station to Mobil taxi station , route two from Old bus station to New bus station, route three from Old bus station around blue Nile hotel to Referral Hospital and the fourth route is From Old bus station to Piazza city center. Depending on this for collecting the travel demand of public transport the researcher first identified the routes origin to destination and the station existed sub cities, Based on this all routes are started at Menahriya subcity and the destination of each route is: route one destination is on Mehal Ketema subcity, route two and route three are destined at Tabour sub city and route four is found in Menahariya subcity. Regarding on this the necessary data for demand analysis from each sub cities were collected from both primary data source and secondary data sources of each for them accordingly below.

**Questionnaire (primary data source):** The data collection for different trip making behavior was collected from home based interview survey. For this purpose questioner was prepared which contain both questions in closed and open ended and distributed to the sampled household level to collect aggregate base year data. Such as number of population per household, number of jobs per household, number of students per household for each zone and age category per household for each zone.

**Secondary data sources:** Number of population of the Menahariya subcity per age category for both sex collected from the statistics office, the number of jobs collected from the private and public institution exists in each analysis zone from Hawassa city civil service office and Number of students had been collected from each school exists in each zone both in private and public schools from Hawassa city education bureau.

Table:3.4.Age based population distribution of Menahariya subcity

| Kebele | Female age distribution | | | | | | |
|---|---|---|---|---|---|---|---|
| | 5-15 | 16-26 | 27-37 | 38-45 | 46-55 | 56-65 | 65+ |
| Guwe stadium | 1266 | 1226 | 1453 | 712 | 248 | 186 | 176 |
| Milinium adebabay | 1265 | 3044 | 2845 | 765 | 503 | 262 | 206 |
| Piassa | 1054 | 2575 | 1905 | 976 | 324 | 210 | 104 |
| Total | 3595 | 6845 | 6203 | 2453 | 1075 | 658 | 486 |
| | Male age distribution | | | | | | |
| | 5-15 | 16-26 | 27-37 | 38-45 | 46-55 | 56-65 | 65+ |
| Guwe stadium | 1124 | 1481 | 1011 | 885 | 134 | 287 | 137 |
| Milinium adebabay | 2002 | 3188 | 2765 | 893 | 543 | 301 | 238 |
| Piassa | 1361 | 2324 | 2189 | 865 | 325 | 158 | 119 |
| Total | 4487 | 6993 | 5965 | 2643 | 1002 | 746 | 494 |

(Source : CSA,2015)

### 3.2.3.2 Method of data collection for supply

The other type of data which helps to assess public transport demand is data which shows existing facility both in movable and fixed facility the following data type was collected by the researcher. To collect data related to transport supply such as paved and unpaved road length; Public bus route, their starting and end point. Number of available vehicle which give public transport services their starting and end point, number and price for single trip. The work has been used check list which shows all the necessary information described above and the researcher went to each governmental office such as city transport bureau municipality and taxi owner enterprises. Also to gather such type of data the researcher had been used secondary sources. Such as Governmental office report; Bulletin prepared by city administration; Magazines prepared by city administration and other non-governmental office and previously published study.

Table:3.5. Road condition detail in the Hawassa City

| Year (G.C) | Asphalt(KM) | Gravel road(KM) | Dry whether road (KM) | Red ash(KM) | Cobble stone (KM) |
|---|---|---|---|---|---|
| 2013 | 56.5 | 312 | 295 | | 81 |
| 2014 | 132.3 | 352 | 325 | | 154 |
| 2015 | 132.3 | 472 | - | 120 | 189 |
| 2016 | 134 | 520 | - | 180 | 240 |
| 2017 | 136 | 520 | 350 | 180 | 320 |
| 2018 | 147 | 582 | 495 | | 361.29 |
| 2019 | 152 | 620 | 511 | 240 | 460 |

Source : (Hawassa city municipality , 2020)

Table:3. 6.Currently registered public transport mode of transport in Hawassa city

| N$^{o}$ | Types of mode | Number of vehicles |
|---|---|---|
| 1 | Mini bus | 568 |
| 2 | City Bus | 17 |
| 3 | Auto rick show | 2752 |
| | Total | 3285 |

Source: (Hawassa city road and transport office, 2018 report)

### 3.2.4 Data collection methodology for passenger fare establishment concern

For this case which is establishing passenger fare using HDM-4 tool the data was collected through different means from both primary and secondary data sources.

**Primary data sources**: through using field measures and video recording.

These include: lane width, number of lane, number of vertical curve , number of horizontal curve, width of the median and traffic volume.

**Secondary data source:** on this concern of study different secondary data source are used for HDM-4 tool from different literature documents, the following table presents the data type and their source**:**

Table:3.7.Collected data type and their respective sources

| No | Data types | Primary data | Secondary data | Sources |
|---|---|---|---|---|
| 1 | Lane width , number of lane, and all road feature | XXX | | Filed measurement |
| 2 | No of vertical curve and No of horizontal curve | XXX | | Field measurement |
| 3 | Width of median and traffic volume | XXX | | Field measurement |
| 4 | New vehicle costs and tire replacement costs | | XXX | W.T consulting PLC |
| 5 | Load factor | | XXX | Hawassa city road and transport office |
| 6 | Spare part cost, average service life of the vehicle and annual km driven | | XXX | W.T consulting PLC |
| 7 | Fuel and oil cost | | XXX | NOC fuel distributor |
| 8 | Length of km of the road | | XXX | Hawassa city road and transport office |
| 9 | Maintenance and crew cost | | XXX | W.T consulting PLC |

Table:3.8.The selected routes road their geometric dimension and traffic flow

| NO | Route | Along the direction of | LW | NL | NI | NHC | NVC | MW |
|---|---|---|---|---|---|---|---|---|
| 1 | Old bus to New bus station | w/amanuel intersection | 3.5 | 3 | 5 | 1 | 2 | 3 |
| 2 | Tigest hotel to Mobile | Megenagna intersection | 3.5 | 3 | 5 | 1 | 3 | 2 |
| 3 | Old bus station to referral hospital | Trufat straight rod | 3.5 | 2 | 5 | 1 | 1 | 2 |
| 4 | atote station to old market | St.gebriel church | 3.5 | 3 | 4 | 1 | 1 | 2 |

Source :( from field measurement)

## 3.3 Methods of Data processing and analysis

### 3.3.1 Method of data analysis for service quality evaluation of taxi transport

The quality of service section of the manual which is the Transit Capacity and Quality of Service Manual (TCQSM,2003) intended to provide a comprehensive look at transit quality of service from a passenger's point-of-view, and a set of performance measures are provided. These measures can be applied to assess existing and projected quality of service as an aid in identifying transit service, facility, and system performance and improvement needs (TCRP, 2003).

Also according to( Jonson and Clark,2005) study the performance of public transport like mini bus taxi is measured by different indicators; in terms of whether the transportation options have financial costs within the targeted user's budget (affordability), whether transportation options exists at the location and time users require (availability), whether the transportation options protect the user's from dangers, often called (safety), and whether the transportation options are considered suitable by users ( comfort quality).Based on this, In order to examine the customer's satisfaction on service quality of minibus taxi, basic check lists or performance indicators were selected for evaluating the service quality of minibus taxi summarized below:

Table:3.9.Service quality evaluating parameters with their attribute

| No | **Parameters** | **Attribute** |
|---|---|---|
| 1 | Reliability | Related to service reliability of public transport, availability and travel time saving issues to perform the promised service dependably and accurately. |
| 2 | Tangibility | Its major concern related to the vehicles passengers loading corresponding to seats, seats comfort and cleanness and ventilation of the transport mode. |
| 3 | Safety and security | Degree of security for Passengers and freedom from danger, risk, or doubt. |
| 4 | Tariff structure and its affordability | is also concern about the structure of fixed tariff, tariff affordability and the level agreement during percentage increments of tariff during peak hour. |

Source: (Samson,2016) study

Therefore, those parameters of service quality were mainly given the greater attention in the analysis. Transport users Satisfaction was expressed in terms of different level of satisfaction. The respective responses of taxi users for all of the parameters stated above were collected by using Likert type Scale on questionnaire paper. In this scale, five responses presented for each particular measure those are very dissatisfied, dissatisfied, averagely satisfied, satisfied and very satisfied on existed quality service of mini taxi transport..

The passenger had selected their level of satisfaction on all respective questions and the researcher using all response of the taxi users inserting the collected data to Microsoft excel software. And the result of response was display on column chart form. So that, based on the result obtained it will be possible to draw conclusion about the general minibus taxi transport services quality.

### 3.3.2 Method of data analysis for minibus taxi distribution

According to different literature reviewed in the literature section for modeling of travel demand the most appropriate transport travel demand modeling for determination of travel demand is the four stage aggregate transport modeling. The modeling start first by

determining number of trip considering base year data called trip generation both trip attraction and production, on the second stage trips which are generated under the first stage was distributed to the routes in the study area network, modal split and traffic assignment in to the available route in the network.

This travel demand model basically needs proper identification of data, sampling of data, collection of data and choosing of fitted models and their calibration on each stage of convectional four stage transport travel demand forecasting model.

For this study the researcher had used four trip purpose types. The trips can be classified according to trip purposes those selected are: home-based work trip, home-based education trip, home-based shopping and home based other trips. Thus using those four trip purposes and based on the method of four stage demand modeling, the researcher intended to distribute minibus taxi transport on selected routes of the city. Four selected trip purposes with their respective purpose are shown below.

- **Home-Based Work (HBW):** This category includes To/From Work or Work-Related Business trips.
- **Home-Based School (HBS)** - This category includes trips to school, college or university for classes, or to school-related meetings.
- **Home-Based Shopping (HBSho)** – One end of trip is shopping activities.
- **Home-Based Other (HBO):** This category includes family and personal business trips such as banking, haircuts, visiting friends and relatives, other Social or Recreational trips taken for entertainment and recreation, and for trips that do not fit any of the other categories.

Now in this section the researcher had discuss the systematic analysis flow of each steps in determining the output of each stage of convectional four stage transport travel demand forecasting model.

#### 3.3.2.1Trip generation

This is the first stage in four stage travel demand modeling it includes both trip production and attraction. To determine number of trip produced and attracted to wards each zone the following steps had been followed:

**Trip production**

The aim of trip production is predicting the total number of trip produced by each zone of the study area. As Ortuzar and willumsen(2011) have demonstrated that common trip production patterns on the basis of following standard trip purposes those are home-based work trip, home based education trip, home-based shopping trip and home-based other purpose trips. Regarding with this for determining the trip production the following procedure was followed by researcher

- Classified and grouped the number of collected population from each zone to the following age categories (5-15), (16-26), (27-37), (38-45), (46-65), $65^{+}$ and Computing the production trip rate for each age categories for each of trip purposes and taking the average trip rate per person for each category per each zone.
- Through using statistical model of categorical analysis to determine the trip production for each zone. Multiply the population per each age category by their corresponding trip rate of production. Finally Origins (production)-Destination (attraction) matrix for all trip purposes were prepared. And put number of trips which were obtained on the above step on the origin (production) column.

**Trip attraction**

This is the non-home end of an HB trip or the destination of an NHB trip to determine the number of trip attracted to wards each zone the following procedure was followed by researcher.

- The researcher prepared the data of number of employment, students; number of other purpose traveler was collected from each public and private institution. Then after the researcher was calculating trip attraction rate for all trips purposes.

Next to this add the number of trips performed per each sampled household towards each purpose of trip. Divided the added trips by the sample size was done next. Then again divide this result by average number of population per household which is the attraction rate per person per day each zone will get now. And finally selecting trip production and attraction model which is the category analysis method. Using this method and the prepared data on the above steps the produced and attracted trip in and towards the zone had been prepared.

- Finally the researcher calculated the number of trips attracted to wards each zone by multiplying the total number of each purpose of traveler by their respective rate the result is the number of trip attracted to wards each zone. The researcher prepared this value on the destination (attraction) row of the produced O – D Matrix. For instance the O—D prepared matrix for each trip purpose is similarly prepared and the O—D matrix table of home to work purpose is shown below:

Table:3.10.Production and attraction table matrix of home to work trip

| Station | Old bus station | New bus station | Mobile | Piazza | Referral | Production |
|---|---|---|---|---|---|---|
| Old bus station | | | | | | **2280** |
| New bus station | | | | | | **1923** |
| Mobile | | | | | | **2018** |
| Piazza | | | | | | **1952** |
| Referral | | | | | | **2223** |
| Attraction | **3365** | **1308** | **2657** | **1489** | **1544** | |

### 3.3.2.2 Trip distribution

In the four-step transportation forecasting model, trip distribution focuses on trip makers' origins and destinations to develop a "trip table", which is a matrix that displays the number of trips going from each origin to each destination. Trip distribution Analysis is performed by using gravity model, in which the trips between two zones are directly proportional to the

number of trips produced in zone i and the number of trips attracted to zone j and inversely proportional to the distance between the two zones.

The equation gravity model analysis can be written as follows:

Tij = Ai BJ oi Pj F(Cij)……..…….Equation 3.4

Where Tij = trips between zone i and zone j;

oi = production in zone i;

Pj =attraction to zone j;

Ai =balancing factor for origin I which is expressed as $1/\Sigma(Bj\ Pj\ F(Cij))nj=1$;

BJ = balancing factor for destination j expressed as $1/\Sigma(Ai\ oi\ F(Cij))nn=1$; and

F(tij) = time deterrence from zone i to zone j

Where, tij = travel time or distance (generalized time from zone i to zone j); and

α = parameter to be calibrated

In the case of trips distributed from Menahariya sub- city, five minibus taxi station destination nodes within Hawassa city taxi station were selected and those are: Old bus station taxi station, Piazza taxi station , Mobil taxi station, Referal hospital taxi station and New bus station taxi stations. The following list below illustrates the selected four trip destinations route for trips generated in Menahariya sub-city around old bus station mini bus taxi fermata.

TAZ-- 1 is Old bus station

TAZ --2 is New bus station

TAZ --3 is Mobile gas station Area

TAZ --4 is Piazza adare Hospital station

TAZ --5 is Referral Hospital taxi station

Through using gravity model, impedance factor and the generated trip of the Origin – destination matrix which was produced for the base year data the inter trip distribution of origin destination matrix had been produced for trip purposes.

From trip distribution table of intra zonal, trip distribution was not balanced in terms of trip attraction and production. So trip distributed matrix was iterating using doubly constrained gravity model on MS Excel prepared template. Then, after the second iteration the constrained constant or balancing factors had been converge to each other and after fourth iteration the constrained constant or balancing factors had been converged to the required condition.

#### 3.3.2.3 Mode choice

The third step of modeling is modal split. An important objective in mode choice modeling is to predict the share of trips attracted to available means of transportation mode. The most commonly applied method to study mode choice is the logit model.

In this research, the modal share of the trips for the selected study area with regard to public transportation system was analyzed. For the development of travel demand modeling, only the public transport means of, Taxi (Minibus), City Bus, and Bajaj were considered.

Based on the selected model which is logit model of modal split is the better method to analyze the third step of the four stage passenger demand forecasting model. So, using the logit method the choice of transport mode analyzed as follow using the following equation.

The generalized cost – time equation is:

$Cij = a1tij^{v} + a2tij^{w} + a3tij^{t} + a4fij$……Equation 3.5

Where: *i* and *j* are origins and destination

$tij^{v}$ - Vehicle travel time

$tij^{w}$ - Waking time

$tij^{t}$ - Waiting time

fij - Monetary charge

The equation of probability of an individual $i$ selecting a mode m, out of N number of total Available modes are given by:

$$P_{ij}^{mode} = \frac{(e^{-\beta * Cij\ mode})}{(\Sigma e^{-\beta * Cij\ modes})} \quad \text{……..……Equation 3.6}$$

Where;

$pij\ mode$-- Probability of using mode

$c\ ij\ mode$-- Generalized value of mode

β -- Parameter for calibration

Finally using the probability matrix for each mode of transport and for each route of trip on trip distribution the probability of choosing the modes had been calculated.

#### 3.3.2.4Traffic assignment

The last step of travel demand modeling in traffic assignment to the road network under study. The required data for traffic assignment are O-D matrix which contains the vehicle volumes to be assigned for each O-D pair, and transportation networks with the appropriate attribute fields. From all traffic assignment methods described in the literature chapter, All-or-Nothing Assignment method is chosen. Because of, All-or-Nothing Assignment does not require much mathematical procedure, it depend on the travel time of the network only.

Under this stage the work had been assigned to determine the required number of mini bus taxi on the selected link of the road network and comparing to the current assigned mini bus taxi transport. Regarding with this the work had been addressed on determination of total number of mini bus taxi for each selected route.

Now the researcher had been started by converting the number of trips obtained on the modal split stage of four stages modeling in to number of trips served by each public mode type. But this study concentrated on mini bus taxi transport mode only. So to determine the required number of minibus taxi vehicle using the formula given below

No of minibus taxi required = $\frac{\text{Flow of minibus}}{\text{Occupancy of minibus taxi}}$ ……..…….Equation 3.7

Where: Occupancy of mini bus = 11

After converting the number of trips in to number of mini bus taxi required for each selected route. The matrix had been prepared which shows the number of mini bus taxi served by per each link of the city. Then the number of mini bus taxi distributed to each selected route had been obtained.

Finally the number of minibus taxi obtained on the above step compared with the existing number of minibus taxi operated now in the selected route of the city.

### 3.3.3 Method of data analysis for establishing passenger fare for minibus taxi

Passenger fare establishment is the process of developing, organizing and setting transportation fares to be charged by transport operators for the service they provide to customers. The fare is established for both freight and passenger. The focus of this research is on passenger fare. According to (Samson,2016) study the passenger fare for the small and medium buses is established on the basis of zonal boundary and the passenger fares are calculated by the zonal transport authority based on a common ground that is primarily set by the Road and Transport Authority.

#### 3.3.3.1.HDM-4 Input Data

Input data are the basic data items required to run HDM-4. The software is applicable to many countries due to the fact the default data are user definable. Every potential user can choose values that suit the local conditions. This enables the software to work with wide ranges of data type and quality. Some of the main input data required are divided into four groups and are discussed below:

❖ **Road Network Data**

This section provides the basic facilities for network referencing within HDM-4. It allows users to define different networks and sub-networks, and to define sections of road, which are the fundamental unit of analysis within HDM-4.

A defined road network divided into different sections with each section considered as homogeneous in terms of its physical attributes (for example, road class, climate, carriageway width, geometry, pavement condition, traffic flow, and axle loading). Then after using aggregate data, user selects for various section of road network defining its characteristics like: speed-flow type, traffic-flow pattern, surface type and road length.

For the first road network (Tigest hotel to Mobil station) its basic characteristics tabulated below:

Table:3.11.Basic characteristics of road network of Tigest hotel to Mobil station

| | Description | Length (KM) | Speed flow type | Surface Type | Traffic flow pattern |
|---|---|---|---|---|---|
| 1 | Tigest Hotel – south star Hotel | 0.7 | Four lane | AC | Commuter |
| 2 | South star to Megenagna | 0.5 | Four lane | AC | Commuter |
| 3 | Megenagna- 22 mazoriya | 0.6 | Four lane | AC | Commuter |
| 4 | 22 mazoriya – Selassie traffic | 0.3 | Four lane | AC | Commuter |
| 5 | Selassie traffic light to Mobile | 0.6 | Four lane | AC | Commuter |

Basic characteristics of road network from Old bus station to New bus station, Tigest Hotel to Piazza and Millinium hall to referral road segment, all road characteristics are attached at the annex.

❖ **Vehicle Fleet**

Vehicle fleet is a category where it describes diverse characteristics of vehicles operating on the road network being analyzed. It comprises a mix of representative vehicle types that use a road network. Parameters specified for the representative vehicles should reflect the overall

physical and performance characteristics of the range of vehicles that use a road network (Gedafa,2006).

Table:3. 12.Vehicle characteristics inputs datas' required in HDM-4

| **Vehicle characteristics** | | |
|---|---|---|
| **Physical** | **Utilization** | **Loading** |
| Passenger car equivalents | Annual KM driving | Number of passengers |
| No of wheel | Annual working hour | Operating weight |
| No of Axle | Average life | % private uses |

- **Traffic Data:**

Accurate traffic data is the most crucial information for getting reliable results from the economic analysis. It starts with describing traffic characteristics of road and must be presented with appropriate level of detail.

According to Gedefa,(2006) studies traffic data types consider the following :

- Traffic Categories including normal, diverted, and generated,
- Traffic Composition including volume and growth rates
- Traffic-Flow pattern and speed flow pattern

- **Road Works Standard:**

This section describes the specification of road work standard used within HDM-4. By definition, standard refers to the target or level of conditions and responses that a road administration aims to achieve specific objectives which are related to functional characteristics of the road network system.

The standards include the road maintenance and improvement standards are followed by the road administrations in their network management and development activities.

For this study since the road network is asphalt road the researcher used the following two standards within two different cases, the two cases are with project case and without project case.

Table:3.13.Asphalt road type project case study standards

| No | Alternative | The required standards |
|---|---|---|
| 1 | With project | Reconstruction of the road |
| | | Asphalt maintenance |
| 2 | Without project | Asphalt maintenance |
| | | ---------- |

### 3.3.4 HDM-4 analysis and processing procedure

#### 3.3.4.1 HDM-4 Software

The Highway Development and Management (HDM-4) system is a software tool that is used to appraise the technical and economic aspects of road investment projects. It consists of different sections for determining necessary parameters. Road User Effect (RUE) is one of the outputs obtained from the model. This comprises vehicle operating cost (VOC) and travel time cost (TTC) for both motorized transport (MT) and non-motorized transport (NMT), and Accident cost. The total road user cost is the sum of these costs. Therefore HDM-4 model will be used for determining the operating costs of the city transportation vehicles and this vehicle operating cost would be used to establish the transportation fare (Samson,2016).

### 3.3.4.2 Procedure of passenger fare establishment after getting VOC from HDM-4

Step 1 Assess the VOC data from the software in the form of (VOC per vehicle--km) .

Step 2: since our vehicle is minibus taxi take the number of seat equal to 11

Step 3: then compute VOC per person for selected minibus vehicle that is:

$$\text{VOC per person-km} = = \frac{VOC\ per\ vehicle-km}{number\ of\ seat}$$

Step 4: next calculate VOC per person through multiplying VOC person-km by the distance of traveling

VOC per person = VOC per person-km (ETB/ person- km) *distance (km)

Step 5: Assume the profit (20- 25)% of VOC per person

Step 6: finally, Total passenger fare per person will get by adding the profit with VOC per person.

Total passenger fare per person = VOC per person + profit

# 4. RESULTS AND DISCUSSION

## 4.1 Result of service quality evaluation

### 4.1.1 Service reliability and availability of mini bus taxi

Service reliability is mostly related to schedule adherence in the existing intra city public transport service. Reliability is the basic aspects to measure the service quality of transportation. The responses of passengers are presented as follow. Accordingly, 43% of respondents are dissatisfied with the service reliability and other (8%) are very dissatisfied. About 31% respondents are on the average side being neutral while about 14% respondents are satisfied. As seen from the numbers, almost half of the respondents (passengers) are beyond dissatisfied in general. On the other hand finding of (Samson, 2016) said that reliability is also related to availability of the required transport modes at the needed time and also related to travel time saving the time that passengers spend in the vehicle during traveling on the taxis vehicle. The following figure 4.1 shows the satisfaction level of passengers on three aspects

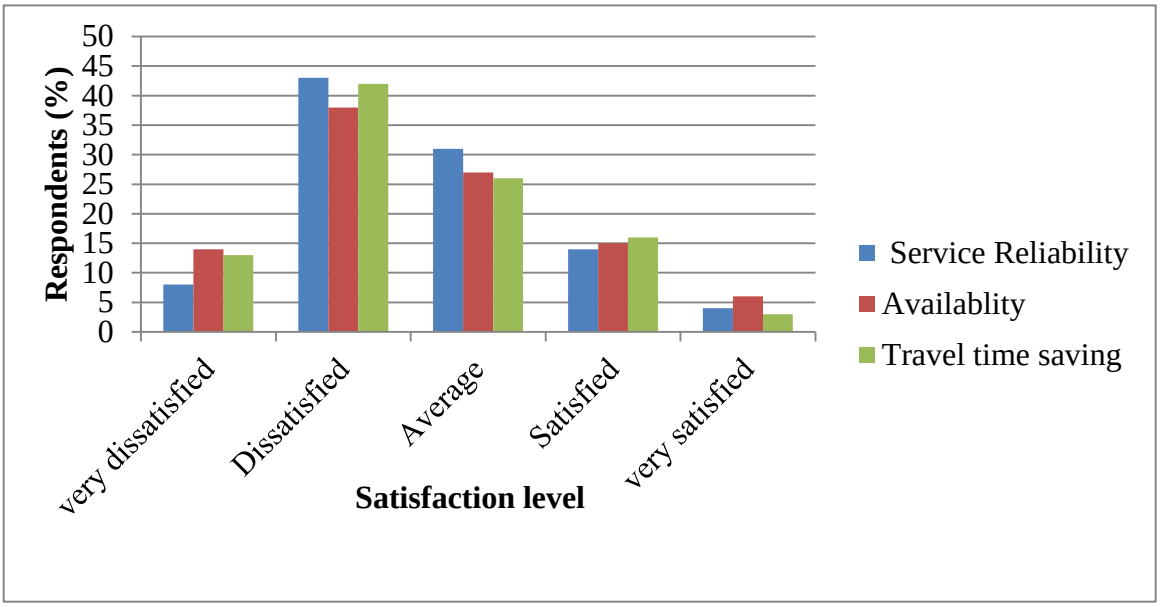



Figure:4. 1.Passenger level of satisfaction on reliability, availability and time saving aspect

The result of how frequently the taxi transport is available in the city shows that, about 38% of the passengers are dissatisfied and 14% of the passengers are very dissatisfied. Also about 27% are average while 15% of the passengers are satisfied. Related to this (Degwale *eta al*,2018) finding indicated that ,regarding the issue of availability of public transport to get into service, almost about 62.3 percent of the respondents replied that waiting for taxi/bus to get transport service took them more than 21-30 minutes and above. Based on this availability of minibus taxi transport in Hawassa city need special improvement to serve the users properly.

Concerning with travel time saving, about 42% of the respondents are dissatisfied and 16% are satisfied while 26% are neutral. The main reason passengers give for not being satisfied is that they spend longer time in the vehicle without starting journey while waiting for the vehicles until loading full seat. According to (Kumelachew, 2018) study compared that, People are choice minibus taxi rather than bus because of taxi has only 12 set chair and it did not take long time in one station. And (Ponnuswamy ,1992)finding also supporting that travel time and travel cost is consistency for mode choice of public transport. This indicates that the relationship between these quality aspects is very important in the intra city taxi transportation industry. Therefore, If there exists a scheduled service and available with enough standard, then passengers will become satisfied with the above aspects of service quality.

### 4.1.2 Tangibility of minibus taxi transport service

The variables used to measure the public transport tangibility constitute the overall physical conditions of vehicles those are vehicles loading condition with corresponding to vehicle seat, seat comfort inside the vehicles and cleanness and ventilation condition of the vehicles.

Concerning about the vehicles loading situation whether with corresponding seat capacity or not, the response of the passengers are about 93 % of the respondents are says No and about 7% of the respondents are say yes, that means most of the taxi are loaded beyond allowable seat capacity. During data collection period, observation was made to assess the service provided by mini bus taxi and since there is no proper distribution of the taxis to all direction

and there is no enough supply of mini bus vehicles the taxis forced to load up to 20 passengers per one minibus taxi. This will reduce the intended quality service of the taxis.

The study result of (Degewale *et al*,2018). Confirmed that, from all factors those affected the tangibility of the public transport ,vehicle loading corresponding to vehicles seats, is very low which is founded at 7.7 percent. That means loading beyond vehicle seat is highly affect the service quality provided under public transport.

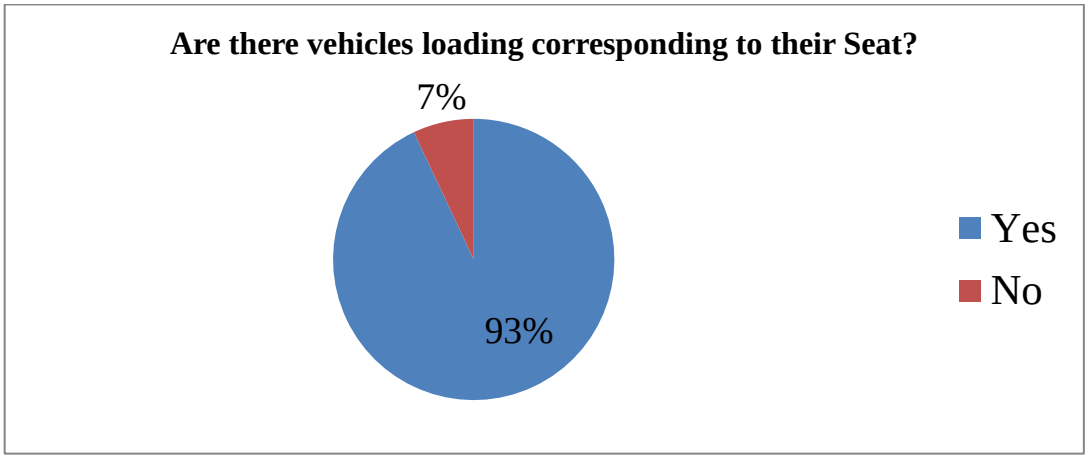



Figure:4. 2.Passenger responses on loading of passenger on taxi

Concerning with the taxis seats comfort inside the vehicles for these services, passengers' satisfaction was assessed. Of the total respondents, about (49%) are dissatisfied and 26% respondents are very dissatisfied. About 19% remain average and only 4% 0f the total respondents are satisfied. However the study of (Kumelachew,2018) result compared the comfort between mini bus and bus transport in this manner the participants who gave less priority to comfort are 0.3 times lower to prefer minibus taxi than bus as compared to the odds of participants who gave priority to comfort. In other words, those of who need comfort are preferred minibus taxi. Generally the main problems raised by passengers on vehicles seats is there is no enough space for legs because of the vehicles load beyond their seats. For instance, for two persons installed seats the taxi operators loaded three person, so the passenger does not sit properly on the seat. Besides this unable to balance their body weight and feels discomfort during traveling on the taxis.

Concerning the vehicles cleanness and ventilation of the taxi transport, the following responses were obtained. Accordingly, 47% respondents were dissatisfied and another 28%

were very dissatisfied while 21% remain average that means most of the passengers about more than half of the respondents are not satisfied by cleanness and ventilation of the taxi transport. Based on this, (Endale,2014) study result indicated that the commitment of taxi operator to keep the taxi clean, and ventilated enough concern has lowest mean score(3.48) and this lead to the passenger subjected for different communicable diseases. The result of both study shows that, the overall physical conditions of vehicles have a considerable negative effect on the degree of passengers 'satisfaction with urban public transport in the study areas

The chart below represents the satisfaction of passengers in these regards.

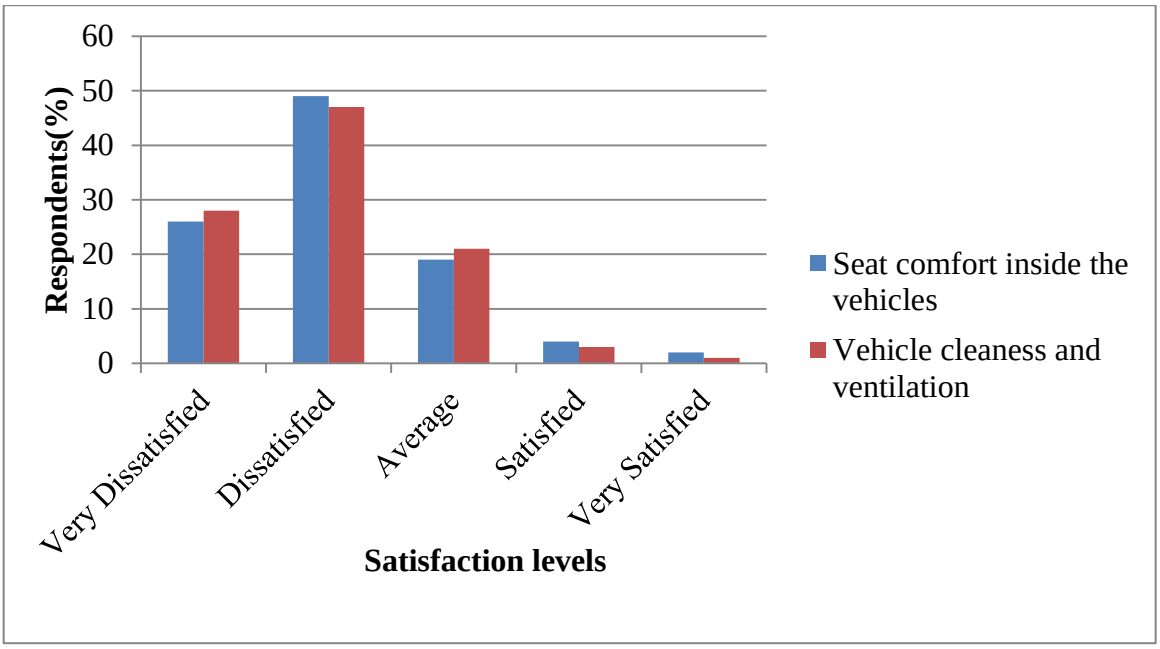



Figure:4. 3.Passenger opinion on comfort and sanitation of taxi

### 4.1.3 Safety and security of the passengers

Passengers were asked to give opinions on their level of satisfaction regarding on the security and safety condition of the taxi transport that they have experienced through repeatedly using the taxi transport. As respondent feedback, the majorities (56%) were dissatisfied; 25% were very dissatisfied while 18% of the passengers were with average satisfaction only 1% was satisfied. the result of this study on safety and security is similar to the finding of (Tegegn,2018)

his finding indicated that to conclude those of who needs both safety and security prefers to minibus taxi rather than bus transport but still about the majority of minibus users are highly disagree on safety and security of mini bus taxi.

The following Figure summarizes the passengers' responses below:

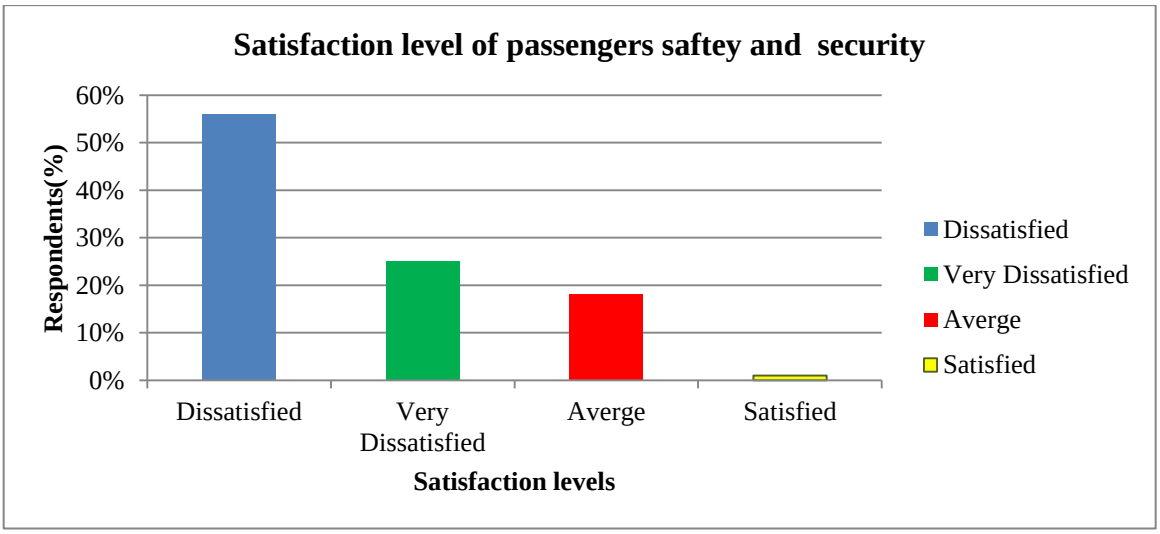



Figure:4. 4.Passenger satisfaction on safety and security of minibus taxi

According to the information obtained from informal discussion with the mini bus taxi users the presence of good lighting on minibuses and at station have a beneficial effect in reducing the opportunities for the crime of pick pocketing, overcrowding of minibuses and poor discipline at minibus station and terminals increases passenger's vulnerability to pickpockets. Besides this (Endale,2014) confirmed that on public taxi operation particularly, stealing is common and people lose their wallets due to pick pocketing. These acts often create a sense of insecurity among passengers and diminish their satisfaction with public transportation services.

### 4.1.4 Tariff structure and affordability

Concerning the current tariff of transportation and its affordability, the following responses are obtained. Of the total respondents, the largest numbers (46%) are dissatisfied and about (16%) of the respondents were found to be very dissatisfied. Additionally, 33% of them agree that the tariff is average for many people while only 5% are satisfied and totally agree with the current tariff. The complain of the passengers is that for one trip which has different destination of boarding the passenger forced to charge the same amount of fare. For instance

if you take one minibus taxis and if its origin is from old bus station and its destination is Piassa the tariff (passenger fare) is 3 birr per person but if someone wants to board at the St. gebriael church which is the place found in between origin and final destination of the taxis route the passengers' will forced to pay 3 birr even if he is not reached at the final destination.

Related to tariff affordability, about 36% of the respondents agree that the tariff is affordable by the average number of passengers. 28% are satisfied and 23% are dissatisfied and 13% are very dissatisfied users who do not think the tariff is affordable by passengers. (Degewale *etal*,2018) study found that operators' complaint about tariff is not related with ignorance of those considerations type of vehicle. Rather the unbalanced demand and supply of transport operators and users leads the operators to request more than the tariff. Also the finding of (Kumlachew,2018) study compared that the participants were used or choice minibus taxi rather than city buses, even though their transport cost is increasing per day. As the p-value indicated that, there is a difference in mode of transport choice in different transportation cost.

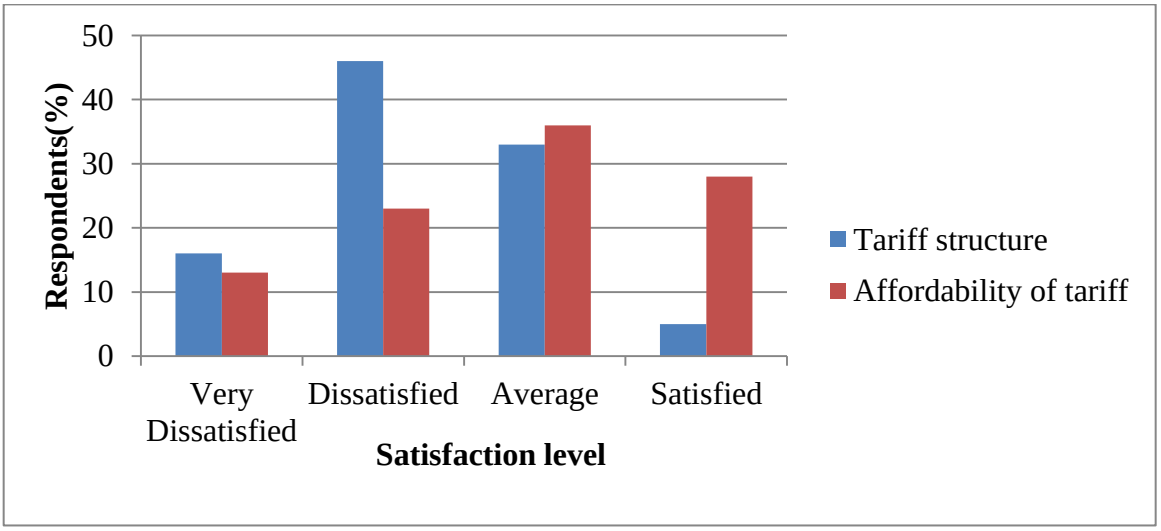



Figure:4. 5.Passenger opinion on tariff structure and its affordability

The other issue passengers were asked about is the level of agreement; they have on the percentage increase in the travelling tariff during peak periods. According to their response, about (27%) of them strongly disagree while about (43%) of respondents disagree on the

situation. The remaining (16%) respondents have average opinion and only (6%) agree when traveling tariff is increased by some percent during peak periods.

In the current city public transportation, if the transportation demand exceeds the available supply and at the night time there will be an increase in usual transportation tariff that was set by transport agency. Usually there will be from 35% –50% increases in the tariff (Kumelachew,2018). The study of (Endale,2014) confirm the above finding, as opinion collected from some passengers, this increase in tariff is usually is not fair and it increases the travelers' expense for transportation. Most of the passengers complain on the amount of increase that it is higher.

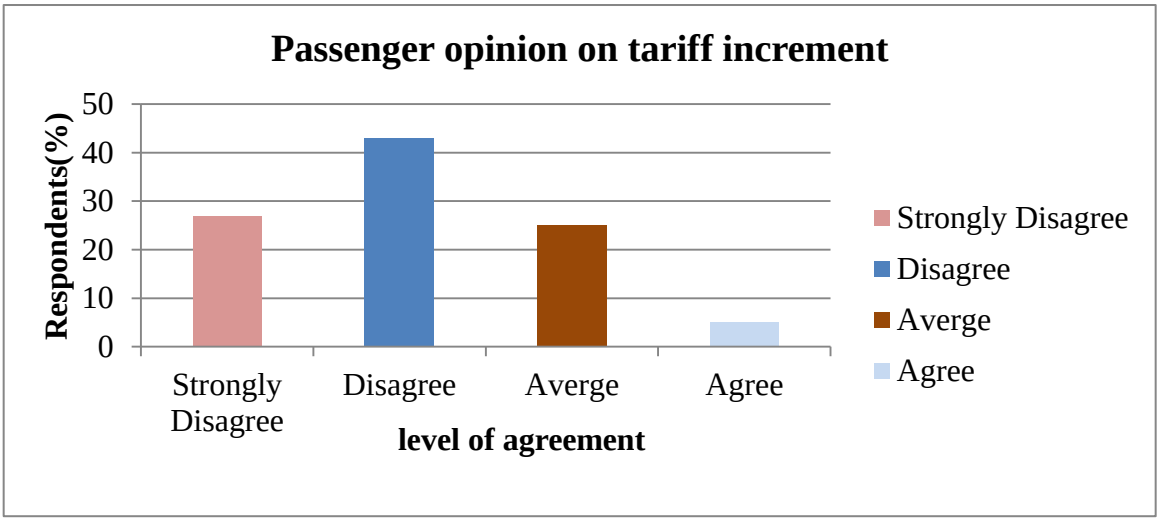



Figure:4. 6.Passenger opinion on increment of passenger fare

### 4.1.5 Over all evaluation of the service quality of mini bus taxi transport

The Service quality of taxi transport was assessed in accordance to many attributes and criteria as stated in the above preceding sub-topics. Finally, the overall level of passenger satisfaction was assessed. In this regard, passengers were asked as to how they evaluate the overall service of the quality of taxis transport in the city and its facilities. The responses were obtained as presented below:

- 52 %were dissatisfied;
- 11% were very dissatisfied; and
- 23% were on the average
- 14% were satisfied

The following figure shows the result obtained from overall assessment of passenger level of satisfaction on taxi transport service quality. The taxi transport has many challenges in delivering the required services under the existing condition. According to (Samson,2016) finding revealed that The statistical distribution of respondents‘ on the existing public transport services in the study area indicated that the majority of respondents (54.3 percent) replied that customers‘ satisfaction on public transport service is medium.

Besides this the finding of (Kumelachew,2018) study concluded that transportation service is sensitive to the characteristics and performance of each mode of transportations. The following variables like Availability, travel cost, travel time, safety, comfort and income level are the most determining factors of modes choice. From the different modes of transportations in Addis Ababa city minibus taxi is the second useable/ chosen transport mode in the city even if its travel cost is high as compared to other public transport.

Based on the combined data obtained through questionnaire and observation, the taxi transport needs major attention to change the current service provision.

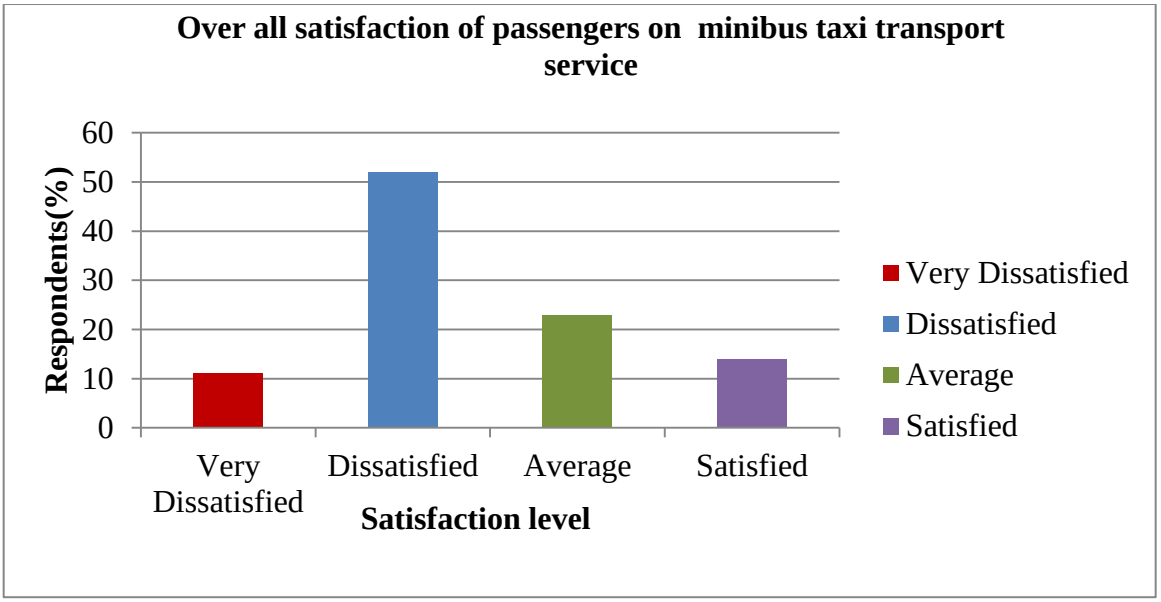



Figure:4. 7. Over all minibus taxi provided service evaluation

Beirado and carabal(2007) also conducted in depth interviews in Porto, Portugal to find out dissatisfying factors of public transport and customers reported that wasted time, too crowded, lack of comfort, time uncertainty, lack of control, unreliability, long waiting times, need to transfer, unable to change route to avoid traffic congestion and lack of flexibility.

### 4.2 Results of minibus taxi distribution using four stage model

In the previous methodology chapters the suitable four stage demand modeling model for public transport transit has been selected by assessing different literatures and the input data to make the analysis. These data have collected from different sources as an input of a primary and secondary data of the thesis. These collected data have analyzed by using four stage demand modeling model. The four steps (trip generation, trip distribution, modal split and traffic assignment) of the four stage model have analyzed as follow:

#### 4.2.1 Trip Generation

It is the first step of modeling activity, which has two parts, namely trip production and trip attraction. This step involves determining trip attraction and trip production. In determination of number of trips produced and attracted for each was selecting trip production and attraction model. Before that first the base year data such as population per zone, total number of jobs and number of schooling had been collected for each Kebeles of the sub city .Next to that the researcher grouped the data of the sub city based on age of population and based on the sex the data presented in the methodology part.

Table:4. 1.The base year data of each Kebeles

| Base year data (2019 G.C) | | | | | | |
|---|---|---|---|---|---|---|
| Kebeles | | Population | Public job | Private job | Student | House hold |
| 1 | Guwe stadium | 10,326 | 1905 | 2301 | 1765 | 1268 |
| 2 | Millinium adebabay | 18,820 | 3542 | 2878 | 2090 | 1954 |
| 3 | Piassa | 14,499 | 2465 | 3087 | 1965 | 1566 |

Source (Endris, 2019)

Now the researcher determine the production rate and attraction rate each sex group per each age category for each station or zone for each purpose of trip home to work, home to school, home to shopping and home other purpose trip rates were determined according to the methods described in the methodology.

Table:4. 2. Trip production rate of each trip purposes

| Home to work purpose | | | |
|---|---|---|---|
| Male sex | | Female sex | |
| Age | Production rate | Age | Production rate |
| 5-15 | 0.2 | 5-15 | 0.25 |
| 16-26 | 0.5 | 16-26 | 0.4 |
| 27-37 | 0.5 | 27-37 | 0.4 |
| 38-45 | 0.5 | 38-45 | 0.3 |
| 46-65 | 0.3 | 46-65 | 0.3 |
| 65+ | 0.2 | 65+ | 0.2 |
| Home to school purpose | | | |
| Male sex | | Female sex | |
| Age | Production rate | Age | Production rate |
| 5-15 | 0.4 | 5-15 | 0.4 |
| 16-26 | 0.5 | 16-26 | 0.4 |
| 27-37 | 0.5 | 27-37 | 0.5 |
| 38-45 | 0.5 | 38-45 | 0.45 |
| 46-65 | 0.2 | 46-65 | 0.2 |
| 65+ | 0.1 | 65+ | 0.1 |
| Home to shopping purpose | | | |
| Male sex | | Female sex | |
| Age | Production rate | Age | Production rate |
| 5-15 | 0.2 | 5-15 | 0.2 |
| 16-26 | 0.5 | 16-26 | 0.65 |
| 27-37 | 0.5 | 27-37 | 0.6 |
| 38-45 | 0.5 | 38-45 | 0.6 |
| 46-65 | 0.4 | 46-65 | 0.5 |
| 65+ | 0.3 | 65+ | 0.4 |

As the above table indicated that the trip production rate is high on the middle age of the population like age of 16-26 and 27-37 ages for all trip purpose. Thus the middle age of passenger was the major user of public transport in the city. The study of (Degewale *etal*,2018) confirmed that in all of the three study areas, there has been significant number of young aged active peoples demanding frequently on a daily base.
Notice that the trip production rate of home to other purpose is attached in the annex.

Similarly, the trip attraction rates was derived from the sample data gathered from sample population and taking the average for each trip intended trip purpose for each category and for each station or zone presented below:

Table:4. 3.Trip attraction rate of each station per each trip purpose

| Station | Trip attraction rate | | | |
|---|---|---|---|---|
| | Home to work | Home to school | Home to shopping | Home to other |
| Old bus station | 1.5 | 1.3 | 1.4 | 1.4 |
| New bus station | 1.3 | 1.1 | 1.1 | 1.4 |
| Mobil | 1.5 | 1.2 | 1.2 | 1.2 |
| Piassa | 1.6 | 1.2 | 1.6 | 1.4 |
| Refferral | 1.4 | 1.3 | 1.2 | 1.2 |

As presented in the Table:4.3 above the trip attraction rates for each purpose is presented and have taken the average for each trip purpose. So 1.46 for home to work ,1.2 for home to school ,1.3 for home to shopping purpose and 1.3 for home to other purpose. The study of (Kebisha,2019) also said that the rate of trip attraction for each sub cities was determined by computing the mean of each trip purpose.

The last step in determination of number of trips production and attraction of each zone was selecting the category analysis method and the data like production and attraction of trip were prepared. The trip production of each purpose of trip was prepared by multiplying the number of population grouped by sex and categorized by age and their corresponding trip production rate. For the case determining trips attracted towards each zone was computed

through each-purpose of trip multiplied by their corresponding trip attraction rate obtained under trip rate determination for each traffic analysis zone, then the total trip was produced and attracted for each trip purpose was tabulated in the Table: 4.4 to 4.7 below which is the final O(production)– D(attraction) matrix for each purpose of trip.

Table:4. 4.Trip production and trip attraction of Home to work purpose

| Station | Old bus station | New bus station | Mobil | Piazza | Referral | Production |
|---|---|---|---|---|---|---|
| Old bus station | | | | | | **2280** |
| New bus station | | | | | | **1923** |
| Mobil | | | | | | **2018** |
| Piassa | | | | | | **1952** |
| Referral | | | | | | **2223** |
| Attraction | **3365** | **1308** | **2657** | **1489** | **1544** | |

Table:4. 5.Trip production and trip attraction of home to school purpose

| Station | Old bus station | New bus station | Mobil | Piazza | Referral | Production |
|---|---|---|---|---|---|---|
| Old bus station | | | | | | **2436** |
| New bus station | | | | | | **1852** |
| Mobil | | | | | | **1982** |
| Piazza | | | | | | **2735** |
| Referral | | | | | | **2283** |
| Attraction | **3043** | **1954** | **3024** | **1318** | **1866** | |

Table:4. 6.Trip production and trip attraction of home to shopping purpose

| Station | Old bus station | New bus station | Mobil | Piazza | Referral | Production |
|---|---|---|---|---|---|---|
| Old bus station | | | | | | **2239** |
| New bus station | | | | | | **1918** |
| Mobil | | | | | | **1919** |
| Piassa | | | | | | **1461** |
| Referral | | | | | | **2164** |
| Attraction | **2543** | **1724** | **1602** | **2761** | **1108** | |

Table:4. 7.Trip production and trip attraction of home to other purpose

| Station | Old bus station | New bus station | Mobil | Piazza | Referral | Production |
|---|---|---|---|---|---|---|
| Old bus station | | | | | | **2645** |
| New bus station | | | | | | **1547** |
| Mobil | | | | | | **1784** |
| Piassa | | | | | | **2037** |
| Referral | | | | | | **2091** |
| Attraction | **2017** | **2439** | **1947** | **2020** | **1924** | |

The result presented on the above tables total trip production and total trip attractions were not equal. Thus this shows that number of trip production and trip attraction were not balanced. The study of (Kebisha,2019) finding confirmed this through when the production and attraction were not balanced this shows that there were trips for each purpose whose origins inside of the study area and their destinations were out of the study area. Hence the next the major concerns were balancing total trip production and attraction through inter zonal trip distribution.

### 4.2.2 Trip distribution

The selected station of for distributing the mini bus taxi starting from around Old bus Station to four different routes, those are

- Old Bus station to Mobile
- Old Bus station to New bus station
- Old Bus Station to Referral hospital
- Old Bus Station to Piazza Adare Hospital

The distribution line looks like in the figure: 4.6 below:

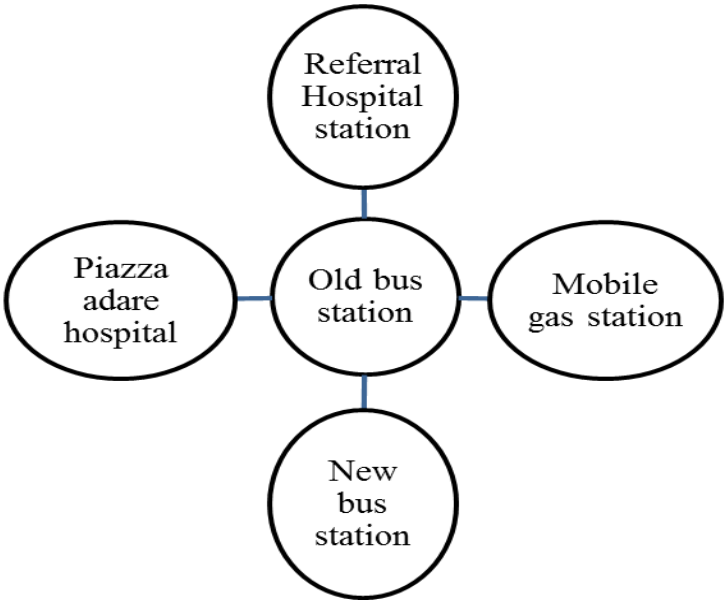



Figure:4. 8.Selected route distribution of the road

The intra zonal trip distribution of each purpose of distribution was not balanced in terms of trip attraction and production. Thus the O – D matrix had been iterated using doubly constrained gravity model in order to adjust the total number of trip at the origin and destination.

Now for showing how the researcher balanced and iterated the doubly constrained gravity model let us take home to shopping purpose trip and the trip production and attraction table is presented below with its iteration process of balancing:

Table:4. 8.Trip production and attraction of home to shopping trip purpose

| Station | Old bus station | New bus station | Mobil | Piazza | Referral | Production |
|---|---|---|---|---|---|---|
| Old bus station | | | | | | **2239** |
| New bus station | | | | | | **1918** |
| Mobil | | | | | | **1919** |
| Piazza | | | | | | **1461** |
| Referral | | | | | | **2164** |
| Attraction | **2543** | **1724** | **1602** | **2761** | **1108** | |

Table:4. 9.First iteration trip distribution for Home to shopping trip purpose

| Station | Old bus station | New bus Station | Mobil | Piazza | Referral | SUM | $O_i$ | $A_i$ |
|---|---|---|---|---|---|---|---|---|
| Old bus | 467 | 338 | 448 | 579 | 407 | 2,239 | 2239 | 1.00 |
| New bus | 534 | 453 | 279 | 353 | 299 | 1,918 | 1918 | 1.00 |
| Mobil | 756 | 196 | 375 | 494 | 98 | 1,919 | 1919 | 1.00 |
| Piazza | 224 | 206 | 363 | 576 | 92 | 1,461 | 1461 | 1.00 |
| Referral | 438 | 420 | 432 | 554 | 320 | 2,164 | 2164 | 1.00 |
| SUM | 2,419 | 1,613 | 1,897 | 2,556 | 1,216 | | | |
| $D_j$ | 2543 | 1724 | 1602 | 2761 | 1108 | | | |
| $B_j$ | 1.05 | 1.07 | 0.84 | 1.08 | 0.91 | | | |

Since the intra zonal trip distribution was not balanced. It should have to be balanced, to balance the trip distribution matrix balancing a column by balancing factor through multiplying each attraction trip with dividing the sum of destination matrix by each destination trips of O-D matrix.

Table:4.10.Second iteration trip distribution for Home to shopping trip purpose

| | Old bus station | New bus Station | Mobil | Piazza | Referral | SUM | $O_i$ | $A_i$ |
|---|---|---|---|---|---|---|---|---|
| Old bus | 491 | 361 | 378 | 625 | 371 | 2,227 | 2239 | 1.00 |
| New bus | 561 | 484 | 236 | 381 | 272 | 1,935 | 1918 | 1.00 |
| Mobil | 795 | 209 | 317 | 534 | 89 | 1,944 | 1919 | 1.00 |
| Piazza | 235 | 220 | 307 | 622 | 84 | 1,468 | 1461 | 1.00 |
| Referral | 460 | 449 | 365 | 598 | 292 | 2,164 | 2164 | 1.00 |
| SUM | 2,543 | 1,724 | 1,602 | 2,761 | 1,108 | | | |
| $D_j$ | 2543 | 1724 | 1602 | 2761 | 1108 | | | |
| $B_j$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | | | |

Through using MS Excel for balancing the intra zonal trip distribution of doubly constrained gravity model the final trip distribution after the fourth iteration had been tabulated as follows

Table:4.11.Final trip distribution results of home to shopping trip purposes

| Stations | Old bus station | New bus station | Mobil | Piazza | Referral | SUM | $O_i$ | $\mathbf{A}_i$ |
|---|---|---|---|---|---|---|---|---|
| Old bus | 496 | 363 | 382 | 631 | 374 | 2,246 | 2239 | 1.00 |
| New bus | 559 | 480 | 234 | 379 | 271 | 1,924 | 1918 | 1.00 |
| Mobil | 789 | 207 | 314 | 528 | 88 | 1,926 | 1919 | 1.00 |
| Piazza | 236 | 219 | 306 | 621 | 84 | 1,466 | 1461 | 1.00 |
| Referral | 463 | 449 | 366 | 601 | 292 | 2,171 | 2164 | 1.00 |
| SUM | 2,543 | 1,718 | 1,602 | 2,761 | 1,108 | | | |
| $D_j$ | 2543 | 1718 | 1602 | 2761 | 1108 | | | |
| $B_j$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | | | |

From the above final intra zonal trip distribution shows that Old bus station had produce large amount of trip for the purpose of home to shopping purpose which is 2239 passenger and piazza station or zone had attract more shopping purpose trip which is 2761 compare to other station. Similarly the study of (Tsegaye,2020) result indicated that from all sub cities Menahariya sub city was attracted more trip those are not included in home to school and home to work trip, this is indicated due to the presence of more shopping purpose place the attraction due to shopping and other purpose trip is more. The other numbers of trip distribution were fairly distributed throughout the links of the road network in the city.

For the rest trip purpose those home to work, home to school and home to other purpose intra zonal balanced final trip distribution results are presented below and for each trip purpose the researcher prepared MS Excel template for iteration process of balancing the O-D matrix up to converged to the required criteria .The O-D matrix balancing iteration process tabular results for each purpose of trip are attached in the annex part.

The final balanced O-D matrix tabular results of the rest three trip purpose results were here below presented:

Table:4.12.The final balanced trip distribution result of the three trip purposes

| Final O-D matrix of Home to Work trip purpose | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| station | Old bus station | New bus station | Mobil | Piassa | Referral | SUM | $O_i$ | $A_i$ |
| Old bus | 568 | 281 | 685 | 355 | 384 | 2,273 | 2280 | 1.00 |
| New bus | 705 | 352 | 343 | 158 | 359 | 1,917 | 1923 | 1.00 |
| Mobil | 780 | 131 | 518 | 410 | 173 | 2,012 | 2018 | 1.00 |
| Piassa | 571 | 94 | 758 | 270 | 254 | 1,946 | 1952 | 1.00 |
| Referral | 743 | 451 | 354 | 296 | 374 | 2,216 | 2223 | 1.00 |
| SUM | 3,366 | 1,309 | 2,657 | 1,489 | 1,544 | | | |
| $D_j$ | 3365.55 | 1308.51 | 2657.34 | 1489.28 | 1543.92 | | | |
| Bj | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | | | |
| Final O-D matrix of Home to school trip purpose | | | | | | | | |

| | Old bus station | New bus station | Mobil | Piassa | Referral | SUM | $O_i$ | $A_i$ |
|---|---|---|---|---|---|---|---|---|
| Old bus | 591 | 408 | 747 | 291 | 382 | 2,418 | 2436 | 1.00 |
| New bus | 583 | 476 | 266 | 147 | 366 | 1,838 | 1852 | 1.00 |
| Mobil | 506 | 351 | 657 | 282 | 171 | 1,967 | 1982 | 1.00 |
| Piazza | 591 | 427 | 729 | 304 | 483 | 2,715 | 2735 | 1.00 |
| Referral | 772 | 292 | 625 | 294 | 464 | 2,266 | 2283 | 1.00 |
| SUM | 3,043 | 1,954 | 3,024 | 1,318 | 1,866 | | | |
| $D_j$ | 3043 | 1954 | 3024 | 1318 | 1866 | | | |
| $B_j$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | | | |

Final O-D matrix of Home to other purpose trip

| | Old bus station | New bus station | Mobil | Piassa | Referral | SUM | $O_i$ | $A_i$ |
|---|---|---|---|---|---|---|---|---|
| Old bus | 405 | 379 | 522 | 502 | 501 | 2,709 | 2645 | 1.00 |
| New bus | 403 | 375 | 190 | 272 | 344 | 1,584 | 1547 | 1.00 |
| Mobil | 546 | 234 | 404 | 410 | 234 | 1,827 | 1784 | 1.00 |
| Piassa | 273 | 779 | 667 | 416 | 350 | 2,086 | 2037 | 1.00 |
| Referral | 390 | 672 | 164 | 420 | 495 | 2,141 | 2091 | 1.00 |
| SUM | 2,017 | 2,439 | 1,947 | 2,020 | 1,924 | | | |
| $D_j$ | 2017 | 2439 | 1947 | 2020 | 1924 | | | |
| $B_j$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | | | |

Generally As observed on the trip distribution O-D final matrix the trip distribution from one station to other station were different per each trip purpose, for instance taking with home to work trip purpose distribution the maximum trip was started from old bus station to Mobil which about 780 and the minimum trip distributed from New bus station to Piassa station which is 98. For home to school purpose the maximum trip distribution was from old bus station to Referral Hospital station which is about 772. Since there is many schools and colleges are present in the route of old bus station to referral Hospital route, more trip due to home to school purpose attracted towards referral Hospital destination. The minimum trip distribution was from Piassa to New bus station and the last. Concerning with this the study

of (Tsegaye, 2020) confirmed this through ,in Hawassa city the dominant purpose of trip are home to work and home to school trip purpose, Specially Tabor sub city(around referral route) due to the presence of many schools trip attracted on home to school purpose was high. Also the finding of (Babay,2016) said that most students are not be able to go abroad for leaning purpose (they should define themselves near home) and 5 to 10% students will go to the neighbor sub cities.

The third purpose of trip distribution which is home to other trip purpose the final O-D matrix indicated that maximum trip distribution was 779 which is from New bus station to Piazza station and the minimum trip is from Mobile to Referral Hospital which is about 164.

### 4.2.3 Modal split analysis

The above distributed trips need choose of transport mode to travel from their origin zone to the destination zone. So, this modal choice is analyzed in the modal split step to select the better transport mode in time and money minimizing. Based on the literature and method of design, the methodology has select the logit method of modal split is the better method to analyses the third step of the four stage passenger demand modeling model. So, using the logit method the choice of transport mode analyzed by first through the general cost of travel equation which is shown at the methodology section and the generalized cost to time value of each route value as shown in the Table: 4.13 below.

Table:4.13.each selected routes generalized time –cost summarized result

| | | Tijv | $tij^w$ | $tij^t$ | Fij | Cij mode |
|---|---|---|---|---|---|---|
| Trips from old bus station to | Coefficient | 0.03 | 0.04 | 0.06 | 0.1 | -- |
| New bus station | Bajaj | 8 | 5 | 4 | 5 | 1.18 |
| | Mini bus | 12 | 5 | 6 | 3 | 1.22 |
| | City bus | 18 | 5 | 15 | 1.5 | 1.79 |
| Mobile station | Bajaj | 6 | 5 | 5 | 3.30 | 1.01 |
| | Minibus | 8 | 5 | 8 | 2 | 1.12 |
| | City bus | 13 | 5 | 14 | 1.5 | 1.58 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Piazza Adare Hospital | Bajaj | 5 | 5 | 3 | 2.6 | 0.79 |
| | Mini bus | 8 | 5 | 8 | 1.6 | 1.08 |
| | City bus | 13 | 5 | 15 | 1.5 | 1.64 |
| Referral Hospital | Bajaj | 10 | 5 | 5 | 5 | 1.3 |
| | Mini bus | 14 | 5 | 7 | 3 | 1.34 |
| | City bus | 22 | 5 | 15 | 1.5 | 1.91 |

Comparatively, though, city bus exhibited the highest waiting and traveling time on a daily transport trips relative to other modes. When we take the entire three modes city transport the frequency of traveling for both Bajaj and mini bus taxi is better compared to the city bus. And also the time limit of city bus transport is 12:00 AM to 12:00 PM, However for Bajaj and mini bus taxi does not have time limit to work their work.

Next to determination of generalized cost to travel time value, the probability of selecting the transport mode from three different transport modes those available in Hawassa city was determined using logit model equation which is shown in the literature part.

Table:4.14. The Probability of choosing the transport mode

| | Old bus station to new bus station | Old bus station to Mobile | Old bus station to Piassa station | Old bus station to referral hospital |
|---|---|---|---|---|
| Bajaj | 0.341 | 0.339 | 0.346 | 0.340 |
| **Minibus** | **0.339** | **0.337** | **0.336** | **0.339** |
| City bus | 0.320 | 0.322 | 0.318 | 0.320 |

The analysis done from the trip started at around Old bus station to the end of each selected destination of mini bus taxi routes. From this analysis the result of probability of choosing transport mode to travel from origin zone (old bus station) to the destination zones (New bus station, Mobile gas station, Piazza adare Hospital and Referral Hospital station) indicated in Table:4.14 above. Since this study targeted only on minibus taxi transport mode the researcher had used the probability of selecting mini bus taxi in each selected route. For

computing the modal share of mini bus taxi in each selected four routes by multiplying the trip making from one station to other station the final iterated trip distribution matrixes result which is found in Tables: 4.11 and 4.12 with the probability matrix results of Table:4.14. For analysis and to compare with the existed assigned of mini bus taxi in the routes the researcher had been added the final iterated all-purpose trip in one and multiplied with their respective probability result of minibus taxi. Thus the probability result with their final iterated each trip results and the final multiplied modal share result is presented in the Table: 4.15 below.

Table:4.15.Determination of Modal share of mini bus taxi

| | Selected routes | | | |
|---|---|---|---|---|
| | Old bus station to New bus station | Old bus station to Mobile | Old bus station to Piazza Adare | Old bus station toReferral Hospital |
| Probability result | **0.339** | **0.337** | **0.336** | **0.339** |
| Trip of home-work purpose | 705 | 780 | 571 | 743 |
| Trip of home to school purpose | 583 | 506 | 591 | 772 |
| Trip of home to shopping purpose | 559 | 789 | 236 | 463 |
| Trip of home to other purpose | 403 | 546 | 273 | 390 |
| Sum of all trip | 2250 | 2621 | 1671 | 2368 |
| Modal share of minibus taxi | **763** | **884** | **562** | **803** |

The above modal share result is very important to allocate mini bus from one station to other station in order to accommodate the generated trip and also it shows that the number of trips for all purpose of trip using a public transport mode of mini bus from old bus station to other four different destination on a daily basis for the existing peak hour of one day. And as you

observed in the Table:4.15 the trip from old bus station to Mobil station was high relative to other route ,this indicated that there is high demand of mini bus taxi for old bus station to Mobil route from all selected route.

The finding of (Kebisha,2019) also compared the demand and preferred of mode of transport based on the location of route in the city like this way in the center of the city choosing of minibus taxi is as more practicable for the purpose of home to school but at the periphery of the city the preferable mode is rick show .

### 4.2.4 Traffic assignment

As the literature indicates, in this stage the traffic flow assigns in to the given routes to reduce the traffic congestion and to save time and money. Besides this according to the study of (Marhew & Rao, 2006) among the aims of traffic assignment one of them is to estimate the number of required vehicles on the links of the network and obtain aggregate network measures. Based on this, in this study its aim is to determine the number of needed mini bus taxi vehicle for already selected and defined routes .Thus the researcher does not concerned on the selection of routes. However the study determine the total number of required min bus taxi vehicles for each selected routes and compared with the Hawassa city transport bureau assigned minibus taxi vehicles.

To determine the required number of mini bus taxi per route the researcher was used the formula which is presented in the methodology section which is flows or modal share results divided by the number of occupancy of mini bus taxi vehicle. According to transport office given data which was collected by interview survey the number of occupancy of mini bus taxi in the city is 11 people per vehicle. According to this the final result of determining the number of mini bus taxi vehicle is presented below:

Table:4.16.The number of required minibus taxi at selected routes of the city

| Routes | Old bus station to New bus station | Old bus station to Mobil station | Old bus station to Piassa Adare Hospital | Old bus station to Referral hospital |
|---|---|---|---|---|
| Flow or modal share result | 763 | 884 | 562 | 803 |
| Occupancy of minibus vehicle | 11 | 11 | 11 | 11 |
| Required number of mini bus taxi per route | **70** | **81** | **51** | **73** |

Having computed the required number minibus taxi needed in each selected route, for route of old bus station to Mobil gas station about 81 number of minibus taxi were needed to overcome the existed mini bus taxi problem in the route. The same thing for route of old bus station to new bus station and to referral hospital is 70 and 73 respectively.

### 4.2.5 Comparison of transport bureau assigned mini bus taxi with this study obtained result

Now the researcher had been compared the founded results of this study with the existed assigned minibus taxi vehicle those are taking the distribution ” Tapela” from Hawassa city transport bureau for each selected four routes only.

Table:4.17.Comparison of assigned minibus taxi with four stage modeling results

| Routes | Four stage demand modeling result of number of required mini bus | The city transport bureau assigned mini bus taxi vehicle per route |
|---|---|---|
| From old bus station to New bus station along the road of Welade amanuel round about | 70 | 34 |
| From old bus station to Mobil gas station along the road of megenagna intersection | 81 | 43 |
| From old bus station to Piassa adare Hospital along the road of St. Gebriel church | 51 | 26 |
| From old bus station to referral Hospital along the road of Trufat intersection | 73 | 42 |

The above Table:4.17 compared that the required and assigned number of mini bus taxi vehicle for a single trip in selected four routes, for instance the number of mini bus needed for the route of old bus station to new bus station is 70 mini bus but assigned minibus in the route is 34 only, for route of old bus station to Mobil gas station the required number is 81 but the existed mini bus were 43, similarly for other two routes the required number of minibus vehicle almost 50 percent greater than the assigned mini bus taxi. Since all the mini bus taxi has no the distribution "Tapela" they work what they wanted routes only. Due to this transport management problem and unbalanced supply and demand of taxi transport is created. The study of (Yeshitela, 2019) confirmed this distribution of public transport was helps the city traffic follow concentration to some specific route and it avoid mess and unwanted accumulation services given by all modes in to specific station. The finding of (Kebisha, 2019) had opposed in this way, minibus taxi have no specific route and no

prohibited route throughout the city and also they have no specific trip distribution. The city transport bureau was given this action as an affirmative action for the taxi driver and owner to accommodate an increasing travel demand of the city from time to time.

Also, the study of the ( Degewale *etal*, 2018) indicated that, there is a problem on supply of minibus taxi in Hawassa city, but this is created due different reason among the reasons stated that minibus taxis would have been supposed to have blue color to serve as urban public transport taxi. However, according to interview data from Hawassa Traffic Police office, owners don‘t wants to change the color because they don‘t likes to limit their transport services to the urban center only.

Thus, according to the result of this study and the finding of other researcher the researcher recognized that, there is a shortage of supply of minibus taxi; also there is no proper traffic management for controlling and distributing available minibus for serving the passenger properly in the city.

Besides this, according to interview data from Hawassa City RTO (attached at the annex), to address and improve the shortage of urban public transport in the short-run, the city administration introduced 410 Code 3 minibus taxis. Besides, to address the challenge long-lastingly, the city administration has organized operators and adjust 70% credit access from Abyssinia Bank and requested the federal government to allow importing 900 Meter Taxis on duty free. However, the federal government is not yet responding.

### 4.3 Result of Passenger fare establishment using HDM-4 software

After the project analysis step is finished, The HDM-4 model generates many reports on different analyses. Vehicle operating cost is of the major interest for this study. Accordingly, it is obtained from the model on the road user cost section of the generated report and the cost presented below. It is given for all sections of the road networks defined previously.

- **Route one (Old bus station to Mobil gas station)**

This road network is divided into five sections as:

- Tigest hotel to South star hotel
- South star Hotel to Megenagna
- Megenagna intersection to 22 Mazoriya
- 22 Mazoriya to Selassie traffic light
- Selassie traffic light to Mobil

The vehicle operating costs for each vehicle type by each section of the road is given below. It is calculated for a 20 years period of analysis and below is presented VOC only for the year of 2021. The whole output is given in the annex section. The model gives the annual average vehicle operating costs in terms of vehicle – kilometer and vehicle – trip. The seat capacity of vehicles was also given 11, therefore the cost per person – kilometer can be obtained by dividing the cost per veh-km by the number of seats of the vehicle.

According to this method of computation the following Tables 4.18 summarized the VOC per person- km, after finding of VOC per person –km for all section, by multiplying with their respective km distance, the researcher obtained the vehicle operating cost per each person- km. Thus the VOC per person- km for route one is presented on the Table: 4.18 below.

Table:4.18.Vehicle operating cost result of route of Tigest hotel –Mobil

| | Tigest hotel to South star hotel route section | | |
|---|---|---|---|
| Vehicle Type | VOC for 2021(ETB) | | |
| | Per vehicle –Km | Number of seat | Per person –Km |
| Minibus | 12.05 | 11 | 12.05/11 =1.0954 |
| Damas | 6.76 | 5 | 6.76/5= 1.35 |
| Heavy bus | 50.81 | 60 | 50.81/60= 0.847 |
| South star Hotel to Megenagna intersection route section | | | |
| Vehicle Type | VOC for 2021(ETB) | | |
| | Per vehicle –Km | Number of seat | Per person –Km |
| Minibus/ | 11.75 | 11 | 1.068 |
| Damas | 6.61 | 5 | 1.322 |
| Heavy Buses | 49.81 | 60 | 0.8301 |
| Megenagna intersection to 22 Mazoriya route section | | | |
| Vehicle Type | VOC for 2021(ETB) | | |
| | Per vehicle –Km | Number of seat | Per person –Km |
| Minibus | 11.68 | 11 | 1.062 |
| Damas | 6.58 | 5 | 1.32 |
| Heavy Buses | 49.51 | 60 | 0.825 |
| 22 Mazoriya to Selassie traffic light route section | | | |
| Vehicle Type | VOC for 2021(ETB) | | |
| | Per vehicle –Km | Number of seat | Per person –Km |
| Minibus | 11.89 | 11 | 1.081 |
| Damas | 6.67 | 5 | 1.334 |
| Heavy Buses | 50.06 | 60 | 0.8343 |
| Selassie traffic light to Mobil route section | | | |
| Vehicle Type | VOC for 2021(ETB) | | |
| | Per vehicle –Km | Number of seat | Per person –Km |
| Minibus | 11.89 | 11 | 1.081 |

| | | | |
|---|---|---|---|
| Damas | 6.67 | 5 | 1.334 |
| Heavy Buses | 50.06 | 60 | 0.834 |

- **Route two (Old bus station to New bus station)**

This road network is divided into three sections as:

- Old bus station to Wanza round about
- Wanza round about to Welde amanuel round about
- Welde amanuel round about to New bus station

Table:4.19. Vehicle operating cost of old bus station to new bus station route

| | Old bus station to Wanza roundabout route section | | |
|---|---|---|---|
| Vehicle Type | VOC for 2021(ETB) | | |
| | Per vehicle –Km | Number of seat | Per person –Km |
| Minibus | 12.52 | 11 | 1.138 |
| Damas | 6.55 | 5 | 1.31 |
| Heavy Buses | 50.85 | 60 | 0.848 |
| Wanza round about to Welde amanuel roundabout route section | | | |
| Vehicle Type | VOC for 2021(ETB) | | |
| | Per vehicle –Km | Number of seat | Per person –Km |
| Minibus | 12.55 | 11 | 1.141 |
| Damas | 6.56 | 5 | 1.312 |
| Heavy Buses | 50.89 | 60 | 0.8481 |
| Weldeamanuel round about to New bus station route section | | | |
| Vehicle type | VOC for 2021(ETB) | | |
| | Per vehicle –Km | Number of seat | Per person –Km |
| Minibus | 12.26 | 11 | 1.115 |
| Damas | 6.44 | 5 | 1.288 |
| Heavy Buses | 49.94 | 60 | 0.832 |

❖ **Route three (Tigest Hotel to Piassa Adare Hospital route)**

This road network is divided into four sections as:

- Tigest Hotel to Mesqel Adebabay Intersection
- Mesqel Adebabay intersection to St. Gebriel church
- St. Gebriel church to Piassa Adare Hospital

Table:4.20.Vehicle operating cost of Tigist hotel to Piassa Adare Hospital route

| | Tigest Hotel to Mesqel Adebabay Intersection | | |
|---|---|---|---|
| Vehicle Type | VOC for 2021(ETB) | | |
| | Per vehicle –Km | Number of seat | Per person –Km |
| Minibus | 12.26 | 11 | 1.115 |
| Damas | 6.60 | 5 | 1.32 |
| Heavy Buses | 49.54 | 60 | 0.83 |
| Mesqel Adebabay intersection to St. Gebriel church section | | | |
| Vehicle Type | VOC for 2021(ETB) | | |
| | Per vehicle –Km | Number of seat | Per person –Km |
| Minibus | 12.44 | 11 | 1.131 |
| Damas | 6.66 | 5 | 1.33 |
| Heavy Buses | 49.97 | 60 | 0.83 |
| St. Gebriel church to Piassa Adare Hospital | | | |
| Vehicle Type | VOC for 2021(ETB) | | |
| | Per vehicle –Km | Number of seat | Per person –Km |
| Minibus | 12.56 | 11 | 1.142 |
| Damas | 6.74 | 5 | 1.35 |
| Heavy Buses | 50.63 | 60 | 0.843 |

Notice that the vehicle operating cost of the fourth route which is Millinium hall to Referral Hospital route computed VOC is attached in the annex.

The above Tables 4:18 to Tables 4:20 gives the vehicle operating costs of transporting vehicles those are mini- buses, Damas taxi and heavy buses for all road networks. Once the

cost per person-km is determined, the total amount of passenger fare which should be charged by transport operators can be obtained by multiplying the distance traveled by the passengers with the unit cost per person-km. As an example, the researcher prepared the passenger fare for one kilometer road using minibus taxi VOC output result. Because on this research our intention is only to establish the passenger fare for mini- bus/ dolphin vehicle taxi the researcher was take the VOC of mini –bus /dolphin vehicle only.

### 4.3.1 Determination of passenger fare for one km road using HDM-4 tool

The researcher had taken the road segment which has the length of one km and it's VOC (Birr/vehicle – km) generated result from HDM-4 is 12.32 Birr/ vehicle—km

Then, VOC (Birr/person—km) = $\frac{12.32 \text{ Birr/ vehicle– km}}{11\ person}$ = 1.12 Birr per person—km

Since the road has a length of 1 km, now to get VOC per one person multiply by one km

So, VOC (Birr/ person) = 1.12 Birr per person * 1km = 1.12 Birr per person

Assuming a 20% of as a profit to be added on the operating cost, the 20% profit assumption is taken based on the actual practice implemented by the Road and Transport Authority when establishing passenger fare. The authority usually uses a profit margin between 20% and 25%. Based on this, the researcher had been taken 20% of VOC (Birr per person) as profit.

Profit (P) = 20% * 1.12

= 0.224 Birr/person

Total passenger fare of one km long road = (1.12+ 0.224) Birr/person = **1.35 Birr/person**

Therefore based on HDM-4 tool the VOC output of total passenger fare that the passenger should have to be paid for the trip of one kilometer (1km) road per one per person computed as 1.35 ETB. But, according to (Hawassa city road and transport office,2018 ) report the passenger fare on minibus transport for 1km road was 0.75 cents, it is less than to HDM-4 based results by 0.60 cents, this implies that HDM-4 based fare is almost 40% greater than the city transport office established passenger fare.

Therefore based on this way the researcher had been computed for each selected route segment road, the passenger fare per person is computed in table below:

Table:4.21.The total summarized passenger fare result of route one road net work

| For section of Tigest Hotel to South star Hotel(0.7km) | |
|---|---|
| Type of fare | Calculated fare |
| Passenger fare per trip | 1.095 * 0.7 = 0.77 |
| Profit (20%) | 0.153 |
| Total passenger fare (ETB per person) | 0.923 |
| For section of south star hotel to Mengenagna intersection(0.5km) | |
| Passenger fare per trip | 1.068 * 0.5 = 0.534 |
| Profit (20%) | 0.107 |
| Total passenger fare (ETB per person) | 0.64 |
| For section of Megenagna to 22 Mazoriya (0.6km) | |
| Passenger fare | 1.062* 0.6 = 0.64 |
| Profit (20%) | 0.13 |
| Total passenger fare (ETB per person) | 0.77 |
| For section of 22 Mazoriya to Selassie traffic light (0.3km) | |
| Passenger fare | 1.081* 0.3 = 0.324 |
| Profit (20%) | 0.065 |
| Total passenger fare (ETB per person) | 0.389 |
| For section of Selassie traffic light to Mobile taxi station (0.6km) | |
| Passenger fare | 1.081*0.6= 0.65 |
| Profit (20%) | 0.13 |
| Total passenger fare (ETB per person) | 0.78 |

Similarly for the other road network i.e. Old bus station to New bus station road network, the passenger fare can be determined. It is given in the following tables for the mini bus /dolphin vehicle type.

Table:4.22.Final summarized passenger fare result of route two road network

| For section of Old Bus station to Wanza round about (0.5km) | |
|---|---|
| Type of fare | Calculated fare |
| Passenger fare per trip | 1.138 * 0.5 = 0.57 |
| profit (20%) | 0.114 |
| Total passenger fare (ETB per person) | 0.684 |
| For section of Wanza round about to welde amanuel round about(1.70km) | |
| Passenger fare per trip | 1.141* 1.7 = 1.94 |
| Profit (20%) | 0.39 |
| Total passenger fare (ETB per person) | 2.33 |
| For section of weldeaamanuel round about to New Bus station(1.9km) | |
| Passenger fare | 1.115 * 1.9 = 2.12 |
| Profit(20%) | 0.42 |
| Total passenger fare (ETB per person) | 2.54 |

For the third selected route which is Tigest Hotel to Piassa Adare Hospital also generalized passenger fare for each section of the road network is tabulated in the following form

Table:4.23. Final summarized passenger fare result of route three road network

| For section of Tigest Hotel to Mesqel Adebabay road sction(0.8km) | |
|---|---|
| Type of fare | Calculated fare |
| Passenger fare per trip | 1.115 * 0.8 = 0.892 |
| Profit (20%) | 0.18 |
| Total passenger fare (ETB per person) | 1.072 |
| For section of Mesqel Adebabay to St.Gebriel church(0.6km) | |

| | |
|---|---|
| Passenger fare per trip | 1.131 * 0.6 = 0.68 |
| Profit (20%) | 0.14 |
| Total passenger fare (ETB per person) | 0.82 |
| For section of St. Gebriel church to Piassa Adare Hospital(0.7km) | |
| Passenger fare | 1.142* 0.7 = 0.79 |
| Profit (20%) | 0.16 |
| Total passenger fare (ETB per person) | 0.95 |

For the last route which is from Millinium Hall to Referral Hospital section computed passenger fare is tabulated below

Table:4.24.Final summarized passenger fare result of route four

| For section of Millinium Hall to Trufat intersction(1.1km) | |
|---|---|
| Type of fare | Calculated fare |
| Passenger fare per trip | 1.009 * 1.1 = 1.20 |
| Profit (20%) | 0.24 |
| Total passenger fare (ETB per person) | 1.44 |
| For section of Trufat intersection to Meshen Mekabr(0.5km) | |
| Passenger fare per trip | 1.12 * 0.5 = 0.56 |
| Profit (20%) | 0.11 |
| Total passenger fare (ETB per person) | 0.67 |
| For section of Meshen Mekaber to TTC warka (0.7km) | |
| Passenger fare | 1.097* 0.7 = 0.77 |
| Profit (20%) | 0.15 |
| Total passenger fare (ETB per person) | 0.92 |
| For section of TTC warka to Circle intersction(1.2km) | |
| Passenger fare | 1.116*1.2 = 1.34 |
| Profit (20%) | 0.26 |
| Total passenger fare (ETB per person) | 1.60 |
| For section of Circle intersection to Referral Hospital (0.6km) | |

| | |
|---|---|
| Passenger fare | 1.115*0.6= 0.67 |
| Profit (20%) | 0.133 |
| Total passenger fare (ETB per person) | 0.80 |

### 4.3.2 Comparison of passenger fare set by transport authority and HDM-4 based established passenger fare

As it was discussed in the preceding sections, the Hawassa city transport authority establishes the passenger fare for all public transport operated under the city. The passenger fare for the mini bus/ dolphin taxis are established by city transport bureaus. The comparison here is with the passenger fare established by the Hawassa city transport authority and by HDM-4 tool generated fare. The passenger fare for the minibus/ dolphin taxi is obtained from the Hawassa city road and transport office which is attached in the annex and the tariff that is under use in the current mini bus taxi transport service.

Table:4.25.Summarized comparison of fare established by transport bureau and HDM-4

| No | Road section | Passenger fare set by Transport authority (ETB) | Passenger fare set using HD4Tool (ETB) |
|---|---|---|---|
| | | Minibus taxi | Minibus taxi |
| Route one ( Tigest Hotel to Mobile taxi station) | | | |
| 1 | Tigest Hotel to South star Hotel | 0.52 | 0.923 |
| 2 | Southstar Hotel to megenagana intersection | 0.38 | 0.64 |
| 3 | Megenagna to 22 Mazoriya | 0.45 | 0.77 |
| 4 | 22Mazoriya to Selassie traffic light | 0.22 | 0.39 |
| 5 | Selassie traffic light to Mobile | 0.43 | 0.78 |
| Route two ( Old Bus station to New Bus Station) | | | |
| 6 | Old Bus station to Wanza round about | 0.37 | 0.684 |
| 7 | Wanza round about to w/amanuel round about | 1.28 | 2.33 |
| 8 | W/amanuel round about New Bus station | 1.35 | 2.54 |
| Route three (Tigest Hotel to Piasssa Adare Hospital ) | | | |
| 9 | Tigest Hotel to Mesqel Adebabay | 0.60 | 1.072 |
| 10 | Mesqel Adebabay to St. Gebriel church | 0.4 | 0.82 |
| 11 | St.Gebrielchurch to Piassa Adare Hospital | 0.57 | 0.95 |
| Route four (Millinium hall to Referral Hospital) | | | |
| 12 | Millinium hall to Trufat intersection | 0.83 | 1.44 |
| 13 | Trufat intersection to Meshen Mekaber | 0.37 | 0.67 |
| 14 | Meshen Mekaber to TTC warka | 0.52 | 0.92 |
| 15 | TTC warka to Circle intersection | 0.90 | 1.60 |
| 16 | Circle intersection to Referral Hospital | 0.38 | 0.80 |

As it is shown in the above Table: 4.25, the passenger fare calculated for this research is greater than the passenger fare established by the transport authority for selected mini bus taxi vehicle types.

When we see in detail for all route the passenger fare established by the HDM-4 is about more than 40% greater than the fare fixed by the office, this is due to as the researcher indicated in the literature the HDM-4 software is considering different parameters that are not considered by transport office like the number of rise and fall curve,roughness condition of the pavement surface, traffic composition of the vehicle and basic vehicle characteristics are some of them. Concerning with this the study of Wilson (2007), indicated that the passenger fare establishment for public transport should consider the existing road condition like the geometric features of the road, traffic composition and surface condition of the road.

The study of (Samson, 2016) also indicated that, despite operators perceived that the existing tariff is unfair; the majority of them (78.4 percent) are working as per the tariff. However, the remaining 21.6 percent of the respondents do charge transport users more price. Making transport users to be clear with the tariffs is important to provide efficient and effective public transport services. Besides, it can also reduce disputes between transport users and operators regarding tariffs. Accordingly, 93.6 percent of respondents replied that they post the tariff to their customers. However, the way of displaying this tariff at Hawassa city not clearly visible to customers; they post a piece of paper containing the tariff within the front top of their Bajaj. But if clearly posting the tariff and their distribution route can help users to know the tariff and the distribution without asking.

Also, the transport office is not manage properly the public transports due to the lesser amount of payment profit obtained may leads them to prioritize their economic benefit rather than serving the people the finding of (Degewale *etal* ,2018) indicates that, the case in Hawassa city is different. Operators stated that, they insist contractual transport service delivery due to low tariffs set. Besides, key informant interviews with TPO and RTO of Hawassa city confirm that high demand of transport service in the city becomes a ripe situation for operators to serve on contractual basis. Data from customers further stated that particularly Bajaj operators don‘t have a habit of serving the public; operators highly prioritize their private interests and economic benefits than serving the public.

The finding of (Kumelachew,2018), his result tried to compare different modes of transport based on the passenger transport expenditure per day in this way, from the participant of the research those who had paid 7- 10 birr per day for transport about 76.7 percent of the respondent chooses minibus taxi, about 8.9 percent were choose bus transport and about 14.4 percent were choose train transport, thus minibus taxi is more preferable for medium incomer public transport user in Addis Ababa.

Besides this as the information obtained from informal discussion with minibus taxi operators , throughout working years to revise and correct the existed passenger fare the transport office only consider rising and falling price of fuel, but the passenger fare is not depend on fuel cost only. It is depend on different component those like spare part cost, new vehicle cost, new tire cost, labor cost and other, the cost of that component are increasing at any time and the transport office didn't consider the variation cost of those components due to this reason it will have an impact for the passenger fare established by transport office.

In general, this is just to compare the passenger fare established based on the vehicle operating cost of HDM-4 and transport office established ones. it doesn't mean that the passenger fare should be applied in the industry. It is to indicate that thorough consideration of factors is necessary. To implement the established passenger fare into practice, its affordability should be well studied. Assessment of passengers' income is also necessary.

# 5. SUMMARY AND CONCLUSION

## 5.1 Summary

The study has presented assessment of minibus taxi transport service challenges and their scientific improvement resolution accordingly. Here in this study major challenges of minibus transport those service quality problems, taxi distribution problem and passenger fare establishment problems were targeted and assessed in detail. Concerning with service quality problem of minibus taxi four major evaluating parameters like reliability and availability, tangibility, safety and security and tariff structure fairness were evaluated using likert scale questionnaire paper and the respondent feedback on all parameters had been collected and inserted to Microsoft excel for analysis. Finally, about more than half of minibus taxi users were dissatisfied on over all provision service of taxi transport. Related with taxi distribution problem, till now in Hawassa city, the minibus taxi have no specific route and no prohibited route throughout the city and also they have no specific trip distribution. The city transport bureau was given this action as an affirmative action for the taxi driver and owner to accommodate an increasing travel demand of the city from time to time. Thus to find the solution scientifically for this problem this research used four stage demand modeling and for all selected routes those starting their origin from old bus station and destined to New bus station, Mobil , Piazza Adare Hospital ,Referral Hospital, the four stage demand modeling result for respectively ordered routes were 70 minibus, 81minibus, 51minibus and 73minibus taxi accordingly. The passenger fare establishment and analysis part also the major concern of this research and HDM-4analysis software was used for establishing passenger fare that is road user cost analysis section of Vehicle operating cost value was used for computing the passenger fare per person for each traveling kilometer. Thus, the HDM-4 result show that for one kilometer traveling road the passenger should have to paid value is about 1.35 Birr per person; However the fare established by transport bureau was 0.75 cents which is about 0.60 cents less than the HDM-4 results. Generally, in deep sight and investigation of minibus taxi transport problem has needed for providing good and improved service for public transport users.

## 5.2 Conclusion

The research dealt with the evaluation of the performance of minibus taxi transport service and passenger fare establishment in the City of Hawassa. Based on the analysis and generated results of the study, the following conclusions have been drawn:

The taxi transport has faces many challenges in delivering the required services under the existing condition from obtained results more than half of mini bus taxi transport users are dissatisfied on over all service provision for instance long waiting periods of customer ,they spend longer time in the vehicle without starting journey while waiting for the vehicles until loading full seats, low security during the transportation service delivery like stealing is common now a days and people lose their wallets due to pick pocketing, concerning with uncomfortable seat of the vehicle also more than 60 % of passenger dissatisfied the passenger does not sit properly on the seat since the operator loaded beyond the capacity and it doesn't has enough space for leg. Thus, all these factors make the overall customers 'satisfaction on urban public transport service delivery poor.

According to the result of four stage demand modeling which is basis on four trip purpose and when we taking home to shopping trip purpose Old bus station had produce large amount of trip which is 2239 passenger and piazza station or zone had attract more shopping purpose trip which is 2761 compare to other station. Under the modal split analysis mini bus taxi was used as the most preferable public transport mode on the route of old bus station to new bus station and to referral hospital. However, the trip from old bus station to Mobile station was high relative to other route. Related to the determination of the number of mini bus taxi, the required number of minibus taxi almost 50 percent greater than the assigned mini bus taxi in each route. This due to the presence of insufficient number of mini bus taxi in the city and poor transport management like they didn't give the distribution "Tapela" for most mini bus taxi vehicles .This leads to unbalanced distribution of minibus taxi in the city. Thus the transport office should take improving action like preparing taxi distribution line through using scientific method of four stage demand or other transport planning model for improving minibus taxi distribution

Concerning with result of passenger fare produced by HDM-4 , the fare produced by HDM-4 is about more than 40% greater than the fare established by Hawassa city transport office at all selected route. The variation is created due to some inputs component for establishing passenger fare is not considered on transport office like the number of rise and fall curve on the road network, roughness condition of the pavement surface, traffic composition of the vehicle and basic vehicle characteristics. Regarding with this, to implement the established passenger fare into practice, its affordability and passengers' income should be assessed and well-studied.

## 5.3 Recommendation

Based on the results of the study, in order to improve the service provided by minibus taxi transportation and solve the existing transportation problems in the city, the following recommendation have been forwarded for considerations.

Since the research indicates that there have been observed huge mini bus taxi transport service quality problems in the city‘s the transport authority and the concerned stakeholders should introduce transport services that improve the comfort, reliability, security and safety of travelers. And should take improvement measure for their service provision by introducing and modernizing the service of mini bus taxi.

Regarding to this to make the exiting minibus taxi transport more efficient, affordable and accessible to the city residents, commuters and tourists the city administration based on detail study should identify routes, provide taxi-bays, construct bus and taxi station, prepare fare setting rules, and franchise certain pilot routes to intra-urban public transport service providers.

The transport sector should have effective and clear way of complaints handling mechanism coming from operators and customers as well as other stakeholders. This might include free SMS and free phone call to solve the existed either service quality problems or passenger fare related problems.

Based on the existed taxi distribution problems to balance the supply and demand, to avoid accumulation of mini bus taxi to one specific route and to improve the service provided to the taxi users. The transport bureau should prepare and give distribution “Tapela” to all existed mini bus taxi based on further detail public transport demand assessment in addition to increasing the number of mini bus taxi.

Concerning with transportation fare of passengers, proper attention should be given to establish passenger fare by studying the actual vehicle operating costs of vehicles. Since the transport office still uses manual hand calculation for establishing passenger fare, they didn't consider some necessary VOC components listed in the previous, so they should have to update their system to use essential software like HDM-4 software. For the transport operators to continue in the service provision, they should be profitable. Therefore, it is important to establish passenger fare by considering the actual industry practice.

.

## REFERENCE


Abate Abreha. 2007. Analysing Public Transport Performance using Efficiency Measures and Spatial Analysis; the case of Addis Ababa, Addis Ababa, Ethiopia

Aczel G.H. 1999. Sampling techniques based on house hold data.4th Ed. White River Junction, Vermont.

Arhin, Errol C. Noel .2013. Evaluation of Bus Transit Reliability in the District of Virginia, Virginia . USA

Assaye Melaku. 2016. Travel Demand Modelling of Addis Ababa: East- West Light Rail Transport. . Msc Thesis, Addis Ababa University, Addis Ababa, Ethiopia

Babey Bezabih. 2016. Analysis of Passenger Demand forecasting Models in the Context of AA LRT. Msc Thesis, Addis Ababa University, Addis Ababa, Ethiopia

Beirão, G. & Sarsfield Cabral, J.A. 2007. Understanding attitudes towards public transport and private car: A qualitative study. Transport Policy, 14 (6), 478-489.

Chang K. 1988. GIS and Transportation Planning In: Medium Proceedings of the 6th National Conference on Transportation Planning for Small and Sized Communities, Idaho

Cochran WG.1963. sampling techniques, 2nd Ed . New York: john wiley and sons .inc

CSA. (2015). Population projection of Ethiopia for all regions at woreda level for 2014-2019 , Addis Ababa

Degewale,Gebeyehu ,Fidilu.M& Regassa..2019 .Assessing customer satisfacition of urban public transport service delivery in selected cities of SNNPRS. ISSN 2409-6938

Eboli, L., and Mazzulla .2012. Performance indicators for an objective measure of public transport service quality. European Transport \ Issue 51, Paper n° 3, ISSN 1825-3997

Edvarsson, B. 1998. Causes of customer dissatisfaction - Studies of public transport by critical incident method. Managing Service Quality, 8 (3), 189-197.

Endale Dlasso.2014. Attitudes of Taxi Users on Service Provision Behavior of Taxi Conductors, the Case of Addis Ababa city. Msc Thesis, Addis Ababa University, Addis Ababa, Ethiopia

Endris Said .2019. Assessing the impact of road geometric characterstics and traffic management on road safty case study alon major selected road in Hawassa city, unpublished thesis, Hawassa university, Hawassa. Ethiopia

Friman, M. & Gärling, T. 2001. Frequency of negative critical incidents and satisfaction with public transport services. II. Journal of Retailing and Consumer Services, 8 (2), 105-114

Gedafa . 2006. "Present Pavement Maintenace Practice." Transportation Research Part B: Methodological 22, no. 3 (1988): 217–232.

Hana Yitages.2017. Economic Impact of Poor Pavement Maintenance in the City of Addis Ababa. Msc Thesis, Addis Ababa University, Addis Ababa, Ethiopia

Hart, juan .August 2012. Increasing customer satisfaction with public transport. Delft University of Technology. Delft. Netherland

Hawassa city Municipality.2020: city structure plan : plan preparation and monitoring work process Hawassa. Ethiopia

Hawassa city road and transport office. 2018. urban public transport study report, Hawassa, Ethiopia

Hensher Traniny.2002. Models for Rail Transportation Part A. Transportation Research, Volumen14A, pp. 205-220.

Hoban, Chris, John Riverson, and Albert Weckerle. 1987.Rural Road Maintenance and Improvement. Washington DC. USA

Holye, Brian .1988.Benefits of linking macro-demand forecasting models and.ITE Journal, Volume 79 (10), pp. 30-39.

Hill N, Brierley G, &MacDougall R. 2003. How to Measure Customer Satisfaction. Gower Publishing, Hampshire.

Illes, R. 2005, public transport in developing countries. NL:Emerald group. Published Ltd Tata. 743p.

John, B., & Russels . 2010. Feasiblity study of a national trip-end model for New Zealand Auckland: NZ Transport Agency .CTR 150p

Jonson, R. & Clark . 2005 .Service Operations Management. Improving Service Delivery(2nded.) London: Ashford Colour Press Ltd.

Juan de dios Ortuzar. and Luis G. Willum .2004 . Quality of service in public transport based on customer satisfaction surveys: A review and assessment of methodological approaches. Transportation Science, DOI: 10.1287/trsc.2014.0544

Juan and Racio .2014. The Geography of Transport Systems. Routledge Taylor & Francis Group. New York. USA

Khan, O. 2007. Modelling Passenger Mode Choice Behaviour Using Computer AIDED Stated Preference Data. Journal of Civil Engineering and Environmental Technology, 4(3), 192-197

Kebisha Assefa .2019 . Assesment of public transport demand of Hawassa city using four stage demand modeling , unpublished thesis, Hawassa university, Ethiopia

Kerali, Henry G.R., Derek McMullen, and J.B. Odoki. 2000. The Determinants of Perceived Service Quality and its Relationship with Satisfaction, Journal of Service Marketing, Vol.14, No.3, pp. 217-231

Kumelachew Gebeyehu..2018.the determinants of choice of transportation mode in Addis Ababa, the Case of Addis Ababa city. Msc Thesis, ST.Mary's University, Addis Ababa, Ethiopia

Kummer, A and Barret, F.2008. stuck in traffic : urban transport in Africa infrastructure country diagnostic.World Bank. Washington DC. USA

Litman A .2015. Best Practices Guidebook (BPG). Evaluating Public Transit Benefits and Costs: Virginia Transport Policy Institute. Virginia. USA

Lulachew Akal. 2016. Assesment of public bus transport service supply in Hawassa city, Ethiopia un published thesis , institute of technology, Hawassa university, Ethiopia

Marhew, T. V., & Rao, K. V. 2006. *introduction to Transport Engineering.* Bombay. Indian pp. 247-171

Mekonnen. M. 2010. Assessment of Customer Satisfaction in Transportation Service Delivery: The Case of Three Terminals of Anbassa City Bus Service Enterprise

Melku Hawaz .2009. situational analysis of motorized transport system in ethiopia, seconadary cities; Case study Hawassa city unpublished thesis, ethiopian civil service college, Addis Abeba.

Meyer, M.D. and Miller, E.J. 2004.*Urban Transportation Planning 2nd ed., New York*: McGraw – Hill Higher Education. Monte Verità / Ascona, March 15. – 17. 2006

Michael, P. 2003. *The Traffic Assignment Problem Models and Methods.* Linkoping, Sweden: Linkoping Institute of Technology. *International Journal of Environmental Issues*, *3*(2), 220-230.

Mulu, E. 2015. Public transportation system: The case of Addis Ababa city .un published thesis.Addis Ababa university. Addis Ababa. Ethiopia

Ortuzar, d. D., & Wilumsen, L. G. 2011. *Modeling Transport.* London: A John Wiley & Sons Ltd. 6(1): 297-305

Palmer, A. & Cole, C.1995.*Service Marketing, Principles and Practice*. United States of America: Prentice-Hall, Inc. USA

Ponnuswany Talnis.1992. Evaluation of Bus Transit Reliability in the District of Columbia, Form DOT F 1700.7 (8-72)

Polat ,Yanliniz; Beligings, Vitosoglu, y. and Turan .2011 . evaluation of urban public transportation efficiency in Kutahaya, Turkay 20, (2011) 885-895

Ramos, G. d., & Bazzab, A. L. 2015. Towards the User Equilibrium in Traffic Assignment Using GRASP with Path Relinking. ITE Journal, Volume 79 (10), pp. 30-39

Ranawana and Hewage.2015 .“Factors Affecting Service Quality in Public Bus Transportation in Sri Lanka” Proceedings of 8th International Research Conference, KDU. pp 111146.

R. Bennett, D.O. Paterson .2000. The Highway Development and management series (HDM-4). A guide to calibration and Adaptation. Vol. 5. No. 2, 2000.

Robert, C. 2006. Alternative Approach to Modeling the Travel-Demand Impact of Smart Growth. *Journal of American planning association. 3*(2), 220-230

Robel D, Bikila ,and Miheret .2017. Simulation experiments and validation for considering bus priority treatments in small cites:case study of hawassa, ethiopia, International Journal of Engineering, Science and Technology Vol. 10, No. 4, 2018, pp. 21-28

Rodriguez, Jean-Paul, Comtois, Claude and Slack Brian .2006 . the Geography of Transport Systems: Jean-Paul Rodrigue, Claude Comtois and Brian Slack, New York, USA

Samson.R.H.2016. Evaluation on inter-city buses terminals and inter-city buses service in case of lambert and Kality terminals. Msc Thesis, Addis Ababa University, Addis Ababa, Ethiopia.

Samiul, H. (n.d.). A Simplified Travel demand Modeling Framwork in context of a Developing country City. European Transport, 52 (5), 1825-3997

Sheth, C;Triants, K; & Teodrovic, D. 2007. Performance evaluation of bus routes from provider and passenger perspective. Journal of Public Transportation, 8 (1): 79-97

SPUTNIC .2012 . Corporate Management, Performance Indicator. Retrieved October 8, 2013.

Tegegn Mesfin ,2018 Evaluating Quality of Service on Public Bus Transportation and Improvement Strategy in Addis Ababa :( A Case Study on Sheger Mass Transport Enterprise). Unpublished thesis,Addis Ababa university, Ethiopia

Transit Capacity and Quality of Service Manual (TCQSM) .2003. Transportation Research board of national Academies (TRB). Transit cooperative Research program(TCRP).

TCRP report 100, 2003.Fare Policies, Structures and Technologies: Update Transit cooperative Research program (TCRP).Transportation Research board of national Academies(TRB)

TRB Report, (2003): A Handbook for Measuring Customer Satisfaction and Service Quality. Transportation Research Board (TRB) National Research Council.

Tsegaye Pawulose . 2020. Evaluation of urban land use characteristics and transportation system interaction in Hawassa city, Ethiopia un published thesis , institute of technology, Hawassa university, Ethiopia

Vilhelmson Y. 2007. Urban Bus Transport Service Quality and Sustainable Development: Understanding the Gaps, Jul. 2014, Vol. 2 Iss. 3, PP. 81-88

Vuchic, V., (2005). Urban transit: Operations, Planning and Economics. John Wiley &Sons,

New York.

Wardrop, J. G., 1952. Some Theoretical Aspects of Road Traffic Research. Proceedings,Institute of Civil Engineers, Part II, Volume Vol. 1, p. 325–378.

Wilson, A. 2007. HDM-4 Introduction to Transport Development and passenger fare establishment essential parameters identification. atransnational transdisciplinary Journal, 33:2, 219-238.

Wood and Johnson, James C. 1989 . Contemporary Transportation: Third Edition, Macmillan Publishing Company, New York, USA

World Bank .2002. Cities on the Move, World Bank Urban Transport Strategy Review, Library of Congress Cataloging-in-Publication, Washington D C, USA

W.T consulting private company.2018. compiling cost of imported and fabricated vehicles : special public transport vehicles, Addis Ababa, Ethiopia

Xin, L. Fu, and F. Saccomanno .2005. "Assessing Transit Level of Service along Travel Corridors Using TCQSM – A Case Study." Presented at the Transportation Research Board Annual Meeting, Washington. DC. USA

Yeshitela Deneke.. 2019 Analysis of Transportation mode choice of the passengers using multinomial logit model for work and school trips in Hawassa city , Ethiopia un published thesis, institute of technology, Hawassa university, Ethiopia

Zheng & jianqing. 2007. *Sustainble Urban Transport Development*: a dynamic optimization Approach. *Transport Reviews* 25(6): 691- 717.

## APPENDIXES

**Appendix A-1:- Questioner**
**Questionnaires for Minibus taxi users for the purpose of service quality evaluation**

**Part I. Background information**

1. Gender:

A. Male B. Female

2. Age (in years):

A. 18-24 B. 25-34 C. 35-44 D. 45-54 E . 55-64

3. Occupation:

A. Student B. Job seeker C. Employed D. Business Person E. Housewife

F.Retired G. Other (if any) _____

4. Which of the following public transportation modes do you use regularly?

A. Large bus B. Mini bus tax\ dolphin C. Damas D. Bajaj

5. Frequency of Public transport usage per week

A . every day B. 1-2 days per week C . 3-4 days per week D. 5 – 6 days per week

E. 6- 7 days per week

**Part II. Travel attributes**

**1.** What is your opinion about satisfaction level of mini- bus taxi service reliability?

| Score | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Interpretation | Verydissatisfied | Dissatisfied | Neutral | Satisfied | Very satisfied |

**2.** How much you satisfied on the availability of mini bus taxi transport at any time ?

| Score | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Interpretation | Verydissatisfied | Dissatisfied | Neutral | Satisfied | Very satisfied |

**3.** To how much level mini bus taxi save the time of traveling related top other mode?

| Score | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Interpretation | Verydissatisfied | Dissatisfied | Neutral | Satisfied | Very satisfied |

**4.** Is the mini bus taxi loading corresponding to inside vehicle seat?
A . Yes B. No

**5.** How much does the seat comfort of mini bus taxi comfortable?

| Score | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Interpretation | Verydissatisfied | Dissatisfied | Neutral | Satisfied | Very satisfied |

**6.** How does the satisfaction level of vehicle cleaness and ventilation?

| Score | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Interpretation | Verydissatisfied | Dissatisfied | Neutral | Satisfied | Very satisfied |

**7.** What does the satisfaction level of about degree of safty and security on taxi transport?

| Score | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Interpretation | Very dissatisfied | Dissatisfied | Neutral | Satisfied | Very satisfied |

**8.** How does you satisfied on tariff structure of mini bus taxi?

| Score | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Interpretation | Very dissatisfied | Dissatisfied | Neutral | Satisfied | Very satisfied |

**9.** What does the satisfaction level of about tariff affordability on taxi transport?

| Score | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Interpretation | Very dissatisfied | Dissatisfied | Neutral | Satisfied | Very satisfied |

**10.** How much level you agreed  on tariff increment of mini bus taxi during peak hour ?

| Score | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Interpretation | Very dissatisfied | Dissatisfied | Neutral | Satisfied | Very satisfied |

**Appendix A-2:- Questioner prepared for the purpose of taxi distribution**
**Questionnaires for city residents**

**A: General Introductory Remarks**

The questionnaires and interview guides are aimed at to collect data for the research on the topic: Evaluating the performance of mini bus taxi transport service and establishing passenger fare.

**I. General Information about the (sample) respondents.**

1. Your gender **1)** Female **2)** Male
2. Your age Category **1/** 5 -15 **2/** 16-26 **3/** 27-37 **4/** 38-45 **5/** 46-65 **6./** $65^{+}$
3. Family size: female_____ male_____ total_____.
4. What are the number of the families whose age above 5 years_____?
5. Your occupation: 1) Employed 2/ Unemployed 3/ student
   4) If any specify_____.
6. Average house hold monthly income( in birr) _____
   **1)** 500-1500 **2)** 1500-3000 **3)** 3,000 - 5,000 **4)** 5,000-8,000 **5**) 8,000-10,000 **6**) above 10,000
7. How many vehicles are available in the house hold level for intra urban transportation service _____?
8. What mode of transport do you use most frequently for the purpose of?
   **A) Work :**1) walking 2)public transport 3) Private Automobile 4) vehicles supplied by employee 5) motor bicycle
   If your answer is public transport, which type of mode you use?
   1) Auto rick show 2) mini bus 3) public bus
   B) **Education**:1) 1) walking 2)public transport 3) Private Automobile 4) vehicles supplied by employee(service) 5) motor bicycle
   If your answer is public transport, which type of mode you use?
   1) Auto Rick show 2) mini bus 3) public bus
   C) **Shopping**: 1) walking 2)public transport 3) Private Automobile 4) vehicles supplied by employee 5) motor bicycle
   If your answer is public transport, which type of mode you use?
   1) Auto Rick Show 2) mini bus 3) public bus
   D) **Other purpose like Recreation, traveling to bus station and other purpose those does not included in the above trip purpose**

1) walking 2)public transport 3) Private Automobile 4) vehicles supplied by employee 5) motor bicycle

If your answer is public transport, which type of mode you use?

1) Auto rick show 2) mini bus 3) public bus

9. If you use public city bus transport for any of the above purpose on average how much time is lost to
   1) **Access the bus stops** 1) 1-3min 2) 3-5min 3) 5-10min 4) over 10min
   2) **Waiting for bus at stops** 1) 1-3min 2) 3-5min 3) 5-10min 4) over 10min
   3) **Arrive to your destination stops**1) 1-3min 2) 3-5min 3) 5-10min 4) >10min
10. If you use mini bus/ dolphin taxi transport for at list one of the above purpose on average how much time is lost to:
   1) **Access to the** mini bus taxi **stops** 1) 1-3min 2.) 3-5min 3.) 5-10min 4.) > 10min
   2) **Waiting for** mini bus taxi **at stops** 1.) 1-3min 2.) 3-5min 3.) 5-10min 4.)>10min
   3) **Arrive to your destination stops** 1.) 1-3min 2) 3-5min 3) 5-10min 4.) >10min
11. How many trips you produce for your main daily activities for the purpose of?
   1) **work :** 1) 1 2) 2 3) 3 4) 4 5) over5
   2) **education :** 1) 1 2) 2 3) 3 4) 4 5) over5
   3) **shopping:** 1) 1 2) 2 3) 3 4) 4 5) over5
   4) **other purpose:** 1) 1 2) 2 3) 3 4) 4 5) over5
12. Which zone is your most often trip destination locations for the purpose of?
   1) **Work _____**
   2) **education_____**
   3) **shopping_____**
   4) **other purpose** _____
13. The reason for selection of the above mode of transport (question number 8) is

    1/ No other option 2/Best in terms of cost 3/ Best in terms of comfort

    4/ifanyother_____
14. Have you ever participated in transportation planning program at any Administration level of the city government?

    1/ Not at all 2/ yes sometimes 3/ Yes always
15. What do you suggest to improve the current system service of mini bus taxi transport?

**Appendix A-3:- Interview papers prepared for collecting information from responsible body transport office**.

**Interview for transport authority**

1. Full name of the organization and main functions with city minibus taxis and related public transport?

2. Number of minibus taxi currently available in the city?

3. How many mini bus taxi operated route in the Hawassa city?

4. In which routes the demand of minibus taxi vehicles more , list the dominant route decreasing order based on the demand of mini bus taxi?

5. Have you give the distribution "Tapela" to all of existed minibus taxi?

6. On what bases the transport office give the distribution "tapela" ?

7. Which methods have the transport office used for assigning the minibus taxi for selected route?

8. Was all minibus taxis had taken the distribution "Tapela" currently?

9. How many people get served by minibus taxi service per day?

10. How the transport office set the passenger fare of mini bus taxi users?

11. On which bases the transport office set or establish the passenger fare?

12. What are the basic considered parameters for establishing passenger fare in transport office?

13. How much that the established fare reliable on drivers and opertors?

14. Do you think that the existing provision of transport service in the City is adequate?

15. Is there any mechanism of control or collaboration with owners of fuel station so that they will consistently provide fuel service to transport operators?

**Appendix B-1 Trip production rate of home to other purpose trip**

| Home to other trip purpose | | | |
|---|---|---|---|
| Male sex | | Female sex | |
| Age | Production rate | Age | Production rate |
| 5-15 | 0.15 | 5-15 | 0.35 |
| 16-26 | 0.6 | 16-26 | 0.5 |
| 27-37 | 0.5 | 27-37 | 0.6 |
| 38-45 | 0.4 | 38-45 | 0.3 |
| 46-65 | 0.35 | 46-65 | 0.2 |
| 65+ | 0.2 | 65+ | 0.2 |

## Appendix B-2 Iteration processed table of home to work trip purpose iterations

| | 1 | 2 | 3 | 4 | 5 | SUM | $O_i$ | $a_i$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 410 | 295 | 586 | 543 | 446 | 2,280 | 2280 | 1.00 |
| 2 | 534 | 389 | 308 | 254 | 438 | 1,923 | 1923 | 1.00 |
| 3 | 576 | 141 | 453 | 642 | 206 | 2,018 | 2018 | 1.00 |
| 4 | 431 | 103 | 678 | 431 | 309 | 1,952 | 1952 | 1.00 |
| 5 | 542 | 479 | 306 | 457 | 439 | 2,223 | 2223 | 1.00 |
| SUM | 2,493 | 1,407 | 2,331 | 2,327 | 1,838 | 10,396 | 10396 | |
| $D_j$ | 3365.55 | 1308.51 | 2657.34 | 1489.28 | 1543.92 | 10364.6 | | |
| $b_j$ | 1.35 | 0.93 | 1.14 | 0.64 | 0.84 | | | |
| First iteration $T_{ij}^1$ | | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | SUM | $O_i$ | $a_i$ |
| 1 | 554 | 274 | 668 | 348 | 375 | 2,218 | 2280 | 1.03 |
| 2 | 721 | 362 | 351 | 163 | 368 | 1,964 | 1923 | 0.98 |
| 3 | 778 | 131 | 516 | 411 | 173 | 2,009 | 2018 | 1.00 |
| 4 | 582 | 96 | 773 | 276 | 260 | 1,986 | 1952 | 0.98 |
| 5 | 732 | 445 | 349 | 292 | 369 | 2,187 | 2223 | 1.02 |
| SUM | 3,366 | 1,309 | 2,657 | 1,489 | 1,544 | 8,177 | | |
| $D_j$ | 3365.55 | 1308.51 | 2657.34 | 1489.28 | 1543.92 | 10364.6 | | |
| $b_j$ | 1.00 | 1.00 | 1.00 | 1.00 | | | | |
| | | | | | | | | |
| second iteration $T_{ij}^2$ | | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | SUM | $O_i$ | $a_i$ |
| 1 | 569 | 282 | 687 | 357 | 385 | 2,280 | 2280 | 1.00 |
| 2 | 706 | 354 | 344 | 159 | 360 | 1,923 | 1923 | 1.00 |
| 3 | 781 | 132 | 519 | 413 | 174 | 2,018 | 2018 | 1.00 |
| 4 | 572 | 94 | 760 | 271 | 255 | 1,952 | 1952 | 1.00 |
| 5 | 744 | 453 | 355 | 297 | 375 | 2,223 | 2223 | 1.00 |
| SUM | 3,371 | 1,315 | 2,663 | 1,497 | 1,549 | 10,396 | 10396 | |
| $D_j$ | 3365.55 | 1308.51 | 2657.34 | 1489.28 | 1543.92 | 10364.6 | | |
| $b_j$ | 1.00 | 1.00 | 1.00 | 0.99 | 1.00 | | | |
| | | | | | | | | |
| Third iteration $T_{ij}^3$ | | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | SUM | $O_i$ | $a_i$ |
| 1 | 568 | 281 | 685 | 355 | 384 | 2,273 | 2280 | 1.00 |
| 2 | 705 | 352 | 343 | 158 | 359 | 1,917 | 1923 | 1.00 |
| 3 | 780 | 131 | 518 | 410 | 173 | 2,012 | 2018 | 1.00 |
| 4 | 571 | 94 | 758 | 270 | 254 | 1,947 | 1952 | 1.00 |
| 5 | 742 | 451 | 354 | 296 | 374 | 2,216 | 2223 | 1.00 |
| SUM | 3,366 | 1,309 | 2,657 | 1,489 | 1,544 | 10,365 | 10396 | |
| $D_j$ | 3365.55 | 1308.51 | 2657.34 | 1489.28 | 1543.92 | | | |
| $b_j$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | | | |

## Appendix B-3 Home to school trip purpose iteration process

| station | Old bus station | New bus s | Mobile | Piassa | Refferral | SUM | $O_i$ | $a_i$ |
|---|---|---|---|---|---|---|---|---|
| Old bus st | 467 | 338 | 448 | 579 | 407 | 2,239 | 2239 | 1.00 |
| New bus st | 534 | 453 | 279 | 353 | 299 | 1,918 | 1918 | 1.00 |
| Mobile | 756 | 196 | 375 | 494 | 98 | 1,919 | 1919 | 1.00 |
| Piassa | 224 | 206 | 363 | 576 | 92 | 1,461 | 1461 | 1.00 |
| Refferal | 438 | 420 | 432 | 554 | 320 | 2,164 | 2164 | 1.00 |
| SUM | 2,419 | 1,613 | 1,897 | 2,556 | 1,216 | 9,701 | 9701 | |
| $D_j$ | 2543 | 1724 | 1602 | 2761 | 1108 | 9738 | | |
| $b_j$ | 1.05 | 1.07 | 0.84 | 1.08 | 0.91 | | | |
| First iteration $T_{ij}^1$ | | | | | | | | |
| | Old bus station | New bus s | Mobile | Piassa | Refferral | SUM | $O_i$ | $a_i$ |
| Old bus stat | 491 | 361 | 378 | 625 | 371 | 2,227 | 2239 | 1.01 |
| New bus s | 561 | 484 | 236 | 381 | 272 | 1,935 | 1918 | 0.99 |
| Mobile | 795 | 209 | 317 | 534 | 89 | 1,944 | 1919 | 0.99 |
| Piassa | 235 | 220 | 307 | 622 | 84 | 1,468 | 1461 | 1.00 |
| Refferral | 460 | 449 | 365 | 598 | 292 | 2,164 | 2164 | 1.00 |
| SUM | 2,543 | 1,724 | 1,602 | 2,761 | 1,108 | 7,574 | | |
| $D_j$ | 2543 | 1724 | 1602 | 2761 | 1108 | 9738 | | |
| $b_j$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | | | |
| Second iteration $T_{ij}^2$ | | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | SUM | $O_i$ | $a_i$ |
| 1 | 494 | 363 | 380 | 629 | 373 | 2,239 | 2239 | 1.00 |
| 2 | 556 | 480 | 234 | 378 | 270 | 1,918 | 1918 | 1.00 |
| 3 | 785 | 207 | 313 | 527 | 88 | 1,919 | 1919 | 1.00 |
| 4 | 234 | 219 | 305 | 619 | 83 | 1,461 | 1461 | 1.00 |
| 5 | 460 | 449 | 365 | 598 | 292 | 2,164 | 2164 | 1.00 |
| SUM | 2,529 | 1,718 | 1,596 | 2,751 | 1,106 | 9,701 | 9701 | |
| $D_j$ | 2543 | 1724 | 1602 | 2761 | 1108 | 9738 | | |
| $b_j$ | 1.01 | 1.00 | 1.00 | 1.00 | 1.00 | | | |

## Appendix B-4 Home to other purpose trip iteration process

| | 1 | 2 | 3 | 4 | 5 | SUM | $O_i$ | $a_i$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 402 | 711 | 557 | 546 | 429 | 2,645 | 2645 | 1.00 |
| 2 | 403 | 345 | 204 | 298 | 297 | 1,547 | 1547 | 1.00 |
| 3 | 527 | 208 | 420 | 434 | 195 | 1,784 | 1784 | 1.00 |
| 4 | 265 | 339 | 697 | 443 | 293 | 2,037 | 2037 | 1.00 |
| 5 | 393 | 624 | 178 | 465 | 431 | 2,091 | 2091 | 1.00 |
| SUM | 1,990 | 2,227 | 2,056 | 2,186 | 1,645 | 10,104 | 10104 | |
| $D_j$ | 2017 | 2439 | 1947 | 2020 | 1924 | 10347 | | |
| $b_j$ | 1.01 | 1.10 | 0.95 | 0.92 | 1.17 | | | |
| First step iteration $T_{ij}^1$ | | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | SUM | $O_i$ | $a_i$ |
| 1 | 407 | 779 | 527 | 505 | 502 | 2,720 | 2645 | 0.97 |
| 2 | 408 | 378 | 193 | 275 | 347 | 1,602 | 1547 | 0.97 |
| 3 | 534 | 228 | 398 | 401 | 228 | 1,789 | 1784 | 1.00 |
| 4 | 269 | 371 | 660 | 409 | 343 | 2,052 | 2037 | 0.99 |
| 5 | 398 | 683 | 169 | 430 | 504 | 2,184 | 2091 | 0.96 |
| SUM | 2,017 | 2,439 | 1,947 | 2,020 | 1,924 | 8,163 | | |
| $D_j$ | 2017 | 2439 | 1947 | 2020 | 1924 | 10347 | | |
| $b_j$ | 1.00 | 1.00 | 1.00 | 1.00 | | | | |
| Second iteration $T_{ij}^2$ | | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | SUM | $O_i$ | $a_i$ |
| 1 | 396 | 757 | 513 | 491 | 488 | 2,645 | 2645 | 1.00 |
| 2 | 394 | 365 | 187 | 266 | 335 | 1,547 | 1547 | 1.00 |
| 3 | 533 | 227 | 397 | 400 | 227 | 1,784 | 1784 | 1.00 |
| 4 | 267 | 369 | 655 | 406 | 340 | 2,037 | 2037 | 1.00 |
| 5 | 381 | 654 | 161 | 411 | 483 | 2,091 | 2091 | 1.00 |
| SUM | 1,971 | 2,372 | 1,913 | 1,974 | 1,874 | 10,104 | 10104 | |
| $D_j$ | 2017 | 2439 | 1947 | 2020 | 1924 | 10347 | | |
| $b_j$ | 1.02 | 1.03 | 1.02 | 1.02 | 1.03 | | | |
| Third iteration $T_{ij}^3$ | | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | SUM | $O_i$ | $a_i$ |
| 1 | 405 | 779 | 522 | 502 | 501 | 2,709 | 2645 | 1.00 |
| 2 | 404 | 375 | 190 | 272 | 344 | 1,585 | 1547 | 1.00 |
| 3 | 545 | 234 | 404 | 409 | 234 | 1,825 | 1784 | 1.00 |
| 4 | 273 | 379 | 667 | 416 | 349 | 2,084 | 2037 | 1.00 |
| 5 | 390 | 673 | 164 | 421 | 496 | 2,144 | 2091 | 1.00 |
| SUM | 2,017 | 2,439 | 1,947 | 2,020 | 1,924 | 10,347 | | |
| $D_j$ | 2017 | 2439 | 1947 | 2020 | 1924 | | | |
| $b_j$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | | | |

## Appendix B- 5 HDM-4 output result of the route of old bus station to new bus station

**Section:** old bus station - wanza round about
**Alternative:** With project

Sect ID: OSWR Road Class: Primary or Trunk

Length: 0.50 km Width: 7.00 m Rise+Fall: 1.00 m/km Curvature: 3.00 deg/km

| | 4WD | Damas | Dolphin or bus mini | heavy bus | Heavy Truck | ISUZU | medium truck | Truck and Trailor | Total |
|---|---|---|---|---|---|---|---|---|---|
| **2021** | 12.75 | 5.49 | 7.14 | 12.36 | 33.75 | 12.76 | 22.16 | 37.51 | 143.92 |
| | 0.85 | 1.06 | 5.38 | 38.25 | 0.00 | 0.00 | 0.00 | 0.00 | 45.55 |
| | 13.60 | 6.55 | 12.52 | 50.61 | 33.75 | 12.76 | 22.16 | 37.51 | 189.47 |
| **2022** | 14.48 | 5.71 | 7.66 | 13.55 | 38.35 | 14.56 | 25.17 | 42.69 | 162.16 |
| | 0.86 | 1.07 | 5.42 | 38.46 | 0.00 | 0.00 | 0.00 | 0.00 | 45.80 |
| | 15.33 | 6.78 | 13.07 | 52.00 | 38.35 | 14.56 | 25.17 | 42.69 | 207.96 |
| **2023** | 14.51 | 5.73 | 7.68 | 13.59 | 38.42 | 14.59 | 25.22 | 42.75 | 162.50 |
| | 0.86 | 1.07 | 5.44 | 38.66 | 0.00 | 0.00 | 0.00 | 0.00 | 46.04 |
| | 15.37 | 6.80 | 13.12 | 52.25 | 38.42 | 14.59 | 25.22 | 42.75 | 208.53 |
| **2024** | 14.55 | 5.75 | 7.70 | 13.63 | 38.49 | 14.62 | 25.27 | 42.82 | 162.83 |
| | 0.86 | 1.08 | 5.47 | 38.85 | 0.00 | 0.00 | 0.00 | 0.00 | 46.27 |
| | 15.41 | 6.83 | 13.17 | 52.48 | 38.49 | 14.62 | 25.27 | 42.82 | 209.10 |
| **2025** | 12.51 | 5.53 | 7.12 | 12.28 | 33.01 | 12.47 | 21.69 | 36.68 | 141.30 |
| | 0.87 | 1.08 | 5.50 | 39.04 | 0.00 | 0.00 | 0.00 | 0.00 | 46.49 |
| | 13.38 | 6.62 | 12.61 | 51.33 | 33.01 | 12.47 | 21.69 | 36.68 | 187.79 |
| **2026** | 13.44 | 5.66 | 7.40 | 12.93 | 35.48 | 13.44 | 23.30 | 39.42 | 151.07 |
| | 0.87 | 1.09 | 5.54 | 39.32 | 0.00 | 0.00 | 0.00 | 0.00 | 46.83 |
| | 14.31 | 6.75 | 12.94 | 52.25 | 35.48 | 13.44 | 23.30 | 39.42 | 197.90 |
| **2027** | 14.41 | 5.80 | 7.71 | 13.64 | 38.09 | 14.47 | 25.01 | 42.38 | 161.50 |
| | 0.88 | 1.10 | 5.57 | 39.56 | 0.00 | 0.00 | 0.00 | 0.00 | 47.11 |
| | 15.29 | 6.90 | 13.27 | 53.20 | 38.09 | 14.47 | 25.01 | 42.38 | 208.61 |

**Section:** Wanza round about- Welde amanuel
**Alternative:** With project

Sect ID: WRWA Road Class: Primary or Trunk

Length: 1.70 km Width: 7.00 m Rise+Fall: 1.00 m/km Curvature: 3.00 deg/km

| | 4WD | Damas | Dolphin or bus mini | heavy bus | Heavy Truck | ISUZU | medium truck | Truck and Trailor | Total |
|---|---|---|---|---|---|---|---|---|---|
| **2021** | 12.85 | 5.50 | 7.16 | 12.42 | 34.00 | 12.86 | 22.33 | 37.80 | 144.92 |
| | 0.85 | 1.06 | 5.38 | 38.23 | 0.00 | 0.00 | 0.00 | 0.00 | 45.52 |
| | 13.70 | 6.56 | 12.55 | 50.65 | 34.00 | 12.86 | 22.33 | 37.80 | 190.44 |
| **2022** | 14.79 | 5.74 | 7.74 | 13.75 | 39.18 | 14.89 | 25.71 | 43.62 | 165.42 |
| | 0.85 | 1.07 | 5.41 | 38.41 | 0.00 | 0.00 | 0.00 | 0.00 | 45.75 |
| | 15.64 | 6.81 | 13.15 | 52.16 | 39.18 | 14.89 | 25.71 | 43.62 | 211.16 |
| **2023** | 14.82 | 5.77 | 7.77 | 13.79 | 39.25 | 14.92 | 25.76 | 43.68 | 165.76 |
| | 0.86 | 1.07 | 5.44 | 38.62 | 0.00 | 0.00 | 0.00 | 0.00 | 45.99 |
| | 15.68 | 6.84 | 13.20 | 52.42 | 39.25 | 14.92 | 25.76 | 43.68 | 211.75 |
| **2024** | 14.86 | 5.79 | 7.79 | 13.83 | 39.32 | 14.95 | 25.81 | 43.75 | 166.09 |
| | 0.86 | 1.08 | 5.47 | 38.81 | 0.00 | 0.00 | 0.00 | 0.00 | 46.22 |
| | 15.72 | 6.86 | 13.25 | 52.65 | 39.32 | 14.95 | 25.81 | 43.75 | 212.31 |
| **2025** | 12.54 | 5.53 | 7.12 | 12.30 | 33.09 | 12.50 | 21.75 | 36.77 | 141.61 |
| | 0.87 | 1.08 | 5.49 | 39.00 | 0.00 | 0.00 | 0.00 | 0.00 | 46.44 |
| | 13.41 | 6.61 | 12.61 | 51.30 | 33.09 | 12.50 | 21.75 | 36.77 | 188.04 |
| **2026** | 13.56 | 5.67 | 7.43 | 13.01 | 35.80 | 13.57 | 23.51 | 39.79 | 152.34 |
| | 0.87 | 1.09 | 5.53 | 39.28 | 0.00 | 0.00 | 0.00 | 0.00 | 46.77 |
| | 14.43 | 6.76 | 12.96 | 52.29 | 35.80 | 13.57 | 23.51 | 39.79 | 199.12 |
| **2027** | 14.66 | 5.82 | 7.77 | 13.80 | 38.73 | 14.72 | 25.43 | 43.10 | 164.04 |
| | 0.88 | 1.10 | 5.56 | 39.53 | 0.00 | 0.00 | 0.00 | 0.00 | 47.07 |
| | 15.53 | 6.92 | 13.34 | 53.33 | 38.73 | 14.72 | 25.43 | 43.10 | 211.11 |

## Appendix B-6 HDM-4 output result for route of old bus station to mobile station

**Section:** Tigest hotel - south star hotel
**Alternative:** with project

Sect ID: THSSH Road Class: Primary or Trunk

Length: 0.70 km Width: 7.00 m Rise+Fall: 1.00 m/km Curvature: 3.00 deg/km

| | 4WD | Damas | Dolphin or Minibus | Heavy bus | Heavy Truck | ISUZU | Medium Truck | Truck and Trailor | Total |
|---|---|---|---|---|---|---|---|---|---|
| **2021** | 10.10 | 5.70 | 6.70 | 12.63 | 34.93 | 12.66 | 22.93 | 38.86 | 144.51 |
| | 0.85 | 1.06 | 5.36 | 38.06 | 0.00 | 0.00 | 0.00 | 0.00 | 45.32 |
| | 10.95 | 6.76 | 12.05 | 50.70 | 34.93 | 12.66 | 22.93 | 38.86 | 189.83 |
| **2022** | 10.54 | 5.82 | 6.95 | 13.28 | 37.42 | 13.58 | 24.56 | 41.66 | 153.79 |
| | 0.85 | 1.06 | 5.37 | 38.17 | 0.00 | 0.00 | 0.00 | 0.00 | 45.45 |
| | 11.38 | 6.88 | 12.32 | 51.45 | 37.42 | 13.58 | 24.56 | 41.66 | 199.24 |
| **2023** | 10.55 | 5.83 | 6.96 | 13.30 | 37.46 | 13.59 | 24.58 | 41.69 | 153.96 |
| | 0.85 | 1.06 | 5.39 | 38.27 | 0.00 | 0.00 | 0.00 | 0.00 | 45.58 |
| | 11.41 | 6.89 | 12.34 | 51.57 | 37.46 | 13.59 | 24.58 | 41.69 | 199.53 |
| **2024** | 10.59 | 5.85 | 6.98 | 13.34 | 37.53 | 13.62 | 24.63 | 41.76 | 154.30 |
| | 0.86 | 1.07 | 5.42 | 38.49 | 0.00 | 0.00 | 0.00 | 0.00 | 45.83 |
| | 11.45 | 6.92 | 12.40 | 51.82 | 37.53 | 13.62 | 24.63 | 41.76 | 200.13 |
| **2025** | 9.79 | 5.66 | 6.51 | 12.11 | 32.49 | 11.76 | 21.35 | 36.11 | 135.77 |
| | 0.86 | 1.07 | 5.44 | 38.68 | 0.00 | 0.00 | 0.00 | 0.00 | 46.05 |
| | 10.65 | 6.74 | 11.95 | 50.78 | 32.49 | 11.76 | 21.35 | 36.11 | 181.83 |
| **2026** | 10.05 | 5.74 | 6.66 | 12.49 | 33.94 | 12.31 | 22.30 | 37.70 | 141.20 |
| | 0.87 | 1.08 | 5.48 | 38.93 | 0.00 | 0.00 | 0.00 | 0.00 | 46.35 |
| | 10.92 | 6.82 | 12.14 | 51.42 | 33.94 | 12.31 | 22.30 | 37.70 | 187.55 |
| **2027** | 10.31 | 5.83 | 6.82 | 12.88 | 35.34 | 12.82 | 23.21 | 39.27 | 146.47 |
| | 0.87 | 1.09 | 5.52 | 39.23 | 0.00 | 0.00 | 0.00 | 0.00 | 46.71 |
| | 11.18 | 6.92 | 12.34 | 52.11 | 35.34 | 12.82 | 23.21 | 39.27 | 193.19 |

**Section:** South star hotel - Megenagna
**Alternative:** with project

Sect ID: SSHM Road Class: Primary or Trunk

Length: 0.50 km Width: 7.00 m Rise+Fall: 10.00 m/km Curvature: 15.00 deg/km

| | 4WD | Damas | Dolphin or Minibus | Heavy bus | Heavy Truck | ISUZU | Medium Truck | Truck and Trailor | Total |
|---|---|---|---|---|---|---|---|---|---|
| **2021** | 9.67 | 5.57 | 6.44 | 12.03 | 32.56 | 11.76 | 21.39 | 36.33 | 135.75 |
| | 0.84 | 1.05 | 5.30 | 37.67 | 0.00 | 0.00 | 0.00 | 0.00 | 44.86 |
| | 10.51 | 6.61 | 11.75 | 49.70 | 32.56 | 11.76 | 21.39 | 36.33 | 180.61 |
| **2022** | 10.00 | 5.66 | 6.64 | 12.55 | 34.60 | 12.51 | 22.71 | 38.62 | 143.29 |
| | 0.84 | 1.05 | 5.31 | 37.75 | 0.00 | 0.00 | 0.00 | 0.00 | 44.95 |
| | 10.84 | 6.70 | 11.96 | 50.30 | 34.60 | 12.51 | 22.71 | 38.62 | 188.24 |
| **2023** | 10.02 | 5.66 | 6.65 | 12.57 | 34.62 | 12.52 | 22.73 | 38.64 | 143.42 |
| | 0.84 | 1.05 | 5.33 | 37.83 | 0.00 | 0.00 | 0.00 | 0.00 | 45.05 |
| | 10.86 | 6.72 | 11.98 | 50.40 | 34.62 | 12.52 | 22.73 | 38.64 | 188.47 |
| **2024** | 10.03 | 5.67 | 6.66 | 12.58 | 34.65 | 12.53 | 22.75 | 38.67 | 143.55 |
| | 0.84 | 1.05 | 5.34 | 37.92 | 0.00 | 0.00 | 0.00 | 0.00 | 45.15 |
| | 10.88 | 6.73 | 12.00 | 50.50 | 34.65 | 12.53 | 22.75 | 38.67 | 188.71 |
| **2025** | 9.67 | 5.59 | 6.44 | 12.02 | 32.29 | 11.66 | 21.22 | 36.04 | 134.93 |
| | 0.84 | 1.06 | 5.35 | 38.01 | 0.00 | 0.00 | 0.00 | 0.00 | 45.26 |
| | 10.51 | 6.65 | 11.79 | 50.02 | 32.29 | 11.66 | 21.22 | 36.04 | 180.19 |
| **2026** | 9.88 | 5.65 | 6.57 | 12.33 | 33.54 | 12.13 | 22.03 | 37.41 | 139.52 |
| | 0.85 | 1.06 | 5.36 | 38.11 | 0.00 | 0.00 | 0.00 | 0.00 | 45.38 |
| | 10.72 | 6.71 | 11.93 | 50.43 | 33.54 | 12.13 | 22.03 | 37.41 | 184.90 |
| **2027** | 10.08 | 5.71 | 6.69 | 12.64 | 34.71 | 12.56 | 22.79 | 38.72 | 143.89 |
| | 0.85 | 1.06 | 5.39 | 38.26 | 0.00 | 0.00 | 0.00 | 0.00 | 45.55 |
| | 10.93 | 6.77 | 12.07 | 50.90 | 34.71 | 12.56 | 22.79 | 38.72 | 189.45 |

## Appendix B-7 HDM-4 output result of route from old bus station to piazza

**Section:** Tiget Hotel - South star hotel
**Alternative:** with project

Sect ID: THSSH Road Class: Primary or Trunk
Length: 0.80 km Width: 7.00 m Rise+Fall: 1.00 m/km Curvature: 3.00 deg/km

| | 4WD | Damas | Dolphin or Mini bus | Heavy Bus | Heavy Truck | ISUZU | Medium Truck | Truck and Trailor | Total |
|---|---|---|---|---|---|---|---|---|---|
| **2021** | 11.90 | 5.55 | 6.97 | 11.95 | 32.43 | 11.73 | 21.30 | 35.81 | 137.64 |
| | 0.84 | 1.04 | 5.29 | 37.58 | 0.00 | 0.00 | 0.00 | 0.00 | 44.75 |
| | 12.74 | 6.60 | 12.26 | 49.54 | 32.43 | 11.73 | 21.30 | 35.81 | 182.39 |
| **2022** | 12.60 | 5.63 | 7.18 | 12.44 | 34.34 | 12.43 | 22.54 | 37.96 | 145.12 |
| | 0.84 | 1.05 | 5.30 | 37.62 | 0.00 | 0.00 | 0.00 | 0.00 | 44.80 |
| | 13.44 | 6.68 | 12.47 | 50.06 | 34.34 | 12.43 | 22.54 | 37.96 | 189.92 |
| **2023** | 12.62 | 5.64 | 7.18 | 12.45 | 34.37 | 12.44 | 22.56 | 37.98 | 145.23 |
| | 0.84 | 1.05 | 5.31 | 37.69 | 0.00 | 0.00 | 0.00 | 0.00 | 44.88 |
| | 13.45 | 6.69 | 12.49 | 50.14 | 34.37 | 12.44 | 22.56 | 37.98 | 190.11 |
| **2024** | 12.63 | 5.65 | 7.19 | 12.47 | 34.39 | 12.45 | 22.57 | 38.00 | 145.35 |
| | 0.84 | 1.05 | 5.32 | 37.77 | 0.00 | 0.00 | 0.00 | 0.00 | 44.97 |
| | 13.47 | 6.70 | 12.51 | 50.23 | 34.39 | 12.45 | 22.57 | 38.00 | 190.33 |
| **2025** | 11.85 | 5.57 | 6.97 | 11.96 | 32.26 | 11.66 | 21.19 | 35.64 | 137.10 |
| | 0.84 | 1.05 | 5.33 | 37.85 | 0.00 | 0.00 | 0.00 | 0.00 | 45.07 |
| | 12.69 | 6.63 | 12.30 | 49.81 | 32.26 | 11.66 | 21.19 | 35.64 | 182.17 |
| **2026** | 12.42 | 5.64 | 7.14 | 12.34 | 33.80 | 12.23 | 22.19 | 37.34 | 143.11 |
| | 0.84 | 1.05 | 5.34 | 37.94 | 0.00 | 0.00 | 0.00 | 0.00 | 45.18 |
| | 13.26 | 6.70 | 12.48 | 50.28 | 33.80 | 12.23 | 22.19 | 37.34 | 188.29 |
| **2027** | 12.97 | 5.71 | 7.31 | 12.73 | 35.28 | 12.78 | 23.16 | 39.00 | 148.95 |
| | 0.85 | 1.06 | 5.36 | 38.07 | 0.00 | 0.00 | 0.00 | 0.00 | 45.34 |
| | 13.82 | 6.77 | 12.67 | 50.80 | 35.28 | 12.78 | 23.16 | 39.00 | 194.28 |

**Section:** South star hotel - St. Gebriel church
**Alternative:** with project

Sect ID: SSHSGC Road Class: Primary or Trunk
Length: 0.60 km Width: 7.00 m Rise+Fall: 1.00 m/km Curvature: 3.00 deg/km

| | 4WD | Damas | Dolphin or Mini bus | Heavy Bus | Heavy Truck | ISUZU | Medium Truck | Truck and Trailor | Total |
|---|---|---|---|---|---|---|---|---|---|
| **2021** | 12.35 | 5.61 | 7.10 | 12.27 | 33.63 | 12.17 | 22.08 | 37.15 | 142.38 |
| | 0.84 | 1.05 | 5.31 | 37.70 | 0.00 | 0.00 | 0.00 | 0.00 | 44.89 |
| | 13.19 | 6.66 | 12.41 | 49.97 | 33.63 | 12.17 | 22.08 | 37.15 | 187.27 |
| **2022** | 13.14 | 5.71 | 7.34 | 12.82 | 35.79 | 12.97 | 23.49 | 39.59 | 150.85 |
| | 0.84 | 1.05 | 5.32 | 37.78 | 0.00 | 0.00 | 0.00 | 0.00 | 44.99 |
| | 13.98 | 6.76 | 12.66 | 50.60 | 35.79 | 12.97 | 23.49 | 39.59 | 195.84 |
| **2023** | 13.16 | 5.71 | 7.35 | 12.84 | 35.82 | 12.98 | 23.51 | 39.61 | 150.98 |
| | 0.84 | 1.05 | 5.33 | 37.86 | 0.00 | 0.00 | 0.00 | 0.00 | 45.09 |
| | 14.00 | 6.77 | 12.68 | 50.70 | 35.82 | 12.98 | 23.51 | 39.61 | 196.07 |
| **2024** | 13.17 | 5.72 | 7.36 | 12.85 | 35.85 | 12.99 | 23.53 | 39.64 | 151.12 |
| | 0.84 | 1.05 | 5.34 | 37.95 | 0.00 | 0.00 | 0.00 | 0.00 | 45.19 |
| | 14.02 | 6.78 | 12.70 | 50.81 | 35.85 | 12.99 | 23.53 | 39.64 | 196.31 |
| **2025** | 11.85 | 5.59 | 6.98 | 11.97 | 32.25 | 11.66 | 21.18 | 35.60 | 137.09 |
| | 0.85 | 1.06 | 5.36 | 38.04 | 0.00 | 0.00 | 0.00 | 0.00 | 45.30 |
| | 12.70 | 6.65 | 12.34 | 50.02 | 32.25 | 11.66 | 21.18 | 35.60 | 182.39 |
| **2026** | 12.33 | 5.65 | 7.12 | 12.29 | 33.52 | 12.14 | 22.01 | 37.00 | 142.07 |
| | 0.85 | 1.06 | 5.37 | 38.14 | 0.00 | 0.00 | 0.00 | 0.00 | 45.42 |
| | 13.18 | 6.71 | 12.49 | 50.44 | 33.52 | 12.14 | 22.01 | 37.00 | 187.49 |
| **2027** | 12.78 | 5.71 | 7.27 | 12.62 | 34.73 | 12.58 | 22.80 | 38.36 | 146.85 |
| | 0.85 | 1.06 | 5.39 | 38.31 | 0.00 | 0.00 | 0.00 | 0.00 | 45.62 |
| | 13.63 | 6.78 | 12.66 | 50.93 | 34.73 | 12.58 | 22.80 | 38.36 | 192.47 |

**Appendix B-8 AADT computations for each routes**

| For Route of old bus station to new bus station | | | | | | | |
|---|---|---|---|---|---|---|---|
| Types of vehicles | Week days | | | | | | |
| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
| Small bus | 3676 | 2486 | 3902 | 3176 | 3065 | 4298 | 1096 |
| Medium bus | 1475 | 1003 | 1886 | 2033 | 1332 | 1984 | 687 |
| Large buses | 643 | 446 | 881 | 732 | 356 | 956 | 503 |
| Medium truck | 381 | 347 | 498 | 354 | 305 | 502 | 203 |
| Heavy truck | 204 | 184 | 342 | 254 | 159 | 365 | 135 |
| Truck and Traior | 148 | 101 | 187 | 143 | 98 | 201 | 87 |
| Sum | 6527 | 4567 | 7696 | 6692 | 5315 | 8306 | 2711 |

| For Route of old bus station to Mobile gas station | | | | | | | |
|---|---|---|---|---|---|---|---|
| Types of vehicles | Week days | | | | | | |
| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
| Small bus | 3101 | 2387 | 3564 | 2976 | 2108 | 3762 | 965 |
| Medium bus | 1245 | 934 | 1863 | 1132 | 847 | 2009 | 576 |
| Large buses | 439 | 398 | 754 | 438 | 301 | 834 | 203 |
| Medium truck | 309 | 289 | 538 | 308 | 276 | 598 | 137 |
| Heavy truck | 187 | 140 | 289 | 183 | 167 | 339 | 103 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Truck and Traior | 105 | 91 | 184 | 102 | 86 | 196 | 67 |
| **Sum** | **5386** | **4239** | **7192** | **5139** | **3785** | **7738** | **2051** |

| **For route of old bus station to Piazza Adare Hospital** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Types of vehicles | Week days | | | | | | |
| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
| Small bus | 3882 | 3079 | 4291 | 3765 | 2876 | 4486 | 1870 |
| Medium bus | 1450 | 1243 | 1983 | 1308 | 1187 | 2190 | 1002 |
| Large buses | 398 | 335 | 590 | 367 | 301 | 654 | 230 |
| Medium truck | 279 | 258 | 335 | 256 | 198 | 354 | 101 |
| Heavy truck | 165 | 143 | 199 | 151 | 103 | 203 | 96 |
| Truck and Traior | 104 | 93 | 134 | 96 | 75 | 142 | 64 |
| **Sum** | **6278** | **5151** | **7532** | **5943** | **4740** | **8029** | **3363** |

| **For route of old bus station to Referral Hospital** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Types of vehicles | Week days | | | | | | |
| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
| Small bus | 2764 | 2338 | 3476 | 2643 | 2193 | 3587 | 1239 |
| Medium bus | 1386 | 1173 | 1892 | 1283 | 1076 | 1982 | 982 |
| Large buses | 392 | 376 | 479 | 376 | 345 | 502 | 202 |
| Medium truck | 253 | 235 | 354 | 241 | 230 | 387 | 197 |
| Heavy | 134 | 132 | 187 | 131 | 94 | 198 | 69 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| truck | | | | | | | |
| Truck and Traior | 104 | 91 | 165 | 101 | 93 | 182 | 59 |
| Sum | 5033 | 4345 | 6553 | 4775 | 4031 | 6838 | 2748 |

**Appendix B-9 HDM-4 input put of road network features characteristics**

| | Description | Length (KM) | Speed flow type | Surface Type | Traffic flow pattern |
|---|---|---|---|---|---|
| 1 | Old bus station – wanza round about | 0.5 | Four lane | AC | Commuter |
| 2 | Wanza – W/amanuel | 1.7 | Four lane | AC | Commuter |
| 3 | W/amanuel—New bus station | 1.9 | Four lane | AC | Commuter |

| | Description | Length (KM) | Speed flow type | Surface Type | Traffic flow pattern |
|---|---|---|---|---|---|
| 1 | Tigest Hotel- Mesqel Adebabay | 0.8 | Four lane | AC | Commuter |
| 2 | Mesqel Adbabay – St. Gebriel church | 0.6 | Four lane | AC | Commuter |
| 3 | St. Gebreil church-Piassa Adare Hospital | 0.7 | Four lane | AC | Commuter |

| | Description | Length (KM) | Speed flow type | Surface Type | Traffic flow pattern |
|---|---|---|---|---|---|
| 1 | Millinium haul – Trufat intersection | 1.1 | Four lane road | AC | Commuter |
| 2 | Trufat intersection – meshen mekaber | 0.5 | Four lane | AC | Commuter |
| 3 | Meshen Mekaber- TTC | 0.7 | Four lane | AC | Commuter |

| | | | | | |
|---|---|---|---|---|---|
| | Warka | | | | |
| 4 | TTC warka – Circle intersction | 1.2 | Four lane | AC | Commuter |
| 5 | Circle intersection- Referral Hospital | 0.6 | Four lane | AC | Commuter |