ADDIS ABABA UNIVERSITY

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SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

ANALYZING PUBLIC TRANSPORTATION OPERATIONS AND MANAGEMENT IN THE CITY OF ADDIS ABABA

(A CASE STUDY ON ANBESSA CITY BUS SERVICE ENTERPRISE)

A Thesis in Road and Transport Engineering

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A Thesis

Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science

The undersigned have examined the thesis entitled '**Analyzing Public Transportation Operations and Management in the City of Addis Ababa (A Case Study on Anbessa City Bus Service Enterprise)**' presented by **Barentu Dawit**, a candidate for the degree of **Master of Science** and hereby certify that it is worthy of acceptance.

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Chair person	Signature	Date

UNDERTAKING

I certify that research work titled “Analyzing Public Transportation Operations and Management in the City of Addis Ababa (A Case Study on Anbessa City Bus Service Enterprise)” is my own work. The work has not been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged / referred.

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Barentu Dawit

ABSTRACT

Public transportation serves as veins to accelerate development in industry, trade, education, health and other services. However, the presence of inefficient operations and management system of public transportation service in most developing countries made passengers to face great inconveniences, as well as additional costs to the daily trips due to substantial delays and variability of travel time. Analyzing public transportation operations and management is paramount for making improvement decisions and evaluate implemented mitigation measures. Performance indicators such as operational, managerial and service quality indicators are important tools used to evaluate public transportation service given by the service provider organization. This research was conducted to evaluate the operational, managerial, and service quality performance using performance indicators of the existing public transportation in the City of Addis Ababa by taking a specific case study on Anbessa City Bus Service Enterprise. To achieve the objective of the study, primary and secondary data was collected through interview, questionnaire, literature survey, and organizational records. The data collected was analyzed using statistical analysis tools based on the predefined indicators and set standards for developing countries. And also HDM-4 VOC of the RED model was used to calculate the vehicle operating costs (VOCs) of ACBSE buses. The result from the analysis showed that; the current operational, managerial and service quality performance is poor; which lacks efficiency, effectiveness, and productivity. Moreover, the customers, the majority of them, 71% were dissatisfied, while 24% and only 5% were averagely and well satisfied respectively by the overall service provision delivered by the Enterprise. Therefore it has recommended, reforming operational strategies, improving the management practices, improving the quality of service delivered, and most importantly modernizing the operation and management systems by integrating ITS and ICT technologies to better solve the deficiencies and facilitate the working condition.

(Key words: Public transportation, operations, management, service quality, performance indicators)

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ACRONYMS AND ABBREVATIONS

AACATA	Addis Ababa City Administration Transport Authority
ACBSE	Anbessa City Bus Service Enterprise
BRT	Bus Rapid Transit
ETB	Ethiopian Birr (currency)
E.C	Ethiopian Calendar
G.C	Gregorian Calendar
GIS	Geographical Information System
HDM	Highway Development and Management
HOV	Heavy Occupancy Vehicle
ICT	Information and Communication Technology
ITS	Intelligent Transportation System
KPBPD	Kilometer per Bus per Day
LED	Light-Emitting Diode
LRT	Light Rail Transit
MetEC	Metals and Engineering Corporation
PPBPD	Passenger per Bus per Day
PTC	Public Transport Corporation
RED	Roads Economic Decision
RPM	Rotations per Minute
TMC	Transport Management Center
TPMO	Transport Program Management Office
VMU	Vehicle Monitoring Unit
VOC	Vehicle Operating Cost

CHAPTER ONE: INTRODUCTION

1.1. Introduction

As stated by White (2002), public transportation is the name given to travel services provided locally that allow lots of people to travel together along set routes. White (2002) further defines 'public transportation' as all modes available to the public irrespective of ownership. The dominant mode of public transportation in developing countries in road-based transportation is the 'conventional' bus. It has wider social and environmental benefits. It is the only one affordable to the urban poor (Armstrong-Wright, 1987).

Addis Ababa, the capital city of Ethiopia serves as a transportation hub to the nation. Among the transportation system, urban public transportation can be mentioned as such. The modes of urban transportation system in the city are generally categorized as motorized and non-motorized transportation. The major modes of the motorized public transportation within the city comprise: LRT (Light Rail Transit), Anbessa bus, minibus taxis, Star Alliance bus, Sheger bus, Higer midi-bus, three wheel cars (Bajaj) and salon taxis. In addition, public service bus and cross-country buses are serving the city during peak hours of working days.

Public transportation serves as veins to accelerate development in industry, trade, education, health and other services in Ethiopia. However, there is no compatible urban transportation supply and effective management in the city of Addis Ababa to meet the increasing trip frequency and mobility needs of the people and goods which resulted in the seriousness of the issue (FDRE Minisry of transport, 2011). The transportation system does not currently meet the demand without substantial delays and variability of travel time (GFDRR, The World Bank Group, 2015). In addition, the system has poor quality regarding to comfort, convenience, and safety issues. Most of this is associated with artificial capacity constraints created by poor management and enforcement practices, rather than physical capacity constraints (GFDRR, The World Bank Group, 2015)

Public transportation operation and management refers to facility management and operation strategies that improve roadway system performance. TMC (Transport

Management Center) in the United States is the hub or nerve center of a transportation management system. It is where information about the transportation network (freeway system, traffic signal system, or transit vehicle network) is collected and processed, and fused with other operational and control data to produce information. (Booz Allen & Hamilton and U.S. Department of Transportation, 1999)

Transportation professional organizations and agencies increasingly recognize the importance of operational strategies for solving transport problems, particularly traffic congestion, and so devote increasing resources to operational programs. This reflects the needs of a maturing transportation system, with shifting emphasis from system construction and expansion to efficiently managing existing system resources. (Victoria Transport Policy Institute, 2010).

Effective traffic management is crucial for effective utilization of existing infrastructure. Yet prevailing traffic management practice in the city of Addis Ababa is very bad, hanging at a lower level. The system is influenced by the following factors:

- Increased on street parking;
- Illegal on street vending;
- Weak traffic regulation enforcement;
- Lack of ITS (intelligent transport systems) application;
- Absence of a well-established traffic management center;
- Absence of efficient mass transit system;
- Lack of one way roots; and
- Lack of traffic Management Process and the like.

The combined effect of all the factors listed above made the operation and management system worse which lead to inefficient public transportation. This is the very reason that motivated the writer to study on the subject.

There are several literatures in the subject area of public transportation. Most of the literatures address the concept and implication on how to fill the gap between demand and supply of the public transportation system. This study tries to address the operation and management glitches on the public transportation system using performance indicators and propose a better practical solution for the existing and future generation.

The study mainly focuses on the operations and management of road based public transportation system, by taking a particular case of the Anbessa City Bus Service Enterprise (ACBSE).

1.2. Problem statement

Even though the public transportation system in Addis Ababa encompass different modes of transportation, there is a major problem of substantial delay, poor mobility, high congestion, longer travel time, longer waiting time, inconvenience, poor traffic safety, low comfort, high cost and the like. Most of the problem arise from the poor operation and management practices in addition to the existence of a big gap between demand and supply.

Poor operation and management practices are caused as a result of poor planning and execution of operational strategies and proper traffic management processes in addition to weak traffic regulation enforcement, poor road usage practices, lack of ITS (intelligent transportation systems) application, absence of traffic management center, and the like. Since effective transportation operation and management is crucial for convenient and robust public transportation, it is mandatory to enhance the city's public transportation system by integrating ITS, and ICT technologies, in addition to creating a productive operational strategies and creating a well-established traffic management center.

1.3. Objectives

1.3.1. General Objective

The general objective of the study is to analyze operational and managerial performance of the public transportation sector in the city of Addis Ababa focusing on the ACBSE and propose efficient and practical solutions and recommendations.

1.3.2. Specific objectives

The specific objectives of the study are to:

- study and explore the existing public transportation system in the city of Addis Ababa, the strategy, plan, implementation, future goal and it's limitation;
- defining operational, managerial, and service quality performance indicators

- asses the performance of the operational, managerial and quality of service delivery of the ACBSE organization; and
- propose efficient and practical solutions and recommendations

1.4. Research questions

- What does the existing public transportation system in the city of Addis Ababa look like?
- What are the strategies, plans and implementation to meet the public transportation policy in Addis Ababa?
- What are the major causes of the existing public transportation problems in Addis Ababa?
- How can the performance of the public transportation in Addis Ababa be measured?
- What parameters can be used in measuring the performance of the operation and management of the public transportation system in Addis Ababa and which parameters can be used to measure the performance of ACBSE?

1.5. Relevance of the study

The research is relevant in the following aspects:

- The product of the study assess the operational, managerial and service quality performance of the ACBSE public transportation service provider. Henceforth, the outcome will give a comprehensive overview of the strength and deficiencies of the service provided, so as it gives an insight for the enterprise.
- The end results would also help AACATA under the City administration, as the owners of the ACBSE, they will get insight into the operational, managerial and service quality characteristics of the service.
- It gives an opportunity for further research by individuals and organizations on the study subject.

1.6. The scope of the study

The study covers overview of the operation and management practices of the public transportation in the city of Addis Ababa focusing on the ACBSE. A framework of certain defined operational, managerial and quality of service indicators will be utilized in the study to evaluate the performances of ACBSE.

1.7. Research design

To have the general overview of what the research process is going to be, the research design is summarized in the figure below:

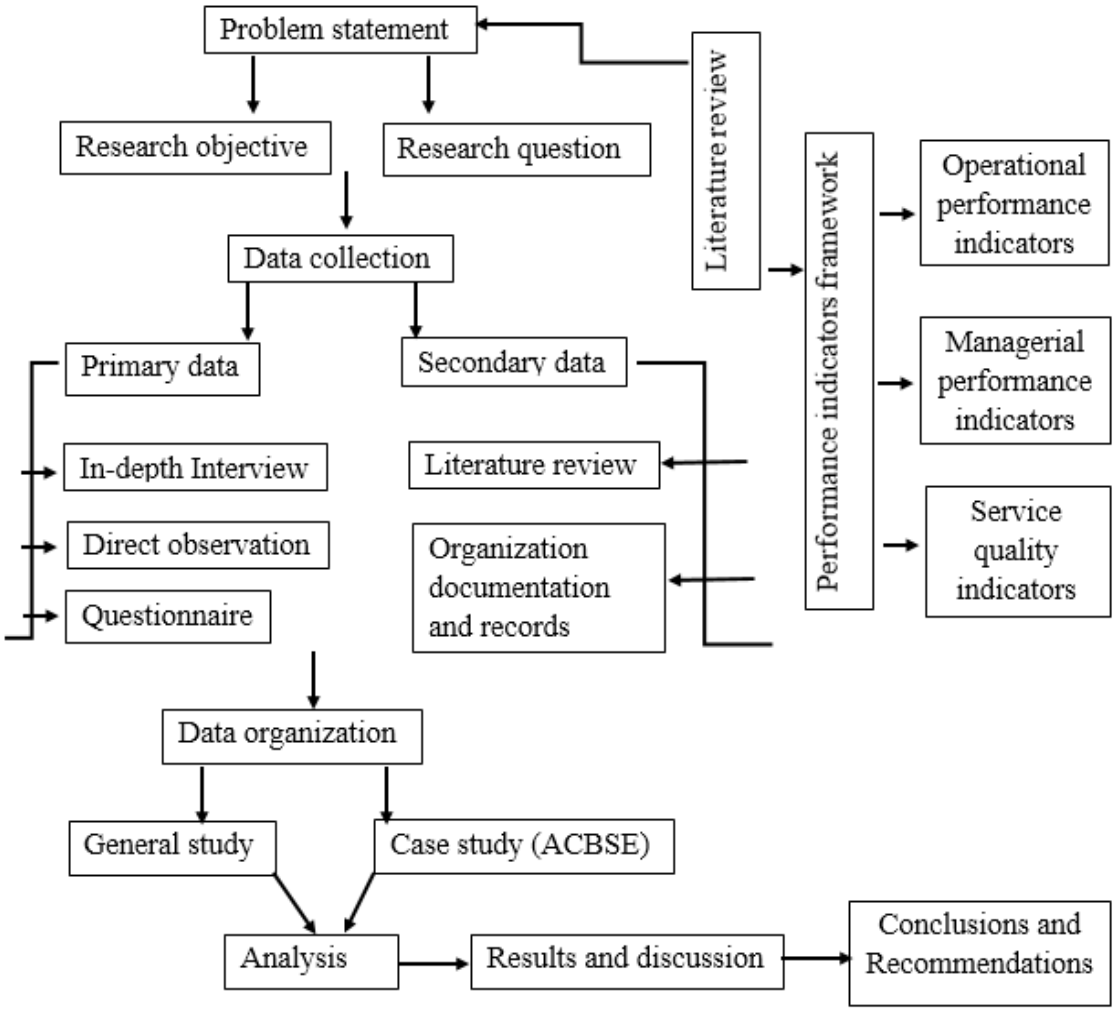


Figure 1-1 Research design

1.8. Limitation of the study

The study is limited to evaluation of the operational, managerial, and service quality performances of the ACBSE among other transportation service providers in the city of Addis Ababa.

There was a problem encountered on the data collection. Some of the data collected from ACBSE organizational records showed discrepancies and also there was unavailability of detailed set goals and policies of the management system in the different management departments. Furthermore, some of the data collection though interview encountered a problem of addressing the main targets as a result of the authorities (the main targets) usually push the interview to the lower level employees.

1.9. Thesis structure

This research paper is organized in six chapters as described below. Chapter One briefly introduces the background for the research, identifies the research problem, defines the research objectives and research questions and shows the general overview how the research aims to achieve the objective. Chapter Two reviews some important literatures regarding the topic at hand, and also identifies and defines operational, managerial and service quality indicators used for measuring the performance of public transportation based on literature survey. Chapter Three presents the material and methodology used. Chapter Four encompasses a case study which briefly describes the cases of ACBSE brief background, operational and service characteristics; management, and financial systems; and the progress in modernizing ACBSE transportation service. Chapter Five discusses the research findings and analyzes the outputs of the case study on the basis of the previously defined and identified indicators. Finally, Chapter Six presents conclusions based on the results and analysis and forward pertinent recommendations for possible use by public transportation operators in Addis Ababa particularly by ACBSE and by policy makers.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

Mostly, public transportation is applicable in urban areas since there is a high demand for mobility. As stated by (ORAAMP, 2010), "It is commonly accepted that cities are the engines of growth in most developing as well as developed countries. More importantly, urban transport can be viewed as the oil that prevents this engine from seizing up."

Economically, transportation is an essential element of city development that, in turn, is a major source of national economic growth. Simply stated, poor transportation inhibits growth. Furthermore, socially, transportation is the means of accessibility to jobs, health education and social services which are essential to the welfare of the city residents. Deteriorating transportation conditions affect all city residents impacting particularly the poor through a decline in public transportation service levels, increased length of journey to work and other essential services and negative impacts on environment, safety and security that the poor are least able to mitigate (World Bank, 2001).

Even though, public transportation plays a big role in maximizing the rate of mobility of an urban population, it also has its own problems if not properly managed and implemented which are being observed in most cities nowadays. These include: congestion, high traffic accident, environmental degradation, low mobility, disruption of urban fabric and the like.

2.2. Public transportation operation and management

Transportation professional organizations and agencies in developed countries increasingly recognize the importance of operational strategies for solving transportation problems, particularly traffic congestion, and so devote increasing resources to operations programs. This reflects the needs of a maturing transportation system, with shifting emphasis from system construction and expansion to efficiently managing existing system resources (Victoria Transport Policy Institute, 2010).

2.2.1. Operational Criteria for Public Transportation

Most transportation operations programs' primary objectives are: reduced congestion, delay and increased traffic capacity. According to some estimates, half of traffic delays result from crashes and breakdowns, weather, construction and special events, which operations programs are designed to address. In a typical city, 10-50% of congestion delays can be avoided with better planning and incident response. Such programs tend to be more cost effective than building additional roadway capacity (Victoria Transport Policy Institute, 2010). By improving interagency planning and coordination, they can increase the efficiency with which public services are provided. For example, by improving real time information available to emergency and roadway departments they can improve the speed and effectiveness with which public agencies can respond to incidents and special events. (Victoria Transport Policy Institute, 2010)

There are different operational criteria followed by different public transportation organization. However, the most common quantifiable criteria in order to determine optimal allocation of resources within the public transportation operation are stated in the Report of the International Collaborative Study (The Demand for Public Transport, 1980) as follows:

- profit maximization;
- use of standards, covering e.g. access to the public transportation network, or frequency of service;
- maximization subject to constraints;
- turnover maximization with a budget constraint;
- maximization of the benefits to public transportation travelers, within a budget constraint. Technically, this corresponds to maximizing 'consumer surplus' i.e. the difference between the amount the traveler is prepared to spend in time and money (and effort) and the amount he/she actually has to spend in order to travel;
- 'Social surplus' maximization within a budget constraint (i.e. maximizing the benefits to society); and
- demand or output maximization, e.g. the maximization of passenger-kms or journeys or vehicle-kms (or journeys) within a budget constraint.

2.2.2. Traffic Management in Public Transportation

According to the Victoria Transport Policy Institute (The Encyclopedia, 2010), transportation management refers to facility management strategies that improve roadway system performance which include:

- Development of regional traffic management centers, which provide real-time information to roadway system operators and users, coordination of traffic incident response, and other management support.
- Improved communications among government agencies, media and roadway users, often involving Intelligent Transportation Systems.
- Traffic signal synchronization, which means that control signals are coordinated to increase traffic volumes.
- Traffic lane management and Road Space Reallocation (such as reversible traffic lanes, and use of parking lanes during peak periods).
- Improved incident prevention and response, so crashes, breakdowns and other events cause less traffic delay.
- Special event and emergency transportation management.
- Improved alternative modes, particularly HOV (heavy occupancy vehicle) and Transit.
- Improved weather information and response to weather events (snow, ice, fog, rain).
- Improved regional transportation Planning and Land Use Management.
- Transportation Demand Management Programs, particularly incentives that encourage travelers to shift from automobile to alternative modes, particularly during congested periods.
- Contingency-Based Planning, which means that specific responses are identified to address possible future conditions, which are deployed as needed.

The aim of a public transportation fleet management, well known as automated vehicle management (AVM) for public transportation fleets, or automated vehicle localization (AVL), for simpler implementation, is to enable the efficient management of bus services by the transportation company organization involved in operations, based on the following main units:

- Planning;
- Operations, monitoring and control; and
- Maintenance service

2.2.3. Transportation Management Center (TMC)

The transportation management center is the hub or nerve center of a transportation management system. It is where information about the transportation network (freeway system, traffic signal system, or transit vehicle network) is collected and processed, and fused with other operational and control data to produce information. The information is then used by system operators to monitor the operations of the transportation system and to initiate control strategies to effect changes in operation. It is also where agencies can coordinate their responses to transportation situations and conditions. Furthermore, the TMC is the focal point for communicating transportation related information to the media and the motoring public (Booz·Allen & Hamilton and U.S. Department of Transportation, 1999).

According to the U.S. Department of Transportation (1999), there are three types of transportation management centers in U.S, namely:

i. Transit Management Centers: are typically tasked with tracking and supporting fleets of transit buses or railcars. It can be particularly critical in mixed fleets, where coordination of the bus/rail interface is essential to client satisfaction and to cost-effective operation of the transit network

ii. Traffic Signal System Centers: typically focus on the monitoring and control of traffic signal networks on urban surface street networks. The functions performed in such a network include monitoring of functional status of all equipment in the signal network, and dispatch of resources to return malfunctioning equipment to operational status, and

iii. Freeway Management Centers: is typically responsible for the monitoring and control of traffic on an interstate highway or comparable limited access roadway. Focusing its efforts on detection, verification, and active management of incidents which reduce roadway capacity.

2.3. Components of Public Transportation management

Public transportation management constitute different management system. Some of the major public transportation management systems are discussed in the subsequent sections below.

2.3.1. Travel demand management activities

Transportation demand management also called travel demand management, is the application of strategies and policies to reduce travel demand, or to redistribute this demand in space or in time. If traffic demand is not managed, the performance of the transportation system will be adversely affected. Managing traffic demand today is about providing travelers, regardless of whether they drive alone, with travel choices, such as work location, route, time, and mode (Nelson, 2000).

Travel demand management pursue to achieve objective of mobility by improving the efficiency of the network and influencing travel, particularly where, when, how and even if travel is needed at all. It aims to give people more choice by improving and informing them of their travel options while at the same time influencing and guiding travel decisions to achieve better outcomes for society.

Managing travel demand is a cost-effective alternative that provides huge benefit to transportation system, as summarized in the table below.

Table 2-1: Transportation demand management benefits

Benefits	Definition
Congestion reduction	Reduced traffic congestion to motorized, bus users, pedestrians and cyclists
Road cost savings	Reduced costs to build, maintain and operate roadway systems
Parking savings	Reduced parking problems and parking facility costs
Consumer savings	Transportation cost savings to consumers
Improved mobility	Improved mobility options, particularly for non-drivers
Road safety	Reduced per capital traffic crash risk
Energy conservation	Reduced per capita energy consumption
Emission reductions	Reduced per capita pollution emissions
Efficient land use	More accessible community design, reduced per capita land consumption
Public fitness and health	Increased physical activity and associated health benefits

2.3.2. Fleet management and scheduling

Fleet management is the optimization of costs, risks and efficiency in fleet operations. Effective fleet management aims at reducing and minimizing overall costs through maximum, cost effective utilization of resources such as vehicles, fuel, spare parts, etc.

Fleet managers touch many aspects of fleet operations, but the basic fleet management activities can be summarized into five main fields according to Spireon (Spireon, Inc, 2017):

1. Operational cost-effectiveness

- Fuel management

Fleet managers must be able to eliminate any possibility for drivers to abuse company fuel spend. Some fleet management solutions integrate a company's fleet fuel purchases and match it with real-time vehicle locations so fleet managers can verify fuel usage.

- Theft & loss

GPS tracking drastically reduces the number of stolen vehicles.

2. Vehicle maintenance

When it comes to maintaining of vehicles, fleet management software enables to set up custom maintenance alerts for regular tire or engine checkups. And since most GPS devices are powered by the vehicle engines, they'll also be able to detect when vehicle engines have low battery. Rather than relying on employees who may or may not report any vehicle issues, it is possible to proactively take care of the vehicles before they unexpectedly break down and avoid costly down-time as a result.

3. Driver/Workforce management

- Vehicle idling

Fleet managers can reprimand drivers for idling, but have not been able to pinpoint when exactly drivers leave engines on unnecessarily. Fleet management software solves this dilemma by detecting when vehicles are running but stationary. With this software, fleet

managers can draw up reports to see which vehicles are idling the most so they can coach drivers to prevent their vehicle idling behaviors.

- Unsafe Driver Behavior

Unsafe driving behaviors (such as speeding, hard braking or going off-route) increase a fleet's insurance premium, waste gas and quickly wear out vehicles. Fleet management software alerts when drivers are engaging in these types of behaviors. Fleet managers who notify their drivers that their driving behaviors are being tracked by GPS technology will also discourage risky driving.

4. Vehicle safety

- Decrease accidents and improve fleet safety

Large or small fleets can get hit with large vehicle damage or worker injury costs. Reducing distracted driving with a solid GPS system that provides safe road routing, maintaining vehicles properly, and providing driver coaching are keys to improving fleet safety.

5. Operational efficiency

Perhaps one of the most important duties, operational efficiency involves moving products or services as quickly as possible to market vendors or customers. GPS vehicle tracking definitely helps when it comes to full vehicle and asset utilization.

2.3.3. Information and communication management

Flow of Information and communication should be well managed for effective and efficient interaction between passengers and public transportation service providers. In recent times, transit agencies are developing new technologies to provide customers with information about transit service. Communications between transit vehicle operators and their central control and between transit vehicle operators and their passengers should be well managed as well.

Information system for passengers may consist of the vehicle information system and information tables at the stops. The vehicle information system consists of the markings the line and the basic route of line, when the electronic panels and acoustic sounds are

used it is possible to give more information to passengers such as the current time, next stop, special character of the stop, tariff zone, emergency situation, and the inspector control (Gnap et al., 2014).

Two-way radios and automatic vehicle location equipment allow transit agencies to know where vehicles are and operate them in an efficient manner and provide real time information to passengers waiting for vehicles at stops and stations. Public address systems, automated stop announcements, passenger-operator intercoms and closed circuit cameras keep passengers informed and increase the safety and security of their transit trip (Gnap et al., 2014).

2.3.4. Maintenance management

Transit agencies should have a plan for the safe and proper management of maintenance resources; including parts, equipment, facilities, fleet, and personnel (Public Transportation Division, 2003). Maintenance management is a better control of the maintenance organization and the related area. To properly control the maintenance of a facility, information is required to analyze what is occurring.

According to Keshara (2008) the basic function of a maintenance management can be:

- preventive maintenance;
- plant and unit record (equipment);
- inventor and spare parts control system, purchasing system;
- document record;
- planning system for maintenance and work order routines; and
- technical/economic analysis of plant history, maintenance and machine availability

2.3.5. Parking management

Parking management includes a variety of strategies that encourage more efficient use of existing parking facilities, improve the quality of service provided to parking facility users and improve parking facility design. Parking management can help address a wide range of transportation problems, and help achieve a variety of transportation, land use

development, economic, environmental objectives (Victoria Transport Policy Institute, 2017).

Manual parking management which is daily and time-consuming concern for most motorists, searching for a vacant parking space, is now being changed with technology based options using GIS and ITS systems. Some of the most important innovative technological parking management system are reported by (Muthanu, 2013) these are:

- Smart parking management systems;
- Intelligent Transportation management systems;
- Geographic Information Systems based parking management systems;

These management systems are significant for Addis Ababa city transportation operations in general and for effective operations of ACBSE in particular.

2.3.6. Financial management

Financial management refers to the efficient and effective management of money (funds) in such a manner as to accomplish the objectives of the organization. It is the specialized function directly associated with the top management. The significance of this function is not seen in the 'Line' but also in the capacity of 'Staff' in overall of a company.

LSC Transportation Consultants (2014) reported that, there are six fundamentals to a good financial system, which are:

- **Financial Reports** that completely disclose all allowable and unallowable expenses.
- **Accounting Records** that can easily track day-to-day expenses and revenue.
- **Internal Control** that ensures assets are used for authorized purposes only.
- **Budget Control** that ensures expenses are in line with the original budget and budgets are tied to agency performance measures.
- Agencies only submit reimbursements for **Allowable Costs** as defined by the federal government.
- Agencies support accounting records with **Source Documentation**, such as cancelled checks, paid invoices, and timesheets.

Agencies need effective financial management trend in order to meet their goals and objectives alongside preparing complete and accurate financial data to report to funding sources how money was spent, what revenues were taken in, and the financial status of the organization.

2.4. General overview of public transportation in Addis Ababa

2.4.1. Existing urban public transportation

Urban transportation in Addis Ababa is carried out by a mixture of public and private ownership. The modes of urban transportation system in Addis Ababa are categorized into motorized and non- motorized traffic. As such, the modes of transport include: LRT (recently came into service); public bus; minibus; taxis and non-motorized transportation. Walking and animal carts dominate the periphery. Based on recent studies by Fenta, (2014), public transportation including Anbessa buses, Sheger buses, Higer mid-buses, Alliance buses, Minibus taxis, and Salon taxis all together provide transportation service for about 48 percent of the passengers while private transportation cover only 9 percent while walking is estimated at 43 percent.

In the city of Addis Ababa, the dominant public bus transportation service providers are ACBSE which is owned by the government and which taxis are owned by the private sector. ACBSE has been operating since 1943 and is mandated to provide public transportation services to the city and the surrounding areas. ACBSE currently serves 124 routes that connect different parts of the city using 460 operational buses. The number of passengers shows high variability during each periods of time that requires fluctuation of number of assigned buses in each route (Eshetie Berhan, 2014). However, the enterprise uses a fixed number of buses scheduled per route in its operation throughout the day. This resulted in, the fact that, some buses move empty while others are overcrowded, which subsequently result in poor performance on bus utilization, distance travelled, number of trips and service quality. A brief background of ACBSE; its route characteristics, operational and managerial performances will be covered in the case study section, chapter five.

In addition to ACBSE fleet, Addis Ababa is served by more than 10,000 minibus taxis that provide services to the community. The minibus taxis operate in five zones on 364

routes and carry more than 1.5 million passengers per day. However, there is clear evidence that the operators break these routes down into smaller sections, particularly at peak times in order to exploit the authorized fare structures and maximize their income by charging extra.

Public transportation service in the city is highly dependent on taxis as a mode despite high fares (taxis are an expensive means of transportation compared to buses), which are not affordable, particularly for the low-income group. This is because, the availability and the travel time the minibus taxis take is minimum compared to the different modes of transportation service providers available in the city.

The minibus taxi transportation system provides employment opportunities to a large number of people estimated at 50,000 (Fenta, 2014). Until recent years, minibus taxis were not regulated regarding routes or areas in which they operated; which is a demand-driven public transportation system that operated without routes maps, timetables or central coordination. Currently however, they are operating along fixed routes categorize and scheduled under different taxi associations which were established recently.

A transportation service provision system for the Federal and Addis Ababa city civil servants was launched in 1998 by involving twenty buses assembled at the Bishoftu automotive and locomotive industry out of the planned 410 buses. The buses transport civil servants to and from work places and also provide for hire services for the general public during the rest of the day. Lack of transportation service is a critical problem in Addis Ababa. It is very common to see people queuing for transportation services for a long time on the main roads of Addis Ababa as they try to race against delays to reach their work places (Fenta, 2014).

The other mode of transportation is the newly launched light rail transit (LRT) which is the first to be built in Sub-Saharan Africa (UITP, 2014). It could be considered as a milestone in the nation's journey out of poverty. Of the two rail lines, the East-West line extends for 17.35 kilometres, stretching from Ayat Village to Torhailoch, traversing the major city centers of Megenagna, Leghar and Mexico Square. The North-South line, which is 16.9 kilometres in length, passes through Menelik Square, Mercato, Lideta, Legehar, Meskel Square, Gotera and Kaliti areas. The two lines have a common track of about 2.7 km between Meskel Square and Lideta area. The transportation services cost

from Birr 2 to Birr 6 per trip which is cheap and is a better mode for the low income passengers in the City (Tsegaye, 2015).

In addition to the above public transportation service providers, a new, Sheger Express bus system has been introduced to the city. With currently very high demand for public transportation, the launch of Sheger Express buses promises some relief. Beneficial features of the Sheger Express bus include ease of access for the elderly, physically challenged, pregnant women, and children, air conditioning and a GPS (YOHANNES, 2016). Passengers can expect a faster commute, with buses arriving at limited stops about every 10 minutes. In the coming few years, Sheger will also introduce two additional new services including the city's first school bus service and Bus Rapid Transit (BRT) system. The BRT will be a high quality public transportation system with an aim to provide faster, more comfortable and cost-effective service through a dedicated bus lane (Addis Fortune, 2016).

Despite the existence of different public transportation services, the city experiences a huge problem in providing efficient transportation services to the city commuters. This is mainly caused due to the lack of proper operational and managerial practices in addition to weak traffic regulation enforcement, lack of ITS (intelligent transportation systems) and ICT application, and absence of traffic management center.

Demand management activities, fleet management and scheduling, communication management, maintenance management, roadway capacity expansion management, and parking management are the crucial mobility entities for effective utilization of existing infrastructure.

2.5. Defining performance indicators of public transportation operation, management and service quality

2.5.1. Introduction

In most cities in developing countries, bus services are faced with very heavy demand, steep rises in both capital and operating costs, and a lack of resources. Thus there is a pressing need to ensure that whatever resources are available for transportation (bus) services are put to the most effective and efficient use possible. For this purpose, there is a need to evaluate the operational performance of bus services and the standard of service being provided to the public. This can be undertaken by the use of certain performance indicators (Armstrong-Wright, 1987).

Performance indicators or measures are navigation tools that can help public transportation authorities and city governments determine where they want to go and how to get there. They have many practical applications including trend analysis, comparisons, target setting, system improvement and incentives for managers and employees. The performance indicators help identify potential problems and optimal solutions (Chhavi, 2011).

According to Abbas (1992), performance indicators (measures) are powerful means of quantifiers that give information of an output of a company (Bus Company). The indicators meant to describe the financial, operational, and level of service development of the company at any point in its life time; which can be used as an input in decisions making. Performance goals should allow the organizations' management to determine how effectively and efficiently an organization has performed in attempting to meet its goals.

Performance evaluation by using predefined indicators is now increasingly being used by transit agencies all over the world and several new tools and information systems are being created that make it easy and more efficient to apply this technique. Chhavi (2011) stated the usefulness of these indicators in the following ways:

- Reporting performance of public transportation to the authorities and public which in many places is required by law or as per a directive of the government.

Usually in most places where it is undertaken, performance evaluation results are published and shared with stakeholders.

- Monitoring service improvements, assessing past interventions, attracting more riders and for increasing the appeal of public transportation.
- Diagnosing problems and the health of the system, making course corrections and refining strategy which means that performance evaluation helps practitioners identify areas in the system which are not functioning adequately and where service standards are not being met, and rectify those.
- Incentivizing quality improvements
- Responding to user feedback.
- Providing decision making bodies with accurate information to support the needed actions for investments, budgeting, etc.
- Providing the public with information on transit performance so they can choose it and use it.
- Setting service standards.
- Aiding internal communications and management, etc.

Performance measures/indicators in public transportation sector can be designed and defined at various levels and ways. Even though there are a number of performance indicators in evaluating public transportation system, some of them will be presented here below according to the context and scope of the study.

2.5.2. Operational performance indicators

Operational key performance indicators help an organization to monitor its operational health. The indicators evaluate the operating performance of the organization using appropriate key performance measures, such as: passenger volumes, fleet utilization, vehicle-kilometers, breakdowns in service, fuel consumption, staff ratios, accident rates, and dead mileage (Armstrong-Wright, 1987). Using data effectively to monitor performance is critical for organizations to continually improve their operational efficiency and fulfill their mission. These should be measured against a range of values usually expected from a reasonably well-run bus company (Armstrong-Wright, 1987). Any deficiencies identified should be examined in order to determine the causes.

2.5.2.1. Passenger Volumes (passengers per bus per day)

A significant indicator of productivity is the number of passengers carried in relation to the capacity of the system (Armstrong-Wright, 1987). This is an indicator of the level of passenger use of each vehicle in service. It is influenced not only by total passenger demand but also by vehicle capacity, length of operating day, length of route, average distance traveled per passenger, the extent to which demand varies between peak and off-peak periods, and the kilometers operated per bus per day.

As with other indicators, it is normally most appropriate to base this calculation on the number of buses licensed. On this basis, and assuming that approximately 85% of the fleet is operational, the normal range for buses with a capacity of 80-100 passengers on city services is between 600 and 1,800 Passengers per bus per day (PPBPD). For articulated buses with a capacity of between 150 and 200 passengers, a normal range would be between 1,500 and 2,500 PPBPD (The World Bank Group, 2006).

According to Armstrong-Wright (1987), a reasonably well-managed bus company should produce in the range as depicted in Table 3-1 below.

Table 2-2 Passengers per bus per day

Type of bus	Crush capacity	Passengers per bus per day (PPBPD)
Single-deck bus	80	1,000 -1,200
Single-deck bus	100	1,200 -1,500
Single or double-deck bus	120	1,500 -1,800
Articulated or double-deck bus	160	2,000 -2,400

(Source; Armstrong-Wright, 1987)

Calculation: Total number of passengers carried (for the operation as a whole, part of the operation such as all services operated by a particular depot, or a particular route) during a period, divided by total number of vehicles licensed (for the operation as a whole, part of the operation, or route) in that period, and then divided by the number of days in the period.

$$PPBPD = \frac{\text{total number of passangers}}{\text{total number of vehicles(bus)} * \text{number of days}}$$

2.5.2.2. Vehicle-kilometers (kilometers per bus per day)

Another indicator of the operational productivity of a bus fleet is the total distance traveled by buses in service. A vehicle should be used as intensively as possible, provided that passenger demand is sufficient to cover the direct costs of operation. A high kilometers per bus per day (kpbpd) figure indicates intensive use, but gives no indication of the viability of the kilometers operated, and therefore does not necessarily imply optimum usage of a vehicle in economic terms. Wasteful or unnecessary use, even though it increases utilization, should obviously be kept to a minimum.

Vehicles are not used every day, and therefore it is important to distinguish between kilometers operated by a bus in the course of a day's work, and average daily kilometers over a year; the latter is more easily calculated, and therefore is the figure which is most commonly used. If, for example, vehicles are available for only 85% of the time, the average daily kilometer figure, if calculated from the annual figure, must be divided by 0.85 to give the actual daily kilometers operated by each vehicle when it is used (The World Bank Group, 2006).

Vehicle-distance can be measured and verified from a number of sources, such as tachometer readings, route distances and trips, and fuel consumption. For a reasonably run bus service, the average kilometers per bus per day should be in the region of 210-to-260 (Armstrong-Wright, 1987). However, kilometers per vehicle are influenced by operating speeds, traffic and road conditions, proportion of idle to running time, and hours of operation each day.

Calculation: Total kilometers operated during a period, divided by total number of buses in operation in that period, and then divided by the number of days in the period.

$$KPBPD = \frac{\text{total kilometers operated}}{\text{total number of vehicles(bus)} * \text{number of days}}$$

2.5.2.3. Fleet utilization

The proportion of a bus fleet that can be put into service each day has a direct bearing on the productivity of the system. This indicator shows the extent to which vehicles are used, the effectiveness of bus maintenance, spares and procurement, and stock keeping as well as staff recruitment and management (Armstrong-Wright, 1987).

There are various measures of utilization; these include mileage or hours (kilometers per vehicle per period or operational hours/days per vehicle per period); analysis of days or hours of operation as a percentage of total available time; or the number of vehicles operated in a day as a percentage of the number available. (The World Bank Group, 2006)

The most useful indicator is the number of vehicles used on revenue-earning service at a particular time (usually peak periods) as a percentage of the number of buses which are available for service at that time (i.e. excluding those undergoing maintenance or repair or not available for other reasons). In most city operations, the morning peak is more concentrated than the evening peak, and therefore it is normally most useful to use this as the basis for calculation.

Utilization normally varies between different times of the day (i.e. between peak and off-peak periods), different days of the week, and different times of the year. According to the study by Armstrong-Wright (1987) with adequate maintenance and staff management, it should be possible to achieve fleet utilization of between 80-90 percent.

Calculation: Number of buses operated during the busiest peak period of the day, expressed as a percentage of the number of buses available for use; this figure should be calculated each weekday. The average for a period should be calculated by taking the average number of buses operated during each weekday morning peak, expressed as a percentage of the average number of buses available during the relevant peak on each weekday in the period.

$$Fleet\ utilization = \frac{\text{avg. number of buses operated during peak period for each week days}}{\text{avg. number of buses avialable on each week days}}\%$$

2.5.2.4. Breakdowns in service

This indicator is a measure of the mechanical reliability of a fleet. In other words, it is an indication of maintenance and driving standards which is the proportion of buses that break down in service and require either assistance from a mobile repair unit or attention at the depot. Overall, it will give an indication of the standard of maintenance as well as of general fleet condition. The older and less well maintained a fleet, the lower the number of kilometers per breakdown is likely to be (The World Bank Group, 2006).

The definition of a mechanical breakdown may vary. The most appropriate definition is any mechanical defect which causes or requires the vehicle to stop, and which makes it impossible or unsafe for it to continue with the journey. Achievable figures vary considerably, depending on factors such as maintenance standards, types of service, operating conditions, fleet age, and driving standards. A well-maintained fleet of buses operated on city services on good roads and with good driving standards should achieve over 20,000 kilometers per breakdown; at the other extreme, poorly maintained buses operating on services in conditions typical of a developing country may achieve as little as 2,500 kilometers per breakdown, or even less, although a typical urban fleet will achieve between 5,000 and 10,000 kilometers per breakdown (The World Bank Group, 2006). According to Armstrong-Wright (1987), a reasonably well maintained fleet would expect to have breakdowns at a rate of no more than 8-to-10 percent of buses in operation each day.

Calculation: total number of kilometers operated over a period (scheduled and unscheduled), divided by the number of breakdowns incurred in that period. Another alternative measure which is sometimes used is the number of breakdowns per day, expressed as a percentage of the number of buses in service. This is less specific since it does not reflect the level of activity, but has the advantage of being much easier to calculate, particularly where accurate kilometer figures are not available.

$$Breakdowns\ in\ service = \frac{\text{total number of kilometers operated}}{\text{the number of breakdown incured}}$$

Or

$$Breakdowns\ in\ service = \frac{\text{number of breakdowns per day}}{\text{number of buses in service}}\%$$

2.5.2.5. Fuel consumption

Fuel consumption will depend on size and load of vehicles, engine type, and the gradients and traffic conditions encountered on route (Armstrong-Wright, 1987). Maintenance and driving standards will have a considerable influence as well. Measured in terms of liters per 100 vehicle kilometers, fuel consumption of a well-run system should fall within the following limits as depicted in Table 3-2 below:

Table 2-3 Fuel consumption

Type	Fuel consumption (liters/kilometers)
Minibuses	20-to-25 liters per 100 kilometers
Regular buses	25-to-50 liters per 100 kilometers

(Source; Armstrong-Wright, 1987)

Calculation: fuel consumed by the vehicle to the ratio of 100 kilometers of distance traveled.

$$Fuel\ consumption = \frac{\text{fuel consumed}}{100\text{km}}$$

2.5.2.6. Staff ratios

According to Armstrong-Wright (1987) the size of the staff employed to put buses into regular service provides a clear indication of the efficiency of bus services. The ranges in Table 3-3 below should be expected:

Table 2-4 staff ratios

	Range
Total staff employed per operating bus	3 - 8
Administrative staff employed per operating bus	0.3 - 0.4
Maintenance staff	0.5 - 1.5

(Source; Armstrong-Wright, 1987)

Calculation: counting the size of the staff employed (maintenance, administrative and other staff members separately) and dividing by the total number of operating bus.

2.5.2.7. Accidents

The level of accidents will provide some indication of the standard of driving and maintenance, but will be greatly influenced by traffic conditions, in particular the volume of pedestrians. According to Armstrong-Wright (1987), in a well-run bus company operating under moderate conditions, accidents per 100,000 bus-kilometers are likely to be in the region of 1.5 to 3.

Calculation: dividing the number of accidents occurred by the operating buses to 100,000 kilometers traveled.

2.5.2.8. Dead mileage (Dead heading)

Dead mileage (also called Dead Heading) is the idle distance covered by the vehicle between the garage and the route terminal stops without carrying any passengers (EFENDİ NASİBOV & UĞUR ELİİYİ, 2013). A bus has to cover the distance from its depot to the starting point of its route before being undertaken on a regular service (Cheikh B. Djiba, 2012). In other words, journeys that are made when buses are not in service and passengers are not being carried is a dead mileage. This usually depends on the location of overnight parking and maintenance depots in relation to the start and finish points of the bus services (Armstrong-Wright, 1987).

Dead mileage incurs costs for the operator in terms of non-revenue earning fuel use, wages, and a reduction in the utilization of the driver's legal hours of driving. Therefore Dead Mileage should be kept minimum as much as possible. Dead mileage could be reduced by the operation of routes specifically timed and routed to facilitate bus movements rather than passenger need. According to Armstrong-Wright (1987), Dead Mileage for a reasonably efficient system would be in the region of 0.6 to 1.0 percent of total vehicle mileage.

Calculation: dividing the dead mileage to the total vehicle mileage and multiply it by 100%.

$$\text{Dead mileage(DM)\%} = \frac{\text{Dead mileage}}{\text{Vehicle mileage}} * 100$$

2.5.2.9. Cost of vehicle (bus) services

The costs of bus services are mainly dependent on local labor and fuel costs, but are greatly influenced by the efficiency of operation and management and by traffic and road conditions. The total cost of bus services constitute operating costs, depreciation, and interest. Vehicle operating cost (VOC) which is a representative of the above three will be discussed below.

Vehicle operating cost (VOC)

VOC by definition are the costs associated with operating a motor vehicle. VOC are made up of fuel, oil, tyre, repairs and maintenance and interest and depreciation costs (Queensland Department of Transport and Main Roads and SKM Consulting, 2011). Vehicle costs can be measured in various ways, including per vehicle-mile, passenger-mile, vehicle-year, household-year, which produce different results (Victoria Transport Policy Institute, 2017).

The Victoria Transport Policy Institute (2017) divided VOC into fixed (also called ownership or time-based, which are unaffected by the amount a vehicle is driven) and variable (also called operating, marginal or incremental, which increase with vehicle mileage). Some costs that are often categorized as fixed, such as depreciation and insurance, actually increase with vehicle mileage. Private cars are usually depreciated over a 10 year period, buses over 20 years, and trains over 30 to 40 years.

Calculation: There are different methods and ways of calculating vehicle operating cost (VOC). Victoria Transport Policy Institute (2017) determine total unit VOC as the sum of costs of fuel, tyres, oil, repairs and maintenance, and interest and depreciation.

$$\text{Unit VOC} = Fuel + Oil + Tyres + Repairs + Depreciation$$

Based on Armstrong-Wright (1987), the total cost of bus service in mixed traffic and bus-only lanes, should be in the region of 2-5 US$ per passenger-kilometer, and in segregated bus ways, involving appreciable infrastructure costs, 5-8 US$ per passenger-kilometer.

2.5.3. Managerial performance indicators

Managerial performance indicators help to evaluate the performance of an organization management activity. Performance management is the term used to refer to activities, tools, processes, and programs that companies create or apply to manage the performance of individual employees, teams, departments, and other organizational units within their organizational influence (Richard S., 1999).

Managerial performance can be measured by looking at two criteria i.e., effectiveness and efficiency. Effectiveness is achieved when the organization pursues the appropriate goals while efficiency is achieved by using the fewest inputs to generate a given output in other words minimizing cost of resources needed to achieve goals. Managerial performance indicators mostly measure an organization performance based on set objectives, visions and goals of the organization (Richard S., 1999). Here below in table 2.5, basic management activities in public transportation service provider organizations is presented with their description.

Table 2-5 Managerial performance indicators

No.	Basic management system in public transportation service provider enterprise	Summarized description
1	Fleet management	• Optimization of costs, risks and efficiency in fleet operations. • Fleet management indicators evaluate how efficient and effective is the fleet management based on set goals and objectives of the service provider organization. • Cost optimization, schedule regularity, plan execution, and operator regulation are some of the indicators to evaluate the fleet management performance.
2	Maintenance management	• Is a better control of the maintenance organization and the related area • Indicators measure maintenance cost per hour, man power utilization and efficiency and etc. • Maintenance schedule regularity, availability of spare parts, maintenance standardization are some of the indicators to evaluate the maintenance management.
3	Financial (revenue) management	• Efficient and effective management of money (funds) in such a manner as to accomplish the objectives of the organization. • Indicators measure how effective and efficient is the financial management system • Some of the indicators include: financial self-sufficiency, proper accounting records, availability of asset management
4	Parking management	• Efficient use of existing parking facilities, improve the quality of service provided to parking facility users and improve parking facility design. • Indicators measure the effectiveness of the parking management activity • Availability of parking infrastructure and management systems are the indicators
5	Personnel management	• Is using and maintaining a satisfied workforce • Indicators measure productivity and utilization of the workforce • Qualified staff procurement, staff commitment and punctuality, staff training availability are some of the indicators to evaluate personnel (staff) management.

2.5.4. Service quality performance indicators

Other important performance indicators that can be used to evaluate the performance of a public transportation quality of service include, level of service performance indicators such as passenger waiting time, walking distance to bus stops, the need to interchange between routes and services, passenger journey times, headway, safety and security, availability of information customer care and etc.

Acceptable levels of service will differ very considerably from one country to another, and will be greatly influenced by income levels; the value placed on time, geographic and climatic conditions; availability of alternative modes, traditional standards, public attitudes and ethnic characteristics (Armstrong-Wright, 1987). These indicators should be measured in a range of values usually accepted as a reasonable level of service to the public.

2.5.4.1. Passenger waiting time

Waiting time at bus stations, is one of the most important quality and effectiveness measures of public transportation (Mir-Davood Salek and Randy B. Machemehl, 1999). Longer waiting times indicate poor service quality as perceived by passengers.

Taking into consideration the different factors and conditions that influence waiting time, it is suggested that to achieve a reasonable level of service in developing countries the average waiting time should be in the region of 5-to-10 minutes, with a maximum waiting of 10-to-20 minutes. The lower end of these ranges would apply to fairly short journeys with high-frequency services and the upper limit would apply to long journeys and low-frequency services (Armstrong-Wright, 1987).

2.5.4.2. Walking distance to bus stops

Walking distance to transit facilities or bus stops is an indicator of the accessibility and service coverage provided by the transportation system. Potential influences on the characteristics and variability of walk distance as an access mode to public transportation include trip purpose, demographics, built environment, local geography and public transportation supply (Rhonda Daniels and Corinne Mulley, 2006).

According to Armstrong-Wright (1987) in reasonably well-served urban areas, passengers should expect to find a bus stop within 300 -500 meters of their home or work place. Distances in excess of 500 meters may be acceptable in low-density areas, but the maximum distance that passengers have to walk to and from a bus stop should not exceed 1,000 meters.

2.5.4.3. Journey times

Journey time is the total time spent to reach a destination from a given origin. Passengers should not be expected to spend more than two-to-three hours each day travelling to and from work (including walking to and from bus stops, waiting time, interchanging, and bus trip times) (Armstrong-Wright, 1987). Excessive journey times may be a reflection of inadequate bus supply or poor scheduling and routing.

Proximity of residential areas to work places, poor traffic and road condition are some of the factors that journey time will depend rather than on the efficiency of the bus service.

2.5.4.4. Headway

Headway regularity can be defined as the evenness of intervals between transit vehicles. An indicator (expressed in %) is calculated as the ratio of the average difference between the actual and the scheduled headway to the scheduled headway (Transportation Research Board, 2003). Nakanishi (1997) Cited by (Laura Eboli, Gabriella Mazzulla, 2012) reported, a transit vehicle was considered “regular” if it is within ±50% of the scheduled interval (for intervals of 10 minutes or less) or within ±5 minutes of the scheduled interval (for intervals greater than 10 minutes).

2.5.4.5. Safety and security

The aspect linked to safety 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. Generally, the term “safety” is used to indicate the possibility of being involved in a road accident, while the term “security” refers to the possibility of becoming the victim of a crime (Laura Eboli, Gabriella Mazzulla, 2012). It could be measured and rated from passengers feedback based on the occurrence of crimes and accidents.

2.5.4.6. Information availability

Another service aspect affecting transit service quality is linked to the availability of information pertinent to the planning and execution of a journey. Passengers need to know how to use transit service, where the access is located, where to get off in the proximity of their destination, whether any transfers are required, and when transit services are scheduled to depart and arrive. Without this information, potential passengers will not be able to use transit service properly (Transportation Research Board, 2003).

2.5.4.7. Customer care

Customer care includes those elements needed to make easier and more pleasant the journey, like courtesy and knowledge of drivers, courtesy and helpfulness of ticket agents, personnel appearance, together with elements linked to the easiness of purchasing tickets or paying fare, and etc. (Eboli & Mazzulla, 2012). Customer care can be evaluated from the feedback of the passengers using the transit system.

2.5.4.8. Comfort

İmre and Çelebi (2016) reported determinants of comfort for buses and BRT in their report, as follows: level of lighting, crowd level in-vehicle (Passenger Load Rate), air-conditioning, smell, seat comfort, level of noise, vibration in vehicle, driver's behavior, driving style, sound level, cleaning in-vehicle, information and guidance, vehicle breakdowns, delays, and weather conditions. Level of comfort can be measured qualitatively, on the basis of satisfaction from passengers through a questionnaire, and quantitatively using statistical analysis.

2.5.5. Summary of the selected performance indicators

Some of the crucial operational, managerial, and other important service quality performance indicators that should be considered, in measuring the performance of a public transportation service provider, has been identified in this chapter based on literature reviews. Here below, a summary of the selected operational, managerial and service quality (level of service) indicators which can be used as tools to measure the performance of Anbessa City Bus Service Enterprise is presented in Table 3-5.

Table 2-6: Summary of the selected performance indicators

Categories of indicators		Description	Measure of:
Operational performance indicators	Passenger volumes (passengers per bus per day)	The number of passengers carried in relation to the capacity of the system	Operational productivity
	Vehicle-kilometers (kilometers per bus per day)	The total distance traveled by buses in service	Operational productivity
	Fleet utilization	The proportion of a bus fleet that can be put into service each day	System productivity
	Breakdowns in service	The proportion of buses that break down in service	Mechanical reliability
	Fuel consumption	The ration of fuel consumed by the vehicle to distance traveled.	Operational efficiency
	Staff ratios	The staff employed to put buses into regular service	Service efficiency
	Accidents	The level of accidents per operating buses	System consistency
	Dead mileage (Dead heading)	Journeys that are made when buses are not in service and passengers are not being carried	Operational productivity
	Cost of vehicle (bus) services (VOC)	The costs associated with operating a motor vehicle	Operational efficiency
Managerial performance indicators	Fleet management and scheduling	Cost optimization, schedule regularity, plan execution, and operator regulation are some of the indicators to evaluate the fleet management performance.	Effectiveness
	Maintenance management	Maintenance schedule regularity, availability of spare parts, maintenance standardization are some of the indicators to evaluate the maintenance management.	Efficiency Effectiveness
	Financial (revenue) management	Some of the indicators include: financial self-sufficiency, proper accounting records, availability of asset management	Efficiency Effectiveness
	Parking management	Availability of parking infrastructure and management systems are the indicators	Efficiency
	Personnel management	Qualified staff procurement, staff commitment and punctuality, staff training availability are some of the indicators to evaluate personnel (staff) management.	Efficiency

Level of service (quality of service) indicators	Passenger waiting time	Average waiting time at bus stations	Service effectiveness
	Walking distance to bus stops	Walking distance to transit facilities or bus stops	Accessibility & proximity
	Journey times	The total time spent to reach a destination from a given origin	Operating flexibility
	Headway	The evenness of intervals between transit vehicles	Regularity
	Safety and security	The degree of safety from crime or accidents	Service effectiveness
	Information availability	The availability of information pertinent to the planning and execution of a journey	Service quality
	Customer care	Elements needed to make easier and more pleasant the journey	Service quality convenience
	Comfort	Level of acceptable comfort of passengers	Service quality

CHAPTER THREE: RESEARCH MATERIALS AND METHODOLOGY

3.1. General

This section of the paper describes how the study was performed using the different techniques and study design. As stated earlier, the aim of this research is to analyze the operation and management performance of the public transportation sector in the city of Addis Ababa focusing on the performance of ACBSE, among the existing public transportation service providers.

3.3. Research methods

The study dealt with a descriptive research method to address the research questions dealing with procedures of surveys, observational studies and a case study.

3.2. Study area description

Addis Ababa is the capital city of Ethiopia with more than four million inhabitants. It is the diplomatic center of Africa and the seat for many international organizations. Being the center of the country, it has a wider role in economic, social, political, and administrative perspectives. The topography of Addis Ababa is hilly to rolling with steep gradients and deep valleys. It is situated at an altitude of about 2500 meters above sea level. The Addis Ababa city administration extends over 540 sq. km of an area. For administrative purpose it is divided into ten sub-cities which are further subdivided into 99 kebeles.

The City's transportation network is characterized by poorly maintained streets and sidewalks, coupled with occupation of sidewalks by economic and human activities, subsequent use of vehicle lanes by pedestrians, for walking, mounting buses, and taxis. Overall, the city transportation system suffers from many inadequacy. The city's road network constitute arterials and sub-arterials composed of the radial and ring roads while the local and collector roads are developed as a grid system within the major road system.

3.3.1. Surveys and counts

Surveys and office visits has been done to gather data on the subject under study, so as to evaluate performance of the existing public transportation service providers.

- Survey data on public transportation providers;
- Survey data on travel lines and facilities;
- Survey data on public transportation vehicles including number, dimension, performance data, condition and etc.;
- Survey data on service provided and schedule;
- Survey data on trip length and fare collection;
- Transit speed and delay surveys to find the distribution of time in respect of; running time, dwelling time at passenger stops, etc.; and
- Passenger volume

3.3.2. Observational studies

Unstructured covert observation was used to study the ongoing behavior of the public transportation system at selected sites and different times (peak hour and off-peak hour on both weekdays and weekends). The sites that were included in the study are:

- Bus terminal sites (Legehar, Megenagna, Mercato, and Menilik square terminals);
- Taxi stations (Torhailoch and Arat-Killo station);
- Composite stations (Torhailoch station, composed of taxi, public bus and midibus station); and
- Bus depots and maintenance service (Yeka depot of ACBSE)

The observational studies on the selected sites were helpful for an insight and cognition of the existing condition, those were:

- the service rate of the PT meeting the demand;
- waiting time of the passengers using the particular mode of PT;
- on-street parking hindering the traffic and cause congestion; and
- safety and convenience

3.3.3. Case study

A case study on the ACBSE was used to study the operational, managerial and service quality performance of the provided transportation service among the existing public transportation service providers in the City.

The study included the following:

- Data collection: The data collected included route performances (number of buses assigned on each root, length, travel duration, bus stops, etc.), number of passenger served, total trips made, revenue collected, parameters of operating costs, accident data, vehicle breakdown data, number of fleet (those operational, under maintenance, and totally out of service), and total distance covered.
- analyses were conducted on the operational, managerial, and quality of service performance of ACBSE
- the HDM-4 Vehicle Operating Costs Module of the RED Model were utilized in estimating VOCs
- based on the analysis, generation of results, discussions, and interpretation were performed.

3.4. Research materials

3.4.1. Materials for data collection

3.4.1.1. Materials for primary data collection

The materials that was used in the primary data collection include:

- In depth Interview: interviews were conducted with an officials of the Addis Ababa City Administration Transport Authority (AACATA) and also with the Planning and Design and Public Relations Department officials of the ACBSE. Minor interviews were also performed with the Operation Department Head, IT-data Processing Unit Head, Management heads of the different departments, maintenance crew, and the administrative staffs of ACBSE.
- Questionnaire: a questionnaire was prepared and surveys conducted on 200 Anbessa City Bus public transportation customers, using random sampling

technique at the four terminals, to evaluate the service quality of the transportation system according to the respondents' opinion.

- Direct observation with notes and recordings was also made to perceive the gap of service provided to the scheduled one.

Efforts was made to use appropriate sampling technique and sample targets on collecting the primary data. Accordingly, before selecting the sample size, a pilot survey was held at the four terminals and then decided to collect a sample size of 200 customers of Anbessa's public transportation service with random sampling technique. Therefore, a questioner on 200 sample size was used by taking account on the homogeneity of the customers' response at the four terminals, the practicability and economic feasibility of the study. In addition, efforts was made to address the targeted population on the interviews haled.

3.4.1.2. Materials for Secondary Data Collection

The materials that were used in the secondary data collection include:

- Literature reviews, supporting the subject under study which include: books, journals, reports, thesis and dissertation, etc.
- The Transport Authority's and other organizational documentation ; and
- Internet

3.4.2. Materials for data analysis

- Statistical analysis tools was used to analyze the data collected based on the predefined indicators.
- HDM-4 VOC of the RED model was used to calculate the vehicle operating costs (VOCs) of ACBSE buses

3.5. Analysis methods and procedures

3.5.1. Operational performance analysis of ACBSE

The analysis for the operational performance of the ACBSE was done based on the collected and organized data using the previously defined nine operational performance indicators for a period of five years analysis period for most of the indicators. Generally, the procedure for the analysis were:

- Collecting and organizing the necessary data required for the calculation defined under each performance indicators
- Calculating the values for each indicators based on the formulas described under each indicator using MS-Excel as a statistical tool, and also the HDM-4 VOC of the Red model to calculate the vehicle operating costs.
- Comparing and contrasting the values obtained for each indicators with the standards given by the World Bank studies.
- Interpreting the results obtained and extracting the major causes and effects for the performances.

3.5.2. Managerial performance analysis of ACBSE

The analysis for the performance of the management of ACBSE was qualitatively done based on the ranking and evaluation of the management activities constructed on the interview made with the different management departments and based on the organization set goals and working standards. The procedures followed were:

- Collecting data through interview made with the different management heads and departments.
- Evaluating the different management activities based on the predefined indicators.
- Identifying the main causes for the inefficiency and ineffectiveness of the different management activities.

3.5.3. Service quality performance analysis of ACBSE

The analysis for the performance of the service quality of ACBSE has been evaluated based on the previously defined seven indicators and customer opinions as an input for the indicators. The procedures followed were:

- Collecting and organizing the necessary data required from the questioner survey (customers of ACBSE) under each performance indicators
- Summing and giving percentile and presenting the output using MS-Excel for each ranks (categories) for each question on the questioner surveyed.
- Interpreting the result obtained based on the majority of the customers surveyed.

CHAPTER FOUR: A CASE STUDY

4.1. Brief background of the ACBSE

The Anbessa organization was first established in 1943 (1935 E.C) by collecting and modifying used trucks and garage materials which were used by the Italian colonial government at that time. In 1959, it was re-established as a share company and expanded its coverage from four to fourteen routes and increased the number of vehicles per route from 2 to 3. In the 1974 Ethiopian Revolution, the company was nationalized and continued the transportation services under the Public Transport Corporation (PTC). In 1994, the company was again re-established and renamed as Anbessa City Bus Service Enterprise (ACBSE) as an autonomous business enterprise by the council of Ministers Regulation No.187/97. In 2011, the Enterprise was transferred to the Addis Ababa City Government under the Addis Ababa Transport Authority (ACBSE Web site, 2012). The company under Addis Ababa Transport Authority, has since grown steadily, acquiring more vehicles in order to meet the increasing demand for its services.

The different departments of the organization including the structure of the enterprise, the operational characteristics, the management and financial system of the enterprise will be briefly discussed in the subsequent sections of this chapter; and will be analyzed and evaluated under Chapter Six based on the indicators defined earlier in Chapter Three.

4.1.1 Organizational structure of the company

Anbessa is the longest experienced public transportation service provider that has been operating for many years in the city of Addis Ababa. It is managed by a board of directors which a policy making and directive body. The enterprise is organized into two core processes (Transport Operation Core Process and Technical Service Core Process) and eight support providing processes under the direction of the general manager. The three depots (Yeka, Shegole and Mekanissa) are organized under depot managers who are responsible for conducting and coordinating the transportation operations under their respective responsibilities. The overall major organizational structure of ACBSE is shown in Figure 4-1 below.

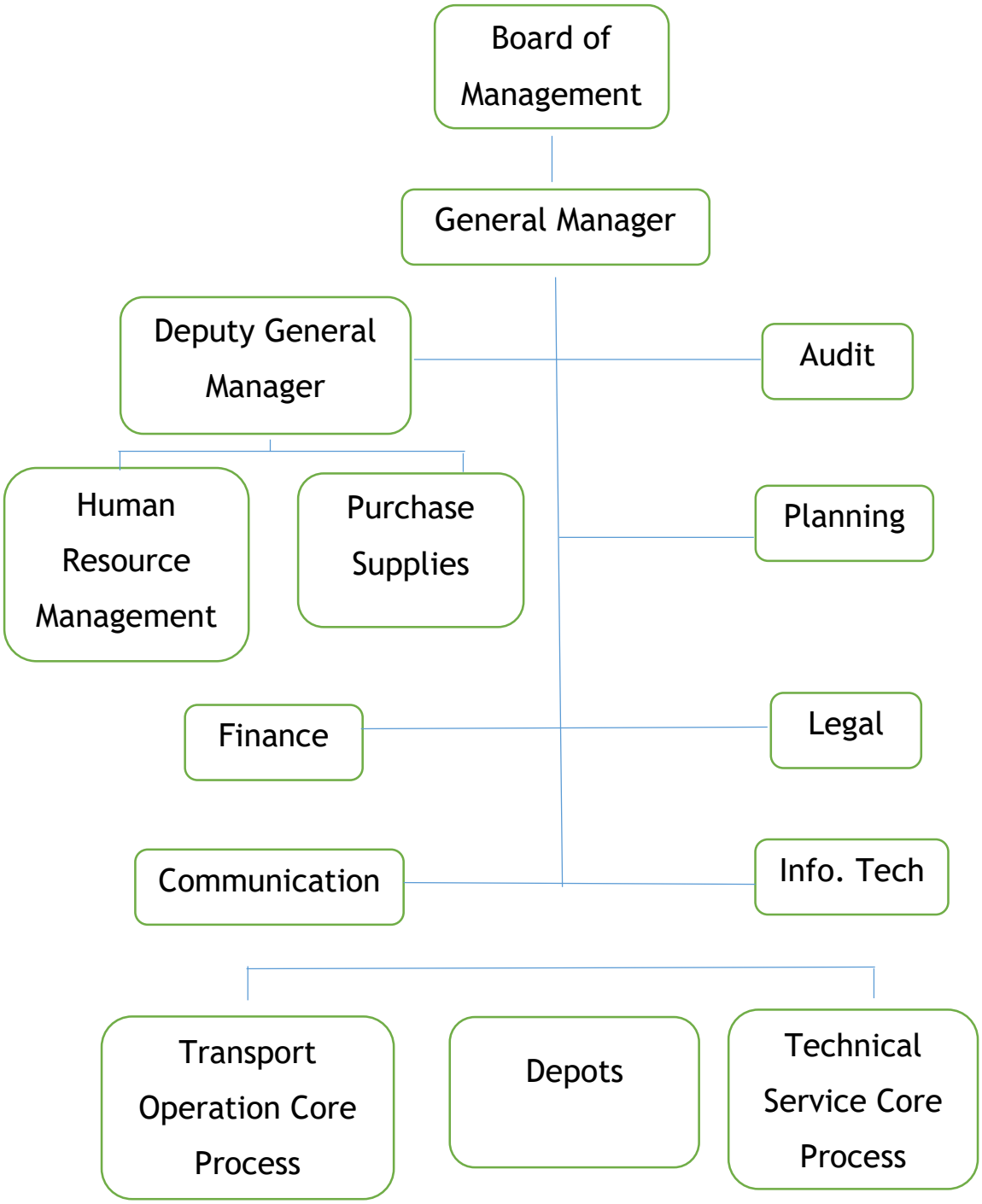


Figure 4-1 Organizational structure of ACBSE

4.2. Operational and service provision characteristics

4.2.1. Services provided by the ACBSE

ACBSE provides three major types of services for commuters namely: transportation service, vehicle maintenance service and annual vehicle technical inspection service and are described in the following sections.

4.2.1.1. Transportation service

Transportation services provided by the ACBSE can further be sub divided into:

(i). Regular scheduled service

This is a service regularly provided by the Enterprise to the commuters based on set schedule on 124 (as of 2009 E.C) fixed routes. Presently, the services are provided by the fleets, dispatched from the three depots namely: Yeka, Shegole and Mekanissa. Four bus terminals (Legehar, Merkato, Menilik Square and Megenanga), twenty eight check points (destinations) and, one thousand four hundred fourteen (1,424) bus stops are the currently available infrastructures that provide services.

(ii). Contract service

This service provides internal and external contract services. The internal contract service is the service given to the employee of the organization without fee and the external contract service is service given to governmental or non-governmental organizations, schools and other institutions based on set agreements (deals).

(iii). Special service

This is a service provided when special occasions occur like mourning, meetings and festivities based on distance and duration of service. Specially, occasions which are linked to governmental organization, ABCSE has an obligation to give service as it is administered by the City Transport Authority.

(iv). Vehicle maintenance service

ACBSE performs maintenance services both for its own vehicles and other vehicles in need of the service. The service is given at all the depots for the company's vehicles and at the Yeka depot for those external vehicles.

(v). Vehicle technical inspection service

ACBSE provides inspection service to all vehicles at the Yeka Depot where the head office is placed. The service is performed using high-tech vehicle inspection machines.

4.2.1.2. Bus routes

The fleet currently owned by ACBSE has been acquired through a number of different routes, which increases from time to time due to the increasing demand by the customers. ACBSE uses demand oriented approach for assigning bus roots, number of buses in each root and also a fixed time schedule for each of the roots. The time schedule of the buses on each root depends based on the number of buses assigned on each root and the length of the roots which as a whole depends on the demand. The routes of the ACBSE are both radial and tangential, which most of them are radial starting from the centre and extending outwards. The ACBSE routes have reached about 124 as of 2017 (2009 E.C) with the total route length of more than 1,725 km. The longest route is Route Number 91 which is 52 km in length and runs from Mercato through Torhailoch to Teji and the shortest route is route number 72 which is 4.9 km in length and runs from Hanna Mariam to Saris Abo. Waiting time for the service is extremely variable. Even though, the expected average waiting time is between 30-90 minutes but the actual fact is well above that range as it was recognized from the observational studies and questionnaire survey. Several factors contribute for the variability of the waiting time (headway), amongst which congestion at peak hours can be considered as the major factor. An average of 12 trips is made daily on this route. The travel time ranges from 25 minutes to 110 minutes for a single trips based on the route length and topography.

Appendix I presents routes with origins, destinations, distances, average number of passenger transported per day, average number of trips made per day, average travel time, and the fares assigned for each route are tallied and presented in tabular form Figure 4-2 below presents the route map of the ACBSE.

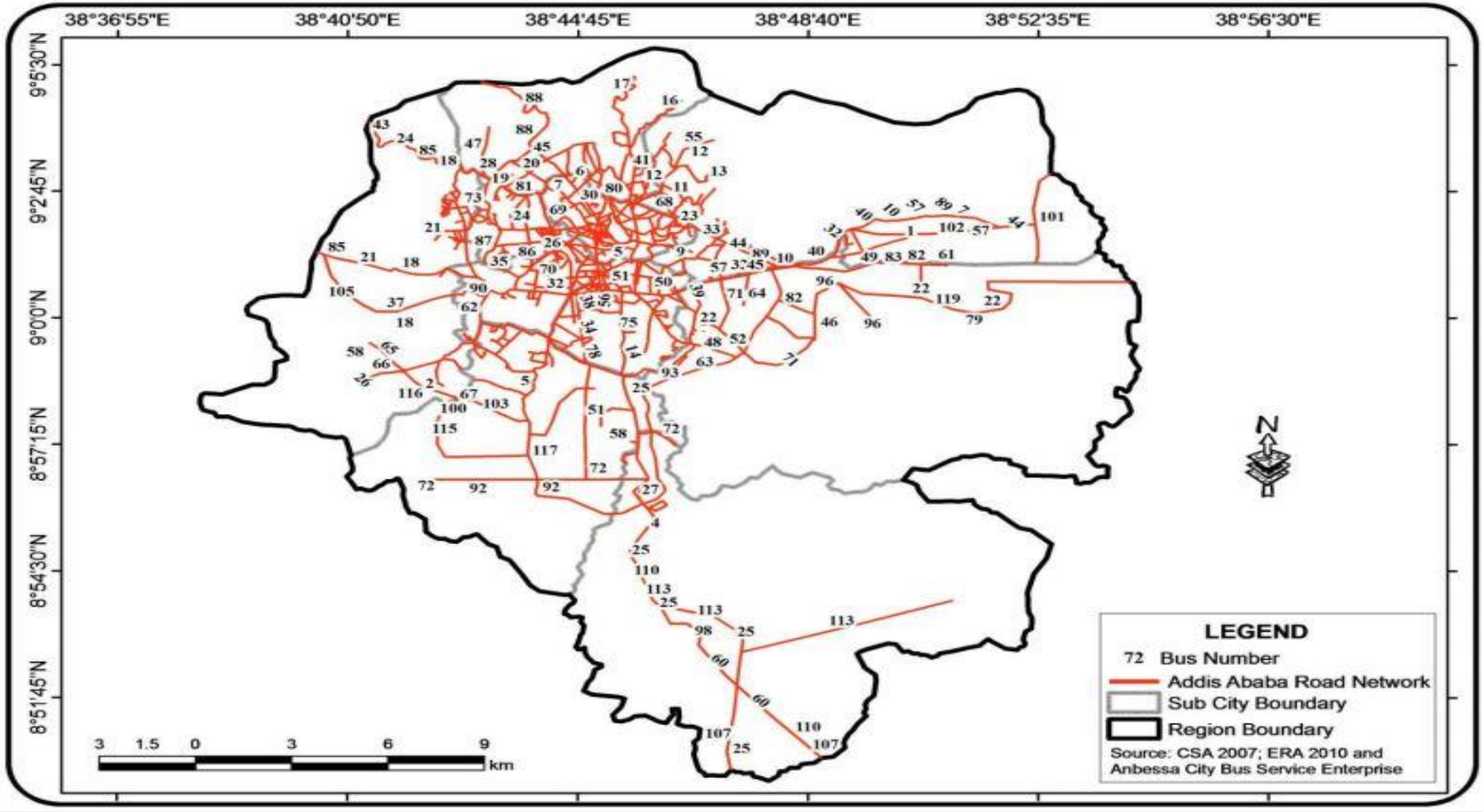


Figure 4-2 ACBSE bus route map

4.2.1.3. ACBSE bus stops

Bus stops are where passenger boarding and alighting take place and are linked together to form a route with origin and destination. There are more than 1,420 bus stops. Each route has different number of bus stops based on their length which are spaced at distances between 350-500 meters on average, unless policy and topographic restriction exists.

4.2.1.4. ACBSE bus terminals

ACBSE has four (4) major terminals, where a high proportion of the routes are operated and minor maintenance and checkups are made. These major terminals are located at Addis Ketema (Mercato), Legehar, Menilik Square, and Megenagna. In addition, some interchanges are also used as minor terminals, which are located at Sidist Kilo, Arat Kilo, Saris Abo, Ayer Tena, Shiro Meda, Menilik Hospital, Bole Michael, Kera, Balcha Hospital and Gerji. Among the major terminals, the Mercato terminal is under maintenance presently, and there is a plan to modernize it. Table 5-1 below presents the distribution of buses at each terminals.

Table 4-1: Distribution of Buses, Trips and Routes on each Terminal

No.	Terminal	No. Of Routes operated	No. Of Buses operated
1	Legehar	21	112
2	Mercato	39	156
3	Menilik II Square	13	64
4	Megenagna	13	53
5	Minor Terminals	33	131
Total		119	516

Source: (ACBSE record 2007 E.C)

As can be seen from the Table 4-1 above, distribution of buses, trips and routes at each terminal, about 75% of the total routes operate from terminals while about 25% operate without terminal.

4.2.1.5. ACBSE bus depots

ACBSE operates from three sites comprising of the Yeka site located on the eastern part of the city; the second depot at Shegole is located on the northwestern of the city and the third site is located at Mekanisa, the southern part of the city. The Yeka depot covers over 70,000 square meters in area, where the Headquarter is located. The operating depot has the facilities for more than 400 buses to be based there. The site also includes the central workshops for the enterprise, the main spare parts warehouse, driver training center, vehicle inspection center, fuel station, parking facilities, and other facilities are included.

The second depot at Shegole has 54,000 square meters of area. The depot has its own fuel station, and light maintenance and running repair facilities as well as a spare parts store operated on a satellite basis from Yeka. It has a capacity of more than 300 buses to be based and operate. Presently, the depot is under re-construction by the Ethiopian government with a better standard quality and necessary facilities.

The third depot at Mekanisa has a site area of nearly 73,000 square meters. It has a capacity of 300 buses to operate from there. In addition to the three depots, a new depot is under construction south of the city at Kality. Table 4-2 below presents the existing depots and their current operational fleet size.

Table 4-2 Depot and their fleet size (only those operational 2009 E.C)

No.	Depots	Types of bus and fleet size			
		DAF Rigid	Bishoftu Rigid	Bishoftu Articulated	Total
1	Yeka	100	48	52	200
2	Shegole	74	66	30	170
3	Mekanissa	30	30	30	90
Total		204	144	112	460

Source: (ACBSE data record)

Table 4-2 above shows the average operational dispatched buses from each depot in 2017 (2009 E.C). The number of fleets available for operation are drastically decreasing. For example, two years ago (2007 E.C), there were 516 operational buses out of 1,006,

but now the size of the operational fleet is only 460. Most of the non-operational buses are out of service which require disposal, and some of them need an extensive maintenance to get back to operation.

4.2.1.6. ACBSE bus maintenance practice

ACBSE perform three (3) types of maintenance activities which are:

- Preventive maintenance: this is a maintenance activity done combining both time and distance related interventions. In this maintenance activity the vehicles are checked, serviced, and inspected in a scheduled way which could be weekly, every two months or six months based on the condition of the vehicles. Preventive maintenance is crucial for the productivity of the operational buses; but, it can be noted that there is a lack of co-ordination between the operational and technical planning functions meant that kilometer data for service scheduling were often received too late for integration with other preventive maintenance activities. This resulted in a loss of accuracy and additional disruption to operations.
- Breakdown maintenance: it is a maintenance activity which is done when vehicles break down. It could be classified into filed level and depot level breakdown maintenance. Filed level breakdown maintenance is done for minor breakdowns which require slight maintenance tools and a few time duration. Depot level breakdown maintenance activities are maintenance activities those require intense repair at the depot and workshop facility and which could take days to maintain.
- Corrective maintenance: it is a bit similar to breakdown maintenance but, unlike breakdown maintenance corrective maintenance require minor repair at the depot level.

4.2.1.7. ACBSE bus driver training and control

ACBSE has a training and control facility for the drivers. ACBSE suffers a high level of turnover of its driving staff, resulting in the need for intensive training of new recruits. One of the biggest problem of the system is, several driver can drive a single bus, which

is difficult to analyze and tell which driver caused the damage in order to train that very driver.

Accidents have averaged some 168 per month (from Hamle 1, 2008 to Sene 30, 2009 E.C) with 12 fatalities occurring in that period. Twenty thousand twenty (2020) number of accidents occurred during that period. The number of accidents that occurred must be considered high, but it is more of a reflection of general chaotic driving standards in the city than those of the enterprise.

4.3. Management system of ACBSE

The management system of ACBSE comprise different management activities the most common, in fleet management, primary control of the route network is carried out at the four main terminals, Megenagna, Mercato, Leghar and Menelik Square. Terminal controllers adjust services as required to balance the implications of late arrivals and lost trips, and re-allocate vehicles accordingly in order to meet the most pressing levels of demand.

The other, in maintenance management system, technicians are also based at the terminals, and carried out some interventions in order to prevent the need for buses to be returned to depot in need for breakdown maintenance, therefore to maintain on field level.

There is poor parking and facility management activities, the terminals are too congested, and poorly laid out to deal with the volume of bus movements and the high number of routes being operated through them. The majority of the bus stops do not have the necessary facility requirements like shading, setting and waiting area. At most of the places there is only posted boards of the route numbers.

4.4. Financial system of ACBSE

Strong financial system is one of the crucial requirement for a well performing company. Efficient and effective management of money (funds) is required to accomplish the objectives of the organization. The financial system of ACBSE regulate, control, monitor, and manage the revenue collected through the normal service, contract service, vehicle maintenance service, and vehicle inspection service; the expenses (wages and

benefits, maintenance expenses, administrative, insurance, and others.); and subsidy from the city government.

Despite the nature of its capital formation, ACBSE makes a charge for the depreciation of its asset base at the full open-market valuation of the cost of acquiring these. In the case of its fleet, vehicles are fully depreciated on a straight-line basis over a period of 8 years in accordance with tax legislation. However, this period is considerably shorter than the likely economic life of these assets, which could be up to 15-20 years. Payback over, say, 12 years would give a truer representation of the values that should be charged to the accounts.

The cash flow of ACBSE is negative which shows the organization is giving service with loss. Table 4-3 below presents the ACBSE financial statement during the past five years 2012 to 2016 (2004-2008 E.C).

Table 4-3 Financial statement of ACBSE (2004 E.C to 2008 E.C)

Financial statement (in ETB)	2004 E.C	2005 E.C	2006 E.C	2007 E.C	2008 E.C
Revenue	260,115,000	341,107,000	393,050,000	356,955,000	302,969,000
Subsidy	151,420,000	176,050,000	311,800,000	364,000,000	312,310,000
Total	411,535,000	517,157,000	704,850,000	720,955,000	615,279,000
Expenditure	432,328,000	597,502,000	723,417,000	739,542,000	621,904,000
Net Income	-20,793,000	-80,345,000	-18,567,000	-18,587,000	-6,625,000

Source: ACBSE record

4.5. Progress in modernizing ACBSE transportation service

Proper integration of ICT and ITS systems in the operations and management activities of a transportation service provide a huge benefit as it can be seen from the experience of different countries. The adoption of location and information based technologies both in vehicles, infrastructure, traffic management, and traveler information services continue to show drastic improvement in the effective and efficient mobility of people and goods as it can be seen from the experience of other countries.

Public transportation in Addis Ababa is yet limited to the implementation of ITS. However, there is a great need and plan for on-going integration of ICT and ITS in public transport. In fact AACATA as the owner of ACBSE in co-operation with the World Bank and with The Transport Program Management Office (TPMO), is under a study to implement ITS packages by phase in ACBSE transportation as well as other public transportation service providers.

Based on the interview held with Ato Habtwold Shewangizaw, one of the officials of AACATA, stated that there is an ongoing process already started on the integration of an Automated Fare Collection System (AFCS) among the ITS packages. The system construction, development, and management was given to the local company "Kifiya" after a tender notice. The system is expected to start service in the coming year 2018.

Moreover, another ITS package, Passenger information system (PIS) is also under process for an integration on board and at the terminals of ACBSE transportation service in addition to the others mass transportation service providers. Ato Habtwold further stated that, another private company from the Netherland owned the project and it is on the process which will start to function in the near future.

Though there are a number of challenges and limitations for the adoptions of ITS, especially those financial resources and lack of advanced knowledge, there is a great reward and savings, implementing the different ITS packages, by tackling the challenges and achieving through partnership and collaborative efforts of the concerned disciplines and institutions.

CHAPTER FIVE: ANALYSIS AND FINDINGS OF THE CASE STUDY

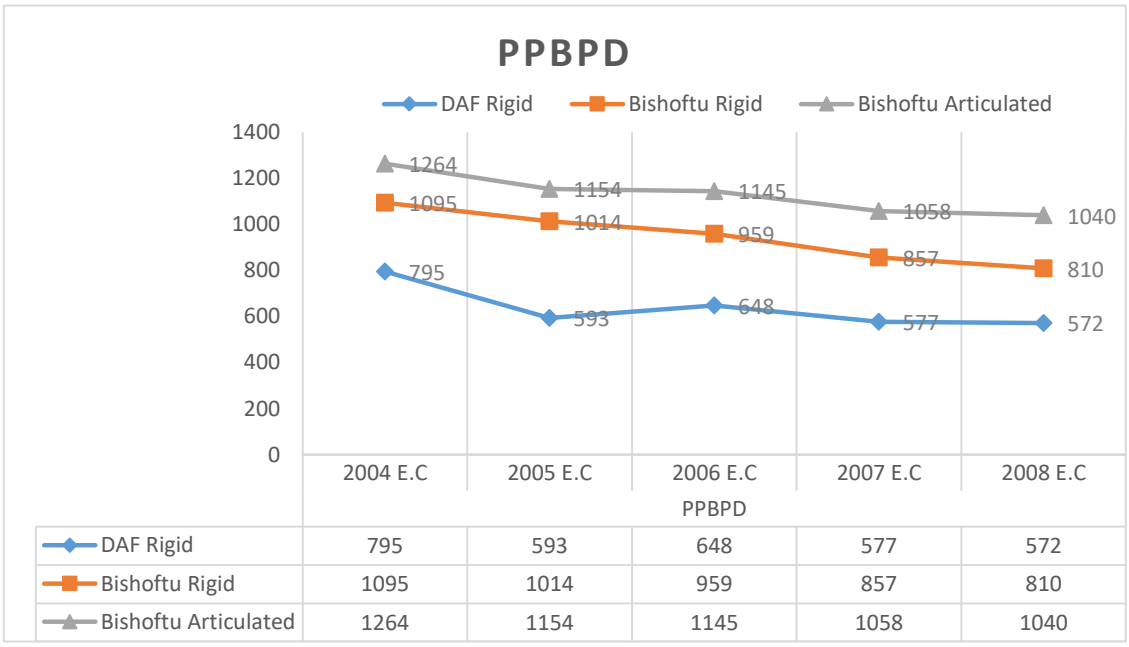
5.1. Operational performance characteristics/analysis

5.1.1. Passenger volumes (passengers per bus per day)

Passenger volume, one of the measure of service productivity which was defined earlier in Chapter Two, can be used in measuring the operational performance of the ACBSE. Passengers per bus per day (PPBPD) is calculated by dividing the total number of passengers traveled by total number of buses operated in each year. The formula used in the calculation of PPBPD is as depicted below.

$$PPBPD = \frac{\text{Total number of passangers per bus type}}{\text{Total number of that bus} * \text{number of days}}$$

Figure 5-1 below illustrates the average number of passengers traveled per bus per day for a period of five years 2012 - 2016 (2004 - 2008 E.C.).



PPBPD

	2004 E.C	2005 E.C	2006 E.C	2007 E.C	2008 E.C
DAF Rigid	795	593	648	577	572
Bishoftu Rigid	1095	1014	959	857	810
Bishoftu Articulated	1264	1154	1145	1058	1040

Figure 5-1: PPBPD by bus type

All the values presented in the figure above are out of the range given by Armstrong-Wright (1987) for rigid and articulated bus (1200-1500, 2000-2400) respectively, for a well performing bus company. Specially, DAF rigid bus transported a very low number of passengers, almost half of the lowest extreme value given by Armstrong. This result

shows low bus operating hour causing low PPBPD due to mechanical breakdown as a result of the ageing effect of the buses apart from the availability of other transportation alternatives. This can be seen clearly from the figure above, the curve falls down year to year. Similarly, for Bishoftu rigid and articulated buses the values falls down for similar reason. Another factor that influence the result could be the route length, shortest routes carry ample passengers where as long routes carry less passenger most of the time. During the period, the DAF Rigid PPBPD decreased by annual average of 4%; similarly, the Bishoftu Rigid and the Bishoftu Articulated PPBPD decreased by 3.7% and 2.4% respectively.

Table 5.1 below shows the performance of the three buses in respect of average, maximum and minimum PPBPD in accordance to the measurement of Armstrong-Wright (1987) which is 1,200-1,500 PPBPD for the rigid bus and 2,000-2,400 PPBPD for the articulated bus. In this respect, the maximum values for the rigid buses fall in the range, which depicts some of the buses are productive. Particularly Bishoftu rigid bus is more productive, operating more hours per day, compared to the others. To be exact, for example, the ACBSE data record shows, 79 Bishoftu rigid buses out of the available 90 Bishoftu rigid buses, 163 out of 350, and 101 out of 350, fall in the range on the years 2004, 2005, and 2006 E.C respectively. But later, the values decreased to 34 and 21 for the years 2007 and 2008 E.C respectively which shows most of the buses are deteriorating year to year producing a low operating hour and this also applies for the other bus types of Anbessa.

Table 5-1: Average, Maximum, and Minimum values of PPBPD for each bus type between 2004 and 2008 E.C

PPBPD						
Bus type		2004	2005	2006	2007	2008
DAF	Average	653	446	550	487	481
	Maximum	1415	923	1247	1034	1174
	Minimum	91	12	38	15	41
Bishoftu Rigid	Average	1091	987	881	792	773
	Maximum	1266	1334	1392	1532	1552
	Minimum	803	378	127	246	357
Bishoftu Articulated	Average	1194	1133	1109	1032	1010
	Maximum	1472	1662	1449	1348	1304
	Minimum	399	247	300	431	440

Source: ACBSE data record and Author analysis results

5.1.2. Vehicle-kilometers (kilometers per bus per day)

Vehicle-kilometers per bus per day (KPBPD) is another indicator used for the performance evaluation of ACBSE to measure operational productivity. The following formula was used in the calculation of the KPBPDs.

$$KPBPD = \frac{\text{Total kilometers operated}}{\text{Total number of vehicles(bus)} * \text{number of days}}$$

KPBPD is calculated first by dividing the total kilometer driven in each route per year by the total number of buses in operation for that particular route and period as shown in the second row of Table 5-2 below and then by dividing it by 365 days, and the results are depicted in the table.

Table 5-2: Total kilometers per bus and kilometers per bus per day

Year (E.C)	2004	2005	2006	2007	2008
Total km/bus	72167.80	70875.70	70315.84	72803.71	67173.56
KPBPD	197.72	194.18	192.65	199.46	184.04

The results showed the average vehicle-km per route per bus for all of the years which were below the lowest extreme as given by Armstrong-Wright (1987) for a well-performing public bus systems in developing countries, which is in the range of 210 km/day to 260 km/day, equivalent to 76,650 km/year to 94,900 km/year. The possible explanations for such low figure from the prevailing situation could be the high rate of break downs, poor maintenance and repair, poor road condition, traffic congestion, and old vehicle.

However, another study by The World Bank Group (2006) assumes vehicles are not available 100% of the time in the course of a day's work. So it suggests an assumption of vehicles availability to be only 85% of the time, specially when the average daily kilometer figure, calculated from the annual figure, must be divided by 0.85 to give the actual daily kilometers operated by each vehicle. The modified KPBPD values calculated based on this assumption fall in the lowest range of values to be productive, given by Armstrong-Wright (1987) as shown in Table 5-3 below.

Table 5-3 Modified kilometers per bus per day

Year (E.C)	2004	2005	2006	2007	2008
KPBPD	197.72	194.18	192.65	199.46	184.04
Modified KPBPD	232.61	228.45	226.65	234.66	216.52

5.1.3. Fleet utilization

Fleet utilization as a system productivity indicator is used in measuring the performance of the ACBSE. The fleet utilization which indicates operational efficiency for each vehicle type (DAF rigid, Bishoftu rigid, and Bishoftu articulated) is computed as the ratio of the average working hour to the daily working hour for a period of five years. The following formula shows the same.

$$\text{Average vehicle utilization } (\%) = \frac{\text{average working hour}}{\text{daily working hour}}$$

$$= \frac{1826.9 hr\ per\ year}{15\text{hr per day} * 168.8\text{days per year}}$$

$$= 72.2\%$$

Based on the above formula, the fleet utilization per vehicle is depicted in Table 5-4 below.

Table 5-4 Fleet utilization per vehicle per period

Year (E.C)		2004			2005			2006			2007			2008		
Bus type		Working days	Working hours	Utilization	Working days	Working hours	Utilization	Working days	Working hours	Utilization	Working days	Working hours	Utilization	Working days	Working hours	Utilization
DAF Rigid	Avg.	168.8	1826.9	72.2	126	1031.6	54.6	145	998.0	45.8	140	917.8	43.6	131	904.2	46.2
	Max.	347.0	5034.7	96.7	345	4535.4	87.6	348	3923.0	75.2	331	3327.4	67.0	340	4837.06	94.8
	Min.	2.0	1.5	5.0	1	0.4	2.3	1	0.3	1.7	1	0.9	6.1	1	0.9	5.7
Bishoftu Rigid	Avg.	200.3	2688.7	89.5	231	2970.4	85.8	212	2256.8	70.9	200	1813.0	60.3	195	1828.27	62.4
	Max.	291.0	4003.5	91.7	356	5328.9	99.8	359	4262.6	79.2	347	3852.8	74.0	333	3870.45	77.5
	Min.	86.0	823.7	63.9	2	5.8	19.4	2	2.5	8.4	2	7.8	26.1	3	16.6	36.9
Bishoftu Articulated	Avg.	218.8	2633.1	80.2	247	2560.1	69	251	2050.6	54.4	252	1842.1	48.8	233	1994.98	57.1
	Max.	309.0	4611.0	99.5	356	5311.3	99.5	350	4579.6	87.2	351	4218.3	80.1	337	3293.75	65.2
	Min.	15.0	116.2	51.6	1	0.9	6	1	7.8	52.0	5	11.0	14.7	4	18.7	31.1

Even though average utilization is the indicator needed to measure the operational efficiency of the vehicles, the maximum and minimum values are computed to show their effect on the average value. Accordingly, one can infer from the table above that the

average values are highly affected mostly by the minimum values which reduced the average utilization of the vehicles.

Regarding the DAF Rigid Bus, the working days for most of the buses are very low, below half of the year. For instance, for the year 2005 E.C (2012/2013 G.C), the average maximum and minimum values (126, 345, and 1) resulted in lower utilization values. The average value, which is 126 working days is only about four months availability for operation in a year. Similarly, most of the buses were available for operation below three months and even less resulting in very low utilization percentages. The major reason for that was frequent breakdown of the buses caused by ageing and lack of proper maintenance.

In the case of the Bishoftu Rigid Buses, the result showed a higher utilization percentage; specially, for the first 2 years of the analysis period (2004 & 2005 E.C). The high values resulted since the buses were brand new and started operation at that period. However, the percentage utilization reduced in the latter years because of age and poor maintenance, as indicated above. Most of the buses operated below seven months of a year on the average.

Similarly, for the Articulated Bishoftu Bus, the results indicated better percentage utilization at the beginning of the analysis years, but later deteriorated. Similar reason to that of the rigid Bishoftu buses apply for the articulated ones too. Most of the buses were operational for about eight months on average. It can be better understood from Figure 5-2 below.

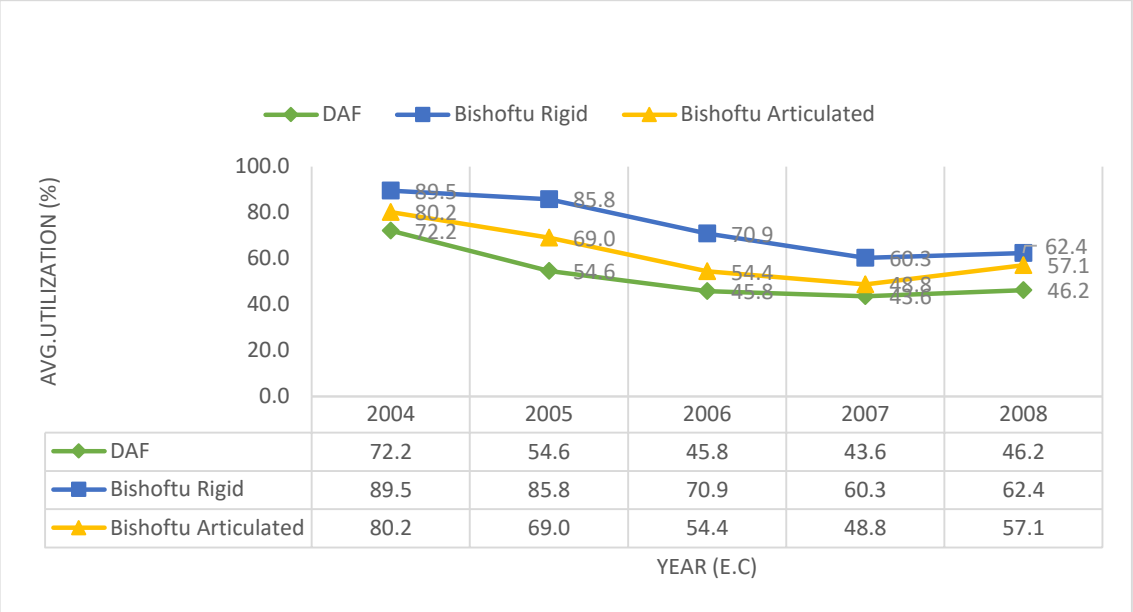


Figure 5-2: Trend of average percentage utilization by bus type

As observed in Figure 5-2 above, trend decreases over the years for all of the bus types as a result of mechanical breakdowns and aging (especially for that of the DAF rigid buses which served for more than 15-20 years, much more than their service lives as provided by the manufacturer). There was a bit improvement in 2008 E.C from the previous year of 2007 E.C as a result of better maintenance provision. The first two years for the Bishoftu Rigid and Articulated buses manifested better utilization percentage indicating good operational efficiency and system productivity. Since they started operation after purchased in that period, breakdowns were minimum and their performances were good.

Another important method to compute utilization is, the number of buses operated during the busiest peak period of the day (morning peak hour), expressed as a percentage of the number of buses available for use. The formula in this regard is stipulated below.

$$Fleet\ utilization = \frac{\text{Avg. number of buses operated during peak period for each week days}}{\text{Avg. number of buses avialable on each week days}}\%$$

$$Fleet\ utilization\ (\%) = \frac{7973}{9905} * 100$$

$$Fleet\ utilization = 80.5\%$$

The vehicle utilization efficiency for the month of June 2017 (Sene 2009 E.C) according to ACBSE data record was calculated to be 80.5% as shown above. This figure falls marginally in the range 80-90 percent as specified by Armstrong-Wright (1987). It shows that the company had good maintenance and repair capability during this particular period. The calculation was made with exclusion of those buses undergoing maintenance or repair or not available for other reasons, to use the number of vehicles used on revenue-earning service. In other words, the calculation shows efficiency of the system to collect revenue from the available/dispatched buses.

5.1.4. Breakdowns in service

Breakdowns in Service is a measure of the mechanical reliability of a fleet. Measured values give an indication of the standard of maintenance as well as of general fleet condition of ACBSE. It is calculated using the following formula as:

$$Breakdowns\ in\ service\ (\%) = \frac{\text{number of breakdowns per day}}{\text{number of buses in service}}$$

Here below in the Table 5.5, the average, maximum and minimum values of the percentage breakdown are computed and presented for the month of June, 2017 (Sene 2009 E.C) as a sample to show the recent performance of the ACBSE regarding service breakdowns**.**

Table 5-5: Percentage breakdown for the month of June 2017 (Sene 2009 E.C)

	Break downs occurred	No. of dispatched buses for operation	% break down
Average	29	453	6.4
Maximum	42	455	9.2
Minimum	16	450	3.6

The results of the percentage breakdown fall within the range given by Armstrong-Wright (1987), which is 8 to 10 percent for a reasonably well maintained fleet. The average value, 6.4% is low that signifies few number of breakdown per operationally available buses in that month. The value by itself implies there was good provision of maintenance and driving standard. However, the results were limited to accounting for of only the dispatched buses on everyday bases which omits already break downed buses

and staying at the depot for maintenance. For instance, the ACBSE operational fleet which was expected to be 573 but dispatched only less than 460 (80.2%) buses every morning. Therefore, it is better to compute the service breakdown in terms of kilometers per breakdown as follows:

$$Breakdowns\ in\ service = \frac{\text{Total number of kilometers operated per day}}{\text{The number of breakdown incured per day}}$$

$$= \frac{61875}{30}$$

$$= 2063\ \text{kms/breakdown}$$

The average total kilometers operated (61,875 per day) to the ratio of average breakdowns per day (30 breakdowns per day) gave the result that breakdowns occurred every 2,063 kilometers driven on the average. The result gain for ACBSE is lower than the extreme value given by The World Bank Group (2006) which is 2,500 kilometers per breakdown for poorly maintained buses operating on services in conditions typical of a developing country. The possible reasons for the lower figure is ageing of the buses, and low driver standards (ACBSE's trend show that, different drivers operate the same bus which makes it difficult to control and identify the faulty driver to give better driver training or even extermination). In addition; traffic congestion, bad road conditions, and steeply slopes of the Addis Ababa roads resulted in frequent vehicle breakdowns.

5.1.5. Fuel consumption

Fuel consumption, another performance indicator was used to measure the ACBSE's operational efficiency. It is computed as:

$$Fuel\ consumption = \frac{\text{Fuel consumed}}{100\text{km}}$$

Even though, there is no recorded data available for the years under analysis, from ACBSE recording and experience, the haulage kilometer per liter fuel of the buses was found to be 2.0 - 2.5 km/l. This means that 0.4 - 0.5 liters of fuel was consumed per kilometer haulage by the buses on the average. This result falls within the range given by Armstrong-Wright (1987) for a well-run system. The following were provided:

- Standard given by Armstrong ----------25 to 50 liters per 100 kilometer.
- Values of ACBSE ----------40 to 50 liters per 100 kilometer.

As it can be seen above, the values fall in the range. Even the value fall in the range of the standard. The values are at the highest extreme to the standard as a result of congested traffic conditions and the steep terrain of Addis Ababa, in addition to conditions of the vehicles.

5.1.6. Staff ratios

Staff ratio is used to measure ACBSE's performance which is an indicator of service efficiency. The staff ratios are presented in Table 5-6 below with the standard given by Armstrong-Wright (1987).

The current total staff of ACBSE is 3,011 employees, excluding the staff at Jimma branch. The number of administrative staff, maintenance staff, drivers, conductors, and others are 302, 257, 872, 981, and 599 respectively.

Table 5-6 staff ratio standard vs. ACBSE's

Staff	Standard	ACBSE
Total staff per operating bus	3 - 8	5.90
Administrative staff per operating bus	0.3 - 0.4	0.53
Maintenance staff per operating bus	0.5 - 1.5	0.45

The ratio of the staffs to buses actually deployed in commercial service daily, rises further to nearly 8.0 which makes it high and unattractive. Amongst the reasons for the relatively high staff to bus ratio are the means of revenue collection using on-board conductors, and the very high proportion of all-day services provided.

5.1.7. Accidents

The number of accidents occurred over time can be an indicator of service consistency of ACBSE. It is computed as the ratio of the number of accidents occurred by the operating buses to 100,000 kilometers traveled.

The number of accidents occurred per 100,000 kilometers traveled by Anbessa buses for the recent year 2008 E.C (2016/2017) was 7.7 which is way far from the standard

provided by Armstrong-Wright (1987) which is in the region of 1.5 to 3 for a well-run bus company.

The result indicates the existing of poor traffic condition which is the major problem of the City, and the very low standard of driving and road user practices. In addition, the quality of maintenance has a great impact on the result.

5.1.8. Dead mileage (Dead heading)

Dead mileage, another important performance indicator of operational productivity is used as a tool to indicate ACBSE's operational productivity. It is computed as the ratio of dead mileage to vehicle mileage.

It has been very difficult to get an accurate data regarding dead mileage (non-revenue kilometer driven) from ACBSE which was one of the limitation faced in computing the dead mileage. However, approximate calculation was made using engineering judgment and weighting factor which include summing up the distances covered by the buses from and to the depots or overnight parking places with respect to the start and finish points at the terminals. Judgments were made using an assumption, of which half of the buses start service at the pre-set origins of all the 124 bus routes while half of them start service at the pre-set destination of the bus routes. For example, root number 1 which traverse from Megenagna to Kara, 4 buses were assigned 2 of them start service in the morning from Megenagna and finish at Kara while the other two start service from Kara and finish at Megenagna according to the schedule. So the dead mileage is calculated by summing the distances (9 km from Yeka depot to Kara and 1.6 km from Yeka depot to Megenagna terminal) for the assigned buses and multiplying by two to account the non-revenue distance traversed by the buses while returning at the depot for an overnight park. Which will be about 42.4 km. Likewise, the non-revenue kilometers (dead mileage) for the buses in all the roots was calculated and found to be about 4507.3 kilometers per day which produced 7.3% dead mileage when computed as a ratio to the total average daily kilometer driven. The result found was far from the extreme range given by Armstrong-Wright (1987) which is in the range 0.6 to 1.0 percent of total vehicle mileage for a reasonably efficient system.

One of the major reason to ACBSE's high percentage of dead mileage is the location of overnight parking and maintenance depots in relation to the start and finish points of the bus service at the terminals. Recently, some of the buses (about 50 buses) have been assigned to an overnight parking at Leghar, Sidest-Killo, Sansuse, and Minillik square. However, this is not enough, much has to be done in order to save the expenses.

5.1.9. Cost of vehicle services/ Vehicle operating cost (VOC)

VOC have been used to measure the performance of ACBSE as an indicator of operational efficiency of the system. Vehicle operating cost composed of: fuel costs, oil (lubricant) costs, tyre costs, repairs and maintenance labor costs, crew costs, interest costs, overhead costs and depreciation costs. It is the summation of all the above parameters.

HDM-4-VOC (Version 3.2) of the RED model module has been used to compute the vehicle operating cost of ACBSE. HDM-4 Vehicle Operating Costs Module computes, for a particular country, vehicle operating costs and speeds as a function of road roughness for nine terrains and road types and nine motorized or non-motorized vehicle types, which are selected among the possible vehicle types. In this case only two types of vehicles were selected that is bus medium for the Bishoftu rigid bus type and bus heavy for the Bishoftu articulated bus type. The shortcoming of the RED Model is it does not account for overhead costs.

Basic input data like: basic road characteristics, terrain type characteristics, road type characteristics, and economic prices of vehicle, tire, fuel, lubricants, maintenance and crew costs, and interest rate were feed into the model. The basic input data of the unit economic costs for the Anbessa buses are presented in the table 5-7 below. Further detailed pictorial representation of the input data is provided in Appendix II.

Table 5-7: Basic input data feed on the RED model

Basic Input Data		
Economic Unit Costs	Bishoftu Rigid	Bishoftu Articulated
New Vehicle Cost (Birr/vehicle)	1,300,000	1,800,000
New Tire Cost (Birr/tire)	9,700	9,700
Fuel Cost (Birr/liter)	16.23	16.23
Lubricant Cost (Birr/liter)	64.52	64.52
Maintenance Labor Cost (Birr/hour)	56.72	64.78
Crew Cost (Birr/hour)	33.67	38.64
Interest Rate (%)	12	12

Source: ACBSE data record

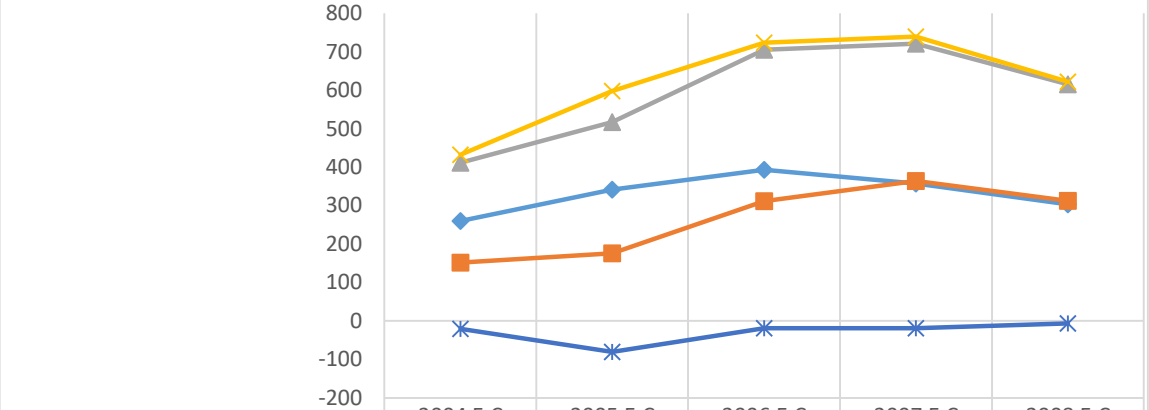
After the necessary data entry, the model executes an Excel macro that computes the results. Here below, the results obtained from the model are presented in Table 5-8. The VOC for terrain type A which is flat and for terrain type B which is rolling and roughness coefficient for a paved road were computed and VOCs produced. Each components of the VOC computed is presented in Appendix II.

Table 5-8: RED-HDM-4-VOCs

		Vehicle operating costs		
Code (label)	**Name (label)**	**Bus Medium ($/veh-km)**	**Bus Heavy ($/veh-km)**	**Average Vehicle Fleet ($/veh-km)**
AX-02	Terrain A / Type X - Roughness 02	7.37	10.38	8.23
AX-03	Terrain A / Type X - Roughness 03	7.42	10.49	8.30
AX-04	Terrain A / Type X - Roughness 04	7.77	10.98	8.68
AX-05	Terrain A / Type X - Roughness 05	8.12	11.50	9.09
AX-06	Terrain A / Type X - Roughness 06	8.47	12.00	9.48
AX-07	Terrain A / Type X - Roughness 07	8.80	12.44	9.84
AX-08	Terrain A / Type X - Roughness 08	9.13	12.89	10.20
BX-02	Terrain B / Type X - Roughness 02	7.35	10.52	8.25
BX-03	Terrain B / Type X - Roughness 03	7.41	10.62	8.32
BX-04	Terrain B / Type X - Roughness 04	7.76	11.11	8.72
BX-05	Terrain B / Type X - Roughness 05	8.13	11.64	9.14
BX-06	Terrain B / Type X - Roughness 06	8.51	12.17	9.55
BX-07	Terrain B / Type X - Roughness 07	8.86	12.64	9.94
BX-08	Terrain B / Type X - Roughness 08	9.21	13.07	10.31

In general, VOCs in the case of ACBSE are very high. Armstrong-Wright (1987) recommends the revenue to cost ratio to be between 1.05:1 to 1.08:1 for the system to be self-sufficient and avoid subsidies. Figure 5-3 below illustrates the trend of ACBSE's yearly revenue, subsidy, expenditure and net income for the past five years 2012 to 2016 (2004 E.C to 2008 E.C).

As it can be seen from the chart, the net cash flow (net income) is negative. In other word, the ratio of revenue to the expenditure is less than one, which means ACBSE is operating at loss. This shows that the cost of operation and maintenance is greater than the revenue collected from subsidy and tariff.



	2004 E.C	2005 E.C	2006 E.C	2007 E.C	2008 E.C
Revenue in millions	260	341	393	357	303
Subsidy in millions	151	176	312	364	312
Revenue including subsidy in millions	412	517	705	721	615
Expenditure in millions	432	598	723	740	622
Net Income in millions	-21	-80	-19	-19	-7

Figure 5-3: Trends of revenue, subsidy, expenditure, and net income

5.2. Performance of the management system

Performance management as it is defined and discussed earlier in Chapter Two is the term used to refer to activities, tools, processes, and programs that companies create or apply to manage the performance of individual employees, teams, departments, and other organizational units within their organizational influence.

ACBSE's managerial performance is measured qualitatively by looking into two criteria: effectiveness and efficiency. Effectiveness is achieved when the organization pursues the appropriate goals while efficiency is achieved by using the fewest inputs to generate a

given output in other words minimizing costs of resources needed to achieve goals (revenues).

Based on the ranking and evaluation of the management activities constructed on the interview made with the different management departments and based on the organization set goals and working standards, ACBSE's management system is qualitatively evaluated.

The operational (fleet) management, maintenance (technical) management, financial (revenue) management, parking management, and personnel (staff management) qualitatively evaluated as discussed below.

5.2.1. Operational/fleet Management

ACBSE's fleet and operational management system involves the management of fleets dispatched and scheduled on route and on time bases for the services provided every day; management of the working force on the operational activities; and management of time for the different operational activities.

Based on the unstructured interview made with the operational management head and other senior staffs on the operational department sector of the Enterprise, the following operational and fleet management problems has been identified:

- Failure to optimize dead haulage which increases vehicle operating costs resulted in incurring unnecessary costs. The management department believes that dead mileage should be monitored and controlled, but there was no effort to quantify and minimize the dead haulage kilometers yet;
- Lack of proper control on keeping schedule regularity of the service provided that made the customers to suffer longer waiting time;
- Inability on providing the fleet size planned to be dispatched for service. Most of the time, below 70% of the fleets are dispatched compared to the planned. Even some of the fleet's breakdown earlier in the day reduce the percentages of availability farther down from the stated value;
- Lack of commitment of some of the operating staffs; and

- Failure to provide at most two drivers per bus for morning and afternoon shift for an operation according to the plan, which resulted in inability to regulate the behaviors of the drivers regarding the damage occurred on the buses.

5.2.2. Maintenance management

The Maintenance Department of ACBSE is under the Technical Service Department. The Maintenance Department manages the three maintenance actions: preventive, breakdown and corrective maintenance activities. The following drawbacks has been identified in the maintenance management activities of the Enterprise.

- Giving a high priority for operational availability than adherence to maintenance schedules, and this inevitably results in a deteriorating technical performance;
- Lack of co-ordination between the operational and technical planning functions meant that distance coverage (kilometer) data for service scheduling were often received too late for integration with other preventive maintenance activities;
- Inability to supply spare parts early on time for the breakdown buses; and
- Lack of standardization of maintenance activities, which most of the time the buses after they have been made ready for operation after maintenance they break again without serving even a kilometer.

5.2.3. Financial (revenue) management

The financial management system of the ACBSE; regulates, controls, monitors, and manages the revenue collected through: normal, contract, vehicle maintenance, and vehicle inspection services. In addition, system performs; the expenses (wages and benefits, maintenance expenses, administrative, insurance, and others); and subsidy from the Addis Ababa City Government (Administration).

Some of the problems of the ACBSE's financial department for its inefficiency in the financial realm are found to be:

- Dependency on subsidy paid by the Addis Ababa City Administration Transport Authority (AACATA) to cover its expenses. Neither has made any consistent commitment to its long-term capital expenditure program;

- Most of the time, large discrepancies occur between the management and audit figures. This is because of lack of proper accounting records and budget control; and
- Lack of commitment and inability to change the unusable assets of the Enterprise into monitory term to generate cash.

5.2.4. Parking management

Parking Management includes a variety of strategies that encourage more efficient use of existing parking facilities, improve the quality of service provided to parking facility users and improve parking facility design. Parking management at ACBSE context focuses on parking at the depots and terminals. Accordingly, to evaluate the parking management, one need to consider parking at depots and terminals separately.

At depot level, the depot placed at Yeka has better parking facilities and management practice compared to the other two depots namely Shegole and Mekanisa. There is poor parking facility at the latter two depots which makes difficult to manage well without having the necessary facilities. Therefore, at these depots, much has to be done to develop the infrastructure. In fact one of the depot found at Shegole is currently under rehabilitation with the necessary facilities including parking. And there is also a plan to rebuild and maintain the Mekanisa depot.

At terminal level, the four major terminals placed at Megenagna, Leghar, Minillik Square and Mercato show that there are poor parking management activities. In fact, it is difficult to say that there is parking management on those places. All the terminals listed above are not designated only for ACBSE's bus fleets, but other transportation service providers also use the terminals which made ACBSE's parking management difficult. Sometimes, the ACBSE buses are obliged to move to the next station without alighting / loading or both of passengers due to lack of space.

5.2.5. Personnel (staff) management

A proper management of staff in an organization is crucial for effectiveness and productivity of the services given by the staffs. On evaluating the staff management of ACBSE the following short comings were identified even though, the management

department believes they are doing at their full capacity in creating a productive workforce.

- Lack of a properly qualified staff procurement at the different departments of the organization;
- Lack of controlling of staff's (drivers, conductors and dispatchers) commitment and punctuality to give service on time;
- Lack of frequent training on how to handle customer complaints and service provision; and
- Providing incentives only for drivers and conductors which discourages other working staffs of the Enterprise.

5.3. Quality of service performance analysis

ACBSE's quality of service has been evaluated based on the defined indicators in Chapter Two and customer opinions as an input for the indicators. As a result, a questionnaire survey was prepared and conducted involving 200 ACBSE's customers where 183 of the questionnaires were fully filled (answered) while the rest were partially filled or not filled at all. Therefore, the analysis was based on the 183 fully filled questionnaires.

The general information gathered from the respondents included the following:

- Sex: of which 46.4% of the respondents were women and 53.6% were men.
- Age: 58% were between the ages of 21-35, while 23%, 11%, and 7% were between the ages of 35-45, above 46, and below 20 respectively.
- Educational level: 61% of the respondents had first degree and diploma while the rest have acquired primary and high school education.
- Occupation: 67% of the customers were employed (both self-employed and employed by third party), 24% were students, and the rest of the respondents were currently unemployed.

About 87% of the customers have used the ACBSE transportation services for more than three years with 69% of them using for more than five years which indicates the larger number of these respondents were expected to have acquired a lot of experience about

the service delivery practice of the Enterprise which may give reliable data based on their experiences to measure the service quality.

Other questions were also asked regarding service quality indicators and are discussed as follows.

5.3.1. Passenger waiting time

Passenger waiting time as one of a service quality indicator was used in measuring the performance of ACBSE's quality and effectiveness of service delivery practice. Based on the customer survey conducted, about 67% of the respondents wait more than 30 minutes to get service, while 24% of the respondents wait 15 – 30 minutes, and others wait 10 – 15 minutes to get service. Figure 5-4 below illustrates customers' opinions on service waiting time for ACBSE's buses.

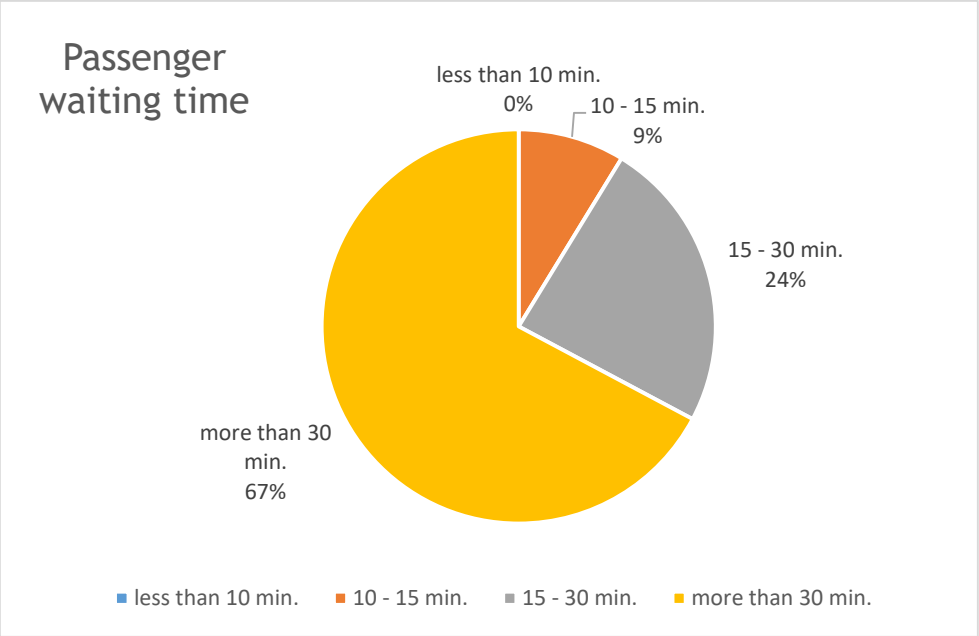


Figure 5-4: Customer opinion on service waiting time

5.3.2. Walking distance to bus stops

Walking distance to ACBSE's Bus Stops was used to measure the performance as an indicator of the accessibility and service coverage provided by the transportation system.

Based on the results of the customer survey, 40 (21.9%), 84 (45.9%), 47 (25.7%), and 12 (6.6%) of the respondents walk in the range of up to 300m, 300 – 500m, 500 – 1000m,

and above 1,000m respectively to access the ACBSE buses service (to and from the bus stops). Figure 5-5 below illustrates the graphical presentation of the same.

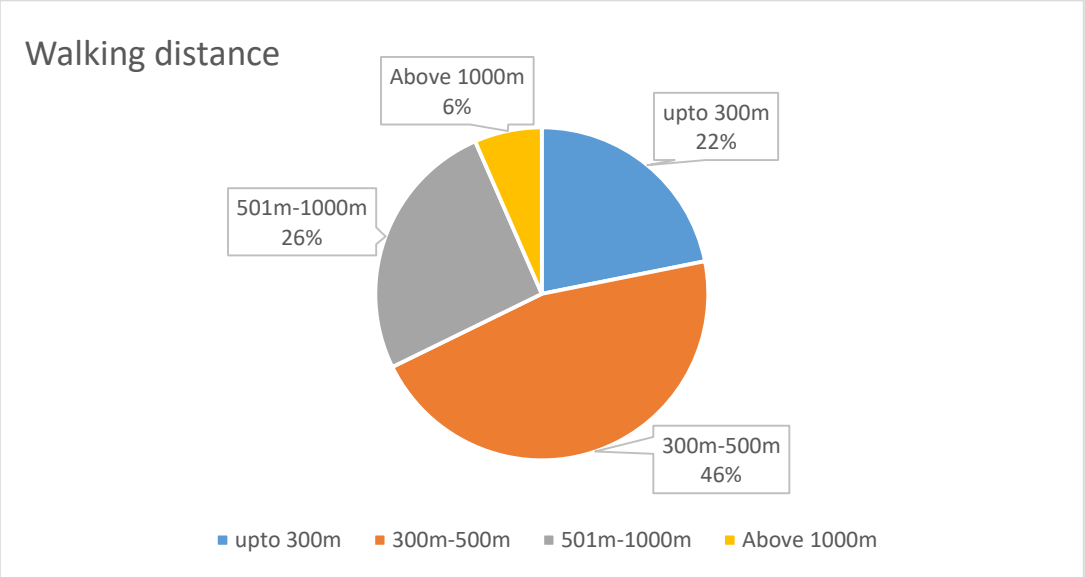


Figure 5-5: Walking distances based on customer survey

More than half, 68% of the customers walk below 500m which is in the range to the standard given by Armstrong-Wright (1987) within 300 to 500 meters for a reasonably well-served urban areas. The standard also put the maximum distance that passengers have to walk to and from a bus stop which should not exceed 1,000 meters. However, about 6% of the customers walk more than a kilometer in the case of ACBSE. But this result is solely based on the customer's opinion about the distance they walk which may not be the real case. So, the result obtained is limited on the accuracy of the answer by the respondents.

5.3.3. Journey times

The third quality of service indicator used in measuring the performance of ACBSE was journey time which could show the adequacy of bus supply, scheduling and routing. From the survey, the following were obtained. Of the total respondents, 67.2%, 27.9%, and 4.9% spent 2 to 3 hours, 1 to 1.5 hours and less than one hour respectively. The result signifies most of the customers spent excess hour for travel. The possible reason could be inaccessibility, inadequacy of bus supply, road condition like congestion, and

others. Figure 5-6 below presents the journey time of ACBSE passengers based on customer service.

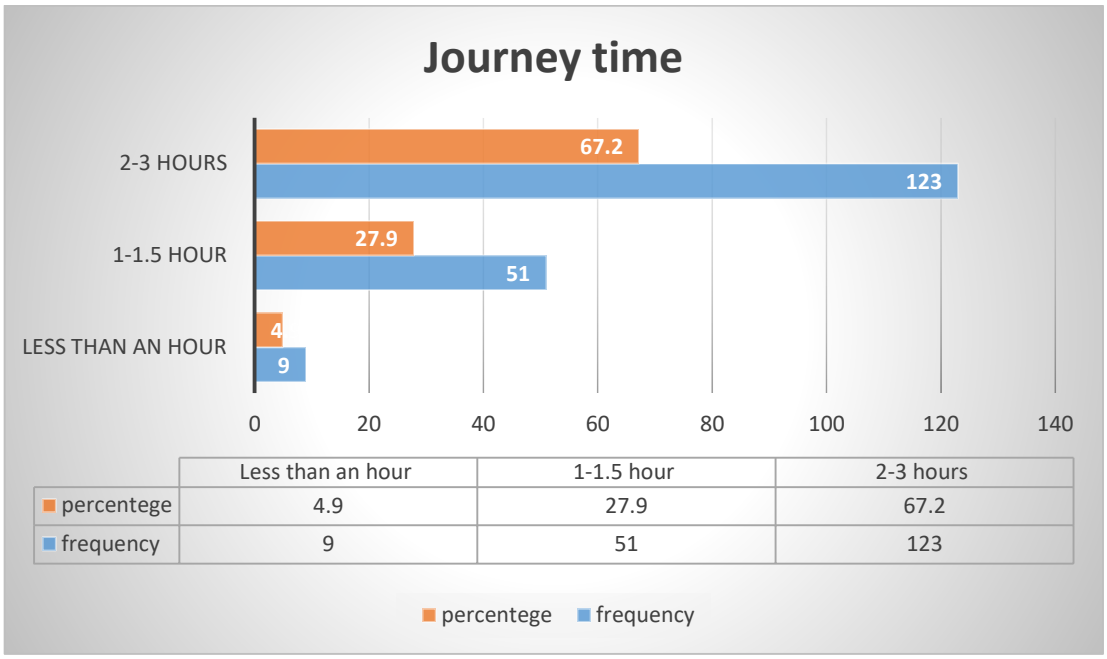


Figure 5-6: Journey time based on customer service

5.3.4. Safety and security

Safety and security was another performance indicator used to evaluate ACBSE. The term "safety" was used to indicate the possibility of being involved in a road accident, while the term "security" was used to the possibility of becoming the victim of a crime. The responded questionnaire indicated the level of safety and security of the ACBSE. Accordingly, the majority of the customers (65%) believe the quality of service given by ACBSE regarding safety and security is below average; 30% believed it is average, while only 4.4% expressed satisfied, filling safe and secured on using the service. Table 5-9 below depict the situation.

Table 5-9: Customers opinions on safety and security of the service given by ACBSE

Magnitude of Factors	Strongly Dissatisfied	Dissatisfied	Average	Satisfied	Strongly Satisfied	Total
Frequency (no.)	24	95	56	8	0	183
Percent (%)	13.1	51.9	30.6	4.4	0	100

5.3.5. Information availability

Availability of information to customers on the service delivered by ACBSE was used as an indicator of service quality in evaluating the performance of ACBSE. Accordingly, the customers responded to the required question (Information regarding basic route line, travel delay and arrival time of buses, tariff, and emergency situation). The result obtained are depicted in Table 5-10 below.

Table 5-10 Customers opinion on information availability on the service given by ACBSE

Magnitude of Factors	Strongly Dissatisfied	Dissatisfied	Average	Satisfied	Strongly Satisfied	Total
Frequency (no.)	105	46	27	5	0	183
Percent (%)	57.4	25.1	14.8	2.7	0	100

As shown in the table above, most of the customers were strongly dissatisfied by lack of information availability at the Enterprise. Some of the customers complained by saying that even the assigned bus on a certain route, change to another route without an announcement making the customers to wait for extra time. In addition, they said that they do not get information unless asked the dispatchers and other staff members of the enterprise by themselves.

5.3.6. Customer care

Customer care was another quality of service indicator used to measure ACBSE's performances and was done using the customers' opinions. The opinions of the customers is illustrated in Figure 5-7 below. The majority (40%) of the customers expressed strong dissatisfaction of the service provided by ACBSE regarding customer care. 33% expressed dissatisfaction, 24% expressed average satisfaction, 3% expressed satisfaction and lastly none has expressed strong satisfaction.

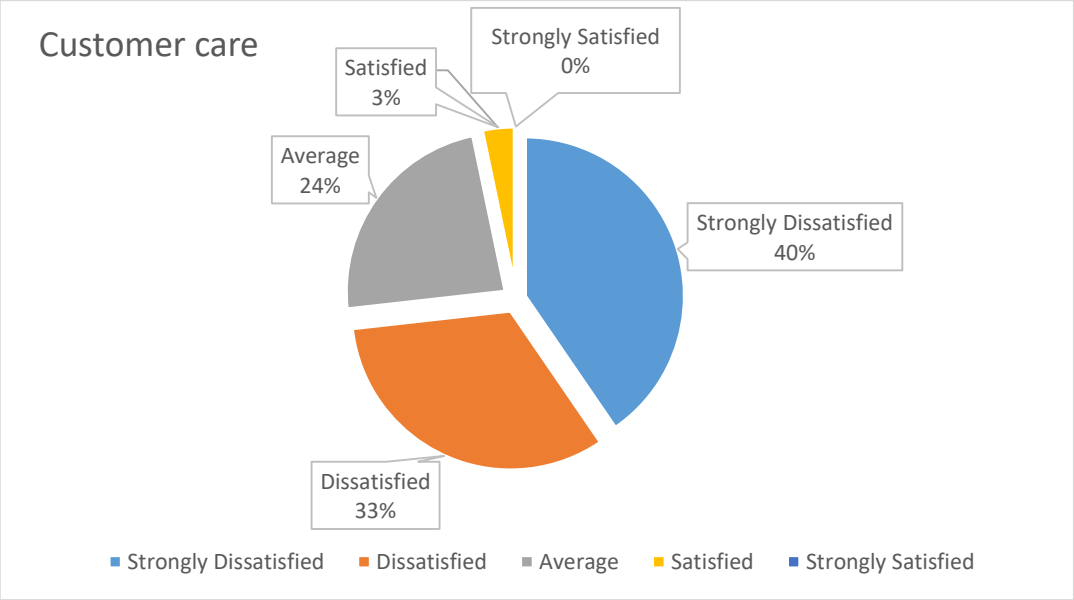


Figure 5-7: Customers' opinion on customer care given by ACBSE

5.3.7. Comfort

The last service quality indicator that was used in the survey was measuring the performance of ACBSE regarding the level of comfort. The comfort measured was regarding crowdedness, neatness, good ventilation and availability of seats in the bus. Accordingly, the following responds were obtained as illustrated in Figure 5-8 below.

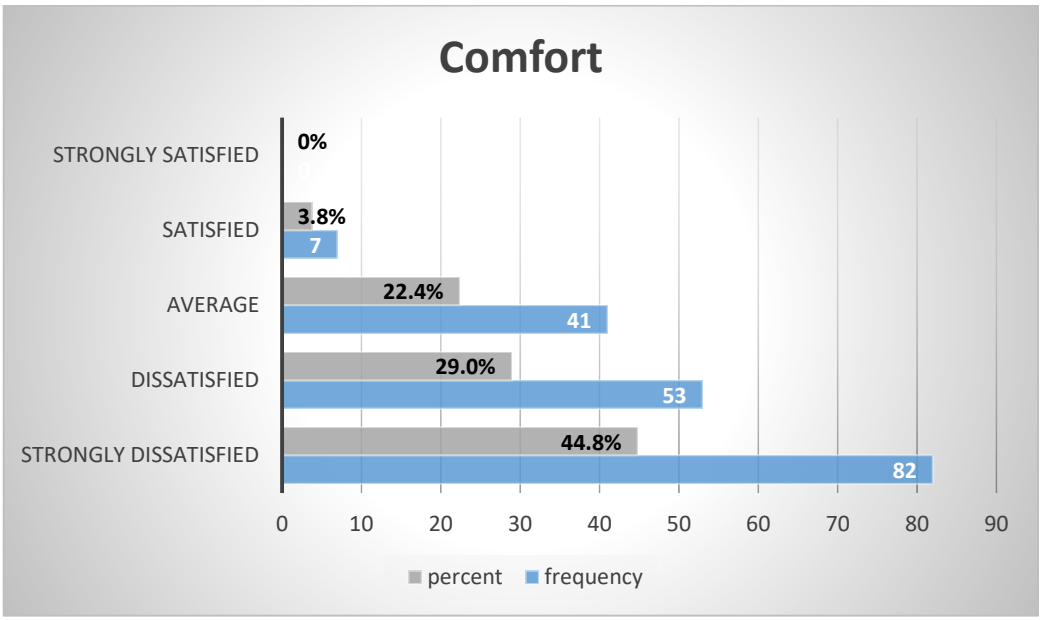


Figure 5-8: Customers' opinions on comfort inside the bus

At last, customers have been asked how they would evaluate their overall satisfaction regarding the service quality offered by ACBSE, and the following results were obtained as illustrated in Figure 5-9 below.

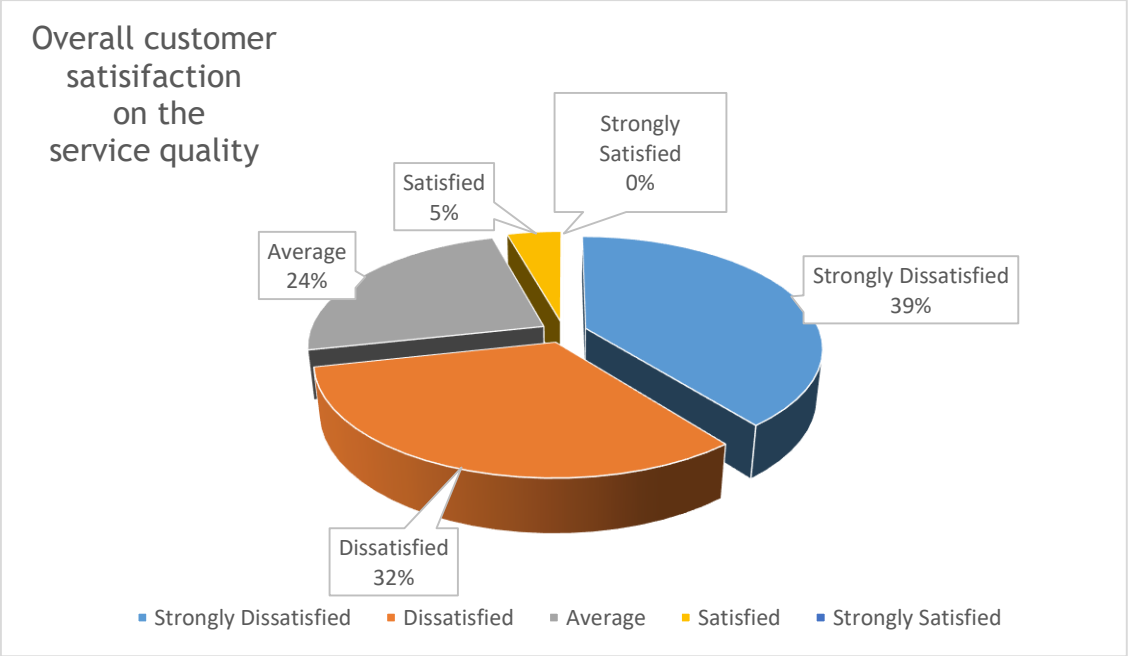


Figure 5-9: Customers overall satisfaction on the service quality of ACBSE

The overall satisfaction as presented in the Figure 5-9 above, 71% of the customers were unsatisfied (customers both strongly dissatisfied and dissatisfied) with the quality of service provided by ACBSE; 24% were averagely satisfied and only 5% were satisfied. The major reasons for the dissatisfactions among various reasons mentioned by the customers were the following:

- High waiting time as a result of failure of the buses to give service according to the schedule headway
- Breakdowns and technical failure of the buses on journey due to ageing of the buses
- Low level of comfort due to overcrowding, lack of neatness, and lack of seat in the bus
- Lack of proper shade at bus stops
- Unethical behavior of some of the staffs of the enterprise

CHAPTER SIX: CONCLUSIONS, RECOMMENDATIONS AND FUTURE RESEACH AREAS

6.1. Conclusions

Evaluating the performance of a public transportation is crucial to identify the root cause of the existing deficiency and shortfall of the transportation system, so that it can be managed for an improvement using different techniques. To do so, performance indicators can be used for the measurement. Three categories of performance indicators were used to evaluate the ACBSE Operational, managerial and service quality performance indicators used to get insight of the existing condition of the Enterprise.

Operational performance indicators evaluate the operating performance of the enterprise using appropriate key performance measures, such as: passenger volumes, fleet utilization, vehicle-kilometers, breakdowns in service, fuel consumption, staff ratios, accident rates, and dead mileage.

Passenger volume per bus per day, kilometer per bus per day, and fleet utilization of the operational indicators used to show productivity of the enterprise. The average passenger volume per bus in a day was found to be below the lower limit given for a well-performing bus system in a developing country. The result in this research showed that there is a low bus operating hour causing low PPBPD due to mechanical breakdown as a result of the ageing effect of the buses. Similarly, the average kilometer per bus per day was found to be below the extreme limit; caused by high rate of break down, poor maintenance and repair, poor road condition, traffic congestion, and vehicle age. The other productivity indicator, fleet utilization was seen in two ways, one as the number of buses operated during the busiest peak period of the day, expressed as a percentage of the number of buses available for use; and the other, as the ratio of the working hour to the daily working hour for a period of five years. As a result, 80.5% of utilization efficiency was found for the recent month of June 2017. Using the former way while much lower decreasing values was found for the past five years in a row 2012-2016 (2004-2008 E.C). From both ways of the computation made, it can be concluded that, there is high mechanical breakdown due to ageing. In addition, there is a high deficiency in the supply of spare parts.

Staff ratio, fuel consumption, and vehicle operating costs were used as operational efficiency indicators to measure and evaluate ACBSE's performances. Staff ratio of ACBSE per operating bus is about 6 which is high caused by using on-board conductors, and the very high proportion of all-day services provided. Buses of ACBSE consume fuel on the average of 40 to 50 liters per 100 kilometers. In spite of congested traffic conditions and the steeply terrain of Addis Ababa, in addition to condition of the vehicles, the values fall near the highest range for a well performing bus. The other operational efficiency indicator, vehicle operating costs (VOCs), figures indicated that the operating cost of the ACBSE was high which makes it unable to cover its costs. The negative net revenue collected by the enterprise indicates this condition, which can be concluded that operations of ACBSE are not profitable.

Breakdown in service is another operational indicator of mechanical reliability used on measuring the performance of the Enterprise. It has been found that the ACBSE fleet breakdown every 2063 kilometer driven on average is very high and frequent compared to the standard. The causes of this were believed to be: ageing of the buses and low driver standards in addition to traffic congestion, bad road conditions, and steeply slopes of the City resulting in frequent vehicle breakdowns. Another important operational indicator of system consistency that is accident occurrence was, measured at 7.7 which is extremely high compared to the standard. Traffic accident which is the major problem of the City is also a problem to ACBSE caused mainly by the existence of poor traffic condition and the very low standard of driving and road user practices.

The second batch of performance indicators, managerial performance indicators, measure the efficiency and effectiveness of the performance of an organization management activity based on set objectives, visions and goals of the organization.

The management activities of the ACBSE which include: operational fleet management, maintenance management, financial (revenue) management, parking management and staff (personnel) management evaluated qualitatively. ACBSE's management activities face various problems that made the management system ineffective and inefficient in some ways. Failure to optimize dead haulage which increases vehicle operating cost; lack of the proper control on keeping schedule regularity; inability on providing the fleet size planned to be dispatched for service are the major causes for the inefficiency of the

operational fleet management activities. While giving a high priority for operational availability rather than adherence to maintenance schedules; inability to supply spare parts early on time for the breakdown buses; lack of standardization of maintenance activities are the main causes among others for the inefficiency of the maintenance management. In addition, dependency on subsidy paid by the Addis Ababa City Administration Transport Authority (AACATA) to cover its expenses; poor parking facilities and management strategies; lack of a properly qualified staff procurement in the different departments of the Enterprise show the deficiency in the financial, parking and staff (personnel) management activities respectively.

The third batch of performance indicators, service quality indicators, measure the quality of service given by ACBSE based on customer survey, such as: passenger waiting time, walking distance to bus stops, passenger journey times, safety and security, availability of information, customer care, and comfort.

Passenger waiting time, as service quality indicator, indicates the service effectiveness of ACBSE. 67% of the customer's surveyed wait more than 30 min to get service, which is high and 68% of them walk up to 500 meters while 26% and 6% walk up to 1,000 meters and above a kilometer respectively that depicts ACBSE's accessibility and proximity of service should be improved. Journey time, operational flexibility indicator of the service quality, 67.2% found to spend 2-3 hours on travel, which signifies most of the customers spent in excess of an hour for travel in a day.

The other service quality indicators: information availability, safety and security, customer care, and comfort measured according to the satisfaction of the customers as 82.5%, 65%, 73%, and 74% are below average respectively. In general, the overall customer satisfaction on the quality of the service delivered by ACBSE found to be 71% below average. The service is thus not satisfactory from a customer perspective, and the quality offered is poor.

Generally, ACBSE's current operational, managerial and service quality performance was found to be poor; which lacks efficiency, effectiveness, and productivity. Integration of ITS and ICT systems promised for an improvement of performance as it can be found through the experiences of different countries that have implemented already. Though there are a number of challenges and limitations for the adoptions of ITS, there is a great

reward and savings after implementation. Moreover, opportunities for improvements on the service delivered should be identified and implemented to tackle the existing problem.

6.2. Recommendations

The research tried to analyze the current performance of ACBSE regarding its operation, management and service quality deficiencies. The situation for the deficiencies unless handled in time, they will continue to impair the performance of ACBSE and continue to deteriorate the quality of its services and may finally force the enterprise out of market. Thus, the following recommendations are drawn under three categories for an improvement.

- *Operational Improvements:*
  - There is an urgent need to replace the very old buses which are still giving service. Since most of the breakdowns in service occurred due to the ageing effect of the buses which are used for operation by ACBSE having more than 15 years, even some more than 20 years of service life.
  - AACATA as the owner of ACBSE, should solve the deficiency of spare parts that made almost half of the Enterprises fleet to be out of service and idle at the depots. As recommendation, AACATA should give the manufacturing and supply of spare parts for a certain companies like MetEC or other companies to save the foreign exchange on importing the spare parts.
  - ACBSE should improve the driver training standards, so that to improve the breakdowns occurring by faulty driving and the high accident rate occurring due to low driving standard.
  - The existing high percentage of dead mileage should be minimized in order to reduce the vehicle operating costs. As a temporary solution, overnight parking of the buses should be done closer to the terminals (especially for those fleets that travel long ways for an overnight park every day) where they start transportation services through co-operation with the city authority. In addition, as a permanent solution the construction of depots closer to the

terminals and to disperse the existing terminals to facilitate overnight parking is significantly necessary.

- *Managerial improvements:*
  - Giving high priority on procurement of qualified staff in required departments of the organization;
  - Modernization of the system using computerization techniques rather than using manual operation for managing activities;
  - To monitor better control on keeping schedule regularity of the service provided. The management should also set up a body of some few supervisors to oversee the work of inspectors
  - ABCSE maintenance management should regulate and control to the adherence of maintenance schedules rather than focusing only operational availability for a better technical performance of the buses.
  - ACBSE staff management should give frequent training on how to handle customer complaints and service provision to satisfy customer needs.
  - ACBSE should pressure AACATA for the purchase of new buses and supply of spare parts to replace the old buses and strengthen its capacity
  - Properly regulating the accounting records that can easily track day-to-day expenses and revenues to eliminate the usual existence of the discrepancies between the management and audit accounts.
  - The idea of integration of an ITS and ICT system should come to existence in order to facilitate and better solve the problems in the management activities.
- *Service quality improvements*:
  - ACBSE should provide better operational and management strategies to make the service quality satisfactory
  - The Enterprise should create a system regarding complaints handling so that it can address the customer's problem on time and satisfactorily.
  - The Enterprise should also give frequent trainings for the staffs on handling of its customers.

- Improving service by announcing current conditions to the customers regarding route lines, travel delays and arrival times of buses, tariff, and emergency situation least to improve the level of satisfaction.
- As it has been said earlier, integration of ICT and ITS systems is highly recommended in order to change the very low level of satisfaction of the customers to a better one.

6.3. Direction for future Research

The existence of other transportation service providers on operation in the city of Addis Ababa should be further studied if had effects on the operation of ACBSE. Moreover, the effect of one performance indicator at the expense of the other as a composite indicator can be studied for further analysis of the situation at hand.

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APPENDIX I-Data from ACBSE

Route characteristics as of 2009 Ethiopian calendar

No. of Routes	Origin-Destination	Distance (km)	Fare (Birr)	Avg. No. of passengers per day	Avg. No. of trips per day	Avg. travel time (min.)
1	Megenagna- Kara	7.7	1.5	846	14	40
2	Kore Mekanissa-Mercato	11.1	2	447	12	46
3	Ayer Tena- Minilik Square	10.8	2	725	10	70
4	Kality-Mercato	19.4	3.5	841	9	90
5	Kore Mekanisa-Minilik Square	12.7	2.6	573	7	53
6	Kera-Semen Addisu Gebeya	9.9	2	387	14	70
7	Megenagna-Aleltu	49	12	741	7	100
8	Kechene-Merkato	9.4	1.5	540	14	38
9	Birass Cilinic Bole School-Piazza	10.5	2	325	9	49
10	Kotebe Collage-Piazza	12.7	2	864	12	53
11	Kolfe-Minilik Hospital	10	2	650	8	60
12	Gurara-Mercato	9.9	2	845	14	58
13	Italy Embassy-Mercato	9.9	2	587	10	48
14	Saris Abo-Minilik Square	12.3	2.6	374	8	60
15	Megenagna-Mercato	10	2	880	12	53
16	Kidanemihret-Mercato	7.9	1.5	779	14	59
17	kusquam-Mercato	9.1	2	926	15	49
18	keraniyo-Mercato	7.3	1.5	783	15	48
19	Asko-Piazza	12.8	2	721	14	50
20	Dile Ber- Mercato	8.6	1.5	540	14	41
21	Flidoro-Mercato	8.6	1.5	940	14	52
22	Summit/condominium/-Legehar	14.3	2.6	760	12	70
23	Lamberet-Mercato	12	2	770	13	53
24	Dire Sololia-Mercato	15.9	2.75	1011	9	70
25	Legehar-Akaki	19	3.5	952	8	80
26	Mercato-Sebeta	25.5	5.5	846	7	74
27	Legehar-Kality	14.9	2.6	530	8	64
28	Asko Sansuzi-Mercato	11.1	2	854	14	51
29	Addisu Sefer-Mercato		2.6	485	7	58
30	Sululta-Mercato	25.8	5.5	774	8	70
31	Legehar-Shiromeda	7.4	1.5	954	15	35

32	Hana Mariyam Kotebe-Legehar	10.6	2	985	12	53
33	Kotebe Gebiriel-4 Kilo	11.4	2	945	15	40
34	Germen Square-Mercato	9.8	2	458	10	60
35	Lebu Musica bet-Mercato	15	2.6	584	8	60
36	Kara Kore-Legehar	11.7	1.5	802	9	70
37	Keraniyo-Minilik Square	12	2	870	10	70
38	Lebu Musica Bet-Germen Square	11	2	541	10	63
39	Bole School Medhanialem-Mercato	9.6	2	498	9	52
40	kara Alo-Mercato	17.9	2.75	708	8	70
41	Eyesus Church-Mercato	8.5	1.5	960	14	50
42	Megenagna-Bole Legehare	9.8	2	401	12	50
43	Megenesha-Mercato	30.2	5.5	750	7	85
44	Legedadi-Mercato	30.4	5.5	537	8	91
45	Legehar-Dilbere	8.6	1.5	798	15	46
46	Gergi-4 Kilo	11.2	2	586	14	41
47	Yenegew Fire School-Mercato	6	1.5	469	13	49
48	Bole Mikhael Square-Minilk Sqare	10.9	2	587	12	49
49	Ayat Condominium-Megenagna	11	2	874	13	40
50	Ayeretena-Megenagna	14.9	2.6	560	13	40
51	Betel Hosipital-Mercato	10.9	2	701	11	51
52	Gergi-Mercato	14.1	2.6	668	10	70
53	Bole Michael-Shiromeda	11.5	2	857	11	67
54	Lafeto-Leghar	9.5	2	546	12	45
55	Legehar-Gurara	9.5	2	724	12	45
56	Saris Abo-Shiromeda	14.2	2.6	870	10	68
57	Kara-Leghar	14.4	2.6	890	10	68
58	Alem Bank-Leghar	12	2	965	10	54
59	Betel Hospital-Mililik Sqare	11.5	2	859	12	54
60	Deber Zeit-Leghar	47.2	8.75	698	4	100
61	Ayat Condominium-Leghar	18	2.75	698	8	67
62	Sebeta-Leghar	23.8	5.5	745	8	85
63	Mercato-Mikililand/Bircheko fabrica	9.1	2	356	10	67
64	6 Kilo-Megenagna Gorfe Aswegaj	9.5	2	804	11	60
65	Mercato-Alem Bank	11	2	560	11	48
66	Mercato-Karakore	10.5	2	890	12	53
67	Mekanisa Jemo-Legehar	10.6	2	904	10	48

68	Torhailoch-Minlik Hospital	10.2	2	561	11	46
69	Philpos Church-Mercato	5.9	1.5	321	9	41
70	Kasanchis-Ayertena	12	2	450	11	71
71	Gerji-Balcha Hospital	10.9	2	597	11	62
72	Hanamariam-Saris Abo	4.9	1	745	15	60
73	Legehar-Wingate School	10.2	2	620	10	70
74	C.M.C Michael-Mercato	14.2	2.75	839	8	47
75	6 Kilo-Kera	10.4	2	879	11	70
76	Megenagna-Kaliti	18.2	2.75	456	9	110
77	Ayertena-Kera	5	1	698	15	35
78	Megenagna-Gofa Condo	12.4	2.6	560	11	70
79	4 Kilo-Summit	14.7	2.6	605	10	53
80	Semen Gebeya-Megenagna	12.4	2.6	753	11	68
81	6 Kilo-Asko	11.1	2	452	10	54
82	Sefera Goro-Balcha Hospital	14.6	2.6	904	15	70
83	Ayat Condominium-6 Kilo	18	2.75	784	9	60
84	Kolfe-Legehar	9.5	2	456	9	60
85	Mercato-Holeta	45	8.75	754	7	90
86	Ayertena-Korki Fabrica	12.3	2.6	865	12	65
87	Wingate college-Ayertena	10.5	2	967	13	42
88	Mercato-Chancho	40	8.75	904	9	90
89	Mercato-Sendafa	44	8.75	444	7	110
90	Bethel Hospital-Legehar	10	2	692	10	73
91	Mercato-Teji	52	12	841	11	85
92	Hanamariam-Balcha Hospital	9.6	2	864	12	41
93	Bole Bulbula-Megenagna	15.2	2.6	715	9	55
94	Piazza-Mekililand Birchko Fabrica	9.9	2	640	13	45
95	Mercato-Addisalem	47	8.75	884	5	100
96	Megenagna-Goro Sefera	9.2	1.5	977	15	58
97	Megenagna-Legetafo	15.8	2.6	984	7	58
98	Dukem-Saris Abo	26.3	5.5	689	7	70
99	Ayertena-Alemgena	9.4	2	886	12	36
100	Jemo Site-Mercato	14.5	2.6	787	10	51
101	Megenagna-Yeka Ayat Con.1sq	12	2	897	10	43
102	Legehar-Karalo	13.7	2.6	789	9	60
103	Jemo -Piazza	12.2	1.25	589	11	59
104	Kera-Worku Sefer	8.3	1.5	323	14	35
105	Lagehar-Anfo meda	12	2	681	10	60
106	Megenagna-Goro	10.8	2	340	10	50
107	Saris Abo-Akaki korkoro Fabrica	11.4	2.00	447	10	50
108	Minilik square-Asco Addisu	9.3	2.00	572	13	50

	Sefer					
109	Saris Abo-tulu dimtu	12	2.00	786	10	45
110	Akaki-6 kilo	24.9	5.50	754	5	85
111	Piazza-Burayu	16.6	2.75	899	7	65
112	Circular Route-Ring Road	9.4	2	799	13	161
113	Kality Total-Koye Feche	8.1	2	718	15	71
114	Saris Abo-Gelan Comdomimium	7.9	2	694	15	71
115	Mexico-Musicabet	9.4	2	436	12	25
116	Jemo kuter 2-Mekanissa	5.6	1	513	12	25
117	Mexico-kotary Condominium	9.2	2.25	481	10	35
118	Tatik kela-Mercato	18	2.75	454	9	70
119	Summit condominium-Megenagna	9.2	2.00	756	11	35
120	Torhailoch-Cherta	12.1	2	421	10	45
121	Jemo Mestawot- Mexico	10	2	455	9	55
122	4 killo-Adisu Gebeya	16.6	3	654	5	55
123	Megenagna-yeka abado		2	980	13	-
124	Megenagna-Akaki kality square	10	5	620	10	-

Yearly operational characteristics parameters for each bus type

2008 E.C									
bus type		working days	trips	passenger	vehicle-km	revenue	working hour	utilization	
DAF	Average	131	1035	74633	11912	112754	904	0.5	46.2
	Maximum	340	4995	382803	53755	515370	4837.06	0.9	94.8
	Minimum	1	1	41	10.6	41	0.85	0.1	5.7
Bishoftu Rigid	Average	195	1798	158089	28578	334127	1828	0.6	62.4
	Maximum	333	4286	488978	87182	919018	3870	0.8	77.5
	Minimum	3	15	1243	209	1940	17	0.4	36.9
Bishoftu Articulated	Average	233	2287	242249	34188	434577	1995	0.6	57.1
	Maximum	337	3737	430365	64580.7	743775	3293.75	0.7	65.2
	Minimum	4	20	2061	288.9	3491.4	18.68	0.3	31.1

2007 E.C									
bus type		working days	trips	passenger	vehicle-km	revenue	working hour	utilization	
DAF	Average	140	1144	80965	12989	127802	918	0.44	43.6
	Maximum	331	3880	279678	44457	542981	3327	0.67	67.0
	Minimum	1	1	15	12	15	1	0.06	6.1
Bishoftu Rigid	Average	200	1969	171648	29747	373276	1813	0.60	60.3
	Maximum	347	4745	517804	74675	1090525	3853	0.74	74.0
	Minimum	2	6	492	115	1355	8	0.26	26.1
Bishoftu Articulated	Average	252	2490	266373	36023	496563	1842	0.49	48.8
	Maximum	351	5285	450392	68552	823051	4218	0.80	80.1
	Minimum	5	21	2153	425	3787	11	0.15	14.7

2006 E.C									
bus type		working days	trips	passenger	vehicle-km	revenue	working hour	utilization	
DAF	Average	145	1579	94084	12356	153418	998	0.46	45.8
	Maximum	348	5967	396535	48805	627263	3923	0.75	75.2
	Minimum	1	1	38	12	63	0.3	0.02	1.7
Bishoftu Rigid	Average	212	3096	203493	32534	437345	2257	0.71	70.9
	Maximum	359	5835	431966	84383	942472	4263	0.79	79.2
	Minimum	2	10	592	23	971	3	0.08	8.4
Bishoftu Articulated	Average	251	3439	287561	30708	521477	2051	0.54	54.4
	Maximum	350	6947	491206	61894	872791	4580	0.87	87.2
	Minimum	1	9	864	104	1728	8	0.52	52.0

2005 E.C									
bus type		working days	trips	passenger	vehicle-km	revenue	working hour	utilization	
DAF	Average	126	1947	74800	11519	129385	1032	0.55	54.6
	Maximum	345	8594	316495	53041	609643	4535	0.88	87.6
	Minimum	1	1	12	7	12	0.35	0.02	2.3
Bishoftu Rigid	Average	231	5335	234046	37570	475475	2970	0.86	85.8
	Maximum	356	9394	439186	81845	967212	5329	1.00	99.8
	Minimum	2	25	1321	185	2594	6	0.19	19.4
Bishoftu Articulated	Average	247	5214	285534	31074	506718	2560	0.69	69.0
	Maximum	356	11511	548615	72288	977627	5311	0.99	99.5
	Minimum	1	3	247	42	247	1	0.06	6.0

2004 E.C									
bus type		working days	trips	passenger	vehicle-km	revenue	working hour	utilization	
DAF	Average	169	3640	134215	23290	261088	1827	0.72	72.2
	Maximum	347	9380	382670	71944	787862	5035	0.97	96.7
	Minimum	2	5	199	0	199	2	0.05	5.0
Bishoftu Rigid	Average	200	5239	219197	31621	408751	2689	0.90	89.5
	Maximum	291	7903	337104	48951	607537	4003	0.92	91.7
	Minimum	86	1680	69861	11659	134286	824	0.64	63.9
Bishoftu Articulated	Average	219	5075	276640	30030	501823	2633	0.80	80.2
	Maximum	309	9449	425399	58596	756580	4611	0.99	99.5
	Minimum	15	292	10368	1744	20120	116	0.52	51.6

Table- fleet utilization month of June 2017 (Sene 2009 E.C)

Month of Sene fleet utilization in %				
Day No. Sene (E.C)	weekdays	No. of operated buses at morning peak	No. of available buses for operation	Utilization %
1	Thursday	366	452	81.0
2	Friday	364	451	80.7
5	Monday	370	456	81.1
6	Tuesday	367	464	79.1
7	Wednesday	340	440	77.3
8	Thursday	369	455	81.1
9	Friday	337	446	75.6
12	Monday	387	456	84.9
13	Tuesday	372	451	82.5
14	Wednesday	362	459	78.9
15	Thursday	360	455	79.1
16	Friday	348	440	79.1
19	Monday	372	450	82.7
20	Tuesday	379	455	83.3
21	Wednesday	357	453	78.8
22	Thursday	349	456	76.5
23	Friday	359	452	79.4
26	Monday	385	461	83.5
27	Tuesday	362	449	80.6
28	Wednesday	355	441	80.5
29	Thursday	362	438	82.6
30	Friday	351	425	82.6
	Total	7973	9905	80.5

APPENDIX II RED-HDM-4-VOC input and output components

Basic Input Data

Country/Region	Addis Ababa
Year	2017

Currency Name	Birr
Exchange Rate Divider to US$	23.17

Terrain Types

Code	Description	Rise & Fall (m/km)	Horizontal Curvature (deg/km)	Number of Rises & Falls (#)	Super_ elevation (%)
A	Flat	15	50	1	2
B	Rolling	20	150	1	2
C	Mountainous	45	300	1	2

Road Characteristics

Altitude (m)	2250.0
Percent Time Driven on Water	0.0
Percent Time Driven on Snow	0.0
Paved Roads Texture Depth (mm)	0.69

Road Types

Code	Description	Surface Type 1-Bituminous 2-Concrete 3-Unsealed	Carriageway Width (m)	Speed Limit (km/hour)	Speed Limit Enforcement (#)	Roadside Friction (#)	NMT Friction (#)
X	Paved	1	7.0	100.0	1.1	1.0	1.0
Y	Gravel	3	6.0	80.0	1.1	1.0	1.0
Z	Earth	3	5.0	70.0	1.1	1.0	1.0

Vehicle Types

Code	Description	Number of Wheels	Number of Axles
1	Not Used	#N/A	#N/A
2	Not Used	#N/A	#N/A
3	Not Used	#N/A	#N/A
4	Bus Medium	6	2
5	Bus Heavy	10	3
6	Not Used	#N/A	#N/A
7	Not Used	#N/A	#N/A
8	Not Used	#N/A	#N/A
9	Not Used	#N/A	#N/A

Vehicle Fleet Characteristics

	Not Used	Not Used	Not Used	Bus Medium	Bus Heavy	Not Used	Not Used	Not Used	Not Used
Economic Unit Costs									
New Vehicle Cost ($/vehicle)	150000	240000	350000	1300000	1800000	400000	420000	780000	890000
Fuel Cost ($/liter for MT, $/MJ for NMT)	21.00	30.00	26.00	16.23	16.23	26.00	26.00	26.00	26.00
Lubricant Cost ($/liter)	24.00	24.00	24.00	64.52	64.52	24.00	24.00	24.00	24.00
New Tire Cost ($/tire)	245.00	275.00	2200.00	9700.00	9700.00	1700.00	2550.00	2550.00	3200.00
Maintenance Labor Cost ($/hour)	26.00	26.00	26.00	56.72	64.78	26.00	26.00	26.00	26.00
Crew Cost ($/hour)	0.00	15.00	15.00	33.67	38.54	15.00	15.00	15.00	15.00
Interest Rate (%)	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Utilization and Loading									
Kilometers Driven per Year (km)	20000	40000	80000	70670	70670	60000	600000	75000	90000
Hours Driven per Year (hr)	800	2000	2500	2500	2500	1500	2500	3000	3000
Service Life (years)	10	9	9	10	10	9	10	10	10
Percent of Time for Private Use (%)	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Vehicle Weight (tons)	1.20	2.00	3.00	6.00	11.00	6.00	12.00	20.00	30.00

Reference Vehicle Adopted to Estimate Roughness as a Function of Speed of Reference Vehicle

Bus Medium

RED-HDM-4-VOC components output

Vehicle Operating Costs Components

		Fuel Costs			Lubricants Costs			Tire Costs			Maintenance Parts Costs		
Code (label)	Name (label)	Not Used ($/veh-km)	Bus Medium ($/veh-km)	Bus Heavy ($/veh-km)	Not Used ($/veh-km)	Bus Medium ($/veh-km)	Bus Heavy ($/veh-km)	Not Used ($/veh-km)	Bus Medium ($/veh-km)	Bus Heavy ($/veh-km)	Not Used ($/veh-km)	Bus Medium ($/veh-km)	Bus Heavy ($/veh-km)
AX-02	Terrain A / Type X - Roughness 02		2.68	4.11		0.14	0.20		0.59	0.79		1.27	1.75
AX-03	Terrain A / Type X - Roughness 03		2.70	4.16		0.14	0.20		0.60	0.81		1.30	1.78
AX-04	Terrain A / Type X - Roughness 04		2.70	4.20		0.14	0.20		0.60	0.83		1.57	2.13
AX-05	Terrain A / Type X - Roughness 05		2.67	4.22		0.14	0.20		0.59	0.85		1.83	2.48
AX-06	Terrain A / Type X - Roughness 06		2.60	4.17		0.13	0.20		0.59	0.86		2.07	2.78
AX-07	Terrain A / Type X - Roughness 07		2.50	4.03		0.13	0.19		0.57	0.86		2.27	3.04
AX-08	Terrain A / Type X - Roughness 08		2.40	3.89		0.13	0.19		0.56	0.83		2.46	3.29
BX-02	Terrain B / Type X - Roughness 02		2.58	4.15		0.13	0.20		0.59	0.81		1.27	1.75
BX-03	Terrain B / Type X - Roughness 03		2.60	4.19		0.13	0.20		0.60	0.83		1.30	1.78
BX-04	Terrain B / Type X - Roughness 04		2.61	4.24		0.13	0.20		0.60	0.85		1.57	2.13
BX-05	Terrain B / Type X - Roughness 05		2.60	4.27		0.13	0.20		0.60	0.87		1.83	2.48
BX-06	Terrain B / Type X - Roughness 06		2.56	4.25		0.13	0.20		0.60	0.89		2.07	2.78
BX-07	Terrain B / Type X - Roughness 07		2.50	4.15		0.13	0.20		0.59	0.90		2.27	3.04
BX-08	Terrain B / Type X - Roughness 08		2.42	4.01		0.13	0.19		0.58	0.88		2.46	3.29

Vehicle Operating Costs Components

		Maintenance Labor Costs			Crew Costs			Depreciation			Interest		
Code (label)	Name (label)	Not Used ($/veh-km)	Bus Medium ($/veh-km)	Bus Heavy ($/veh-km)	Not Used ($/veh-km)	Bus Medium ($/veh-km)	Bus Heavy ($/veh-km)	Not Used ($/veh-km)	Bus Medium ($/veh-km)	Bus Heavy ($/veh-km)	Not Used ($/veh-km)	Bus Medium ($/veh-km)	Bus Heavy ($/veh-km)
AX-02	Terrain A / Type X - Roughness 02		0.46	0.53		0.38	0.45		1.49	2.05		0.35	0.51
AX-03	Terrain A / Type X - Roughness 03		0.47	0.53		0.38	0.45		1.49	2.05		0.35	0.51
AX-04	Terrain A / Type X - Roughness 04		0.52	0.58		0.39	0.45		1.51	2.07		0.36	0.51
AX-05	Terrain A / Type X - Roughness 05		0.56	0.63		0.39	0.46		1.57	2.15		0.37	0.51
AX-06	Terrain A / Type X - Roughness 06		0.59	0.67		0.41	0.47		1.69	2.32		0.38	0.53
AX-07	Terrain A / Type X - Roughness 07		0.62	0.70		0.44	0.51		1.85	2.53		0.41	0.57
AX-08	Terrain A / Type X - Roughness 08		0.65	0.73		0.48	0.57		2.00	2.75		0.44	0.63
BX-02	Terrain B / Type X - Roughness 02		0.46	0.53		0.42	0.49		1.49	2.05		0.39	0.55
BX-03	Terrain B / Type X - Roughness 03		0.47	0.53		0.42	0.49		1.49	2.05		0.39	0.55
BX-04	Terrain B / Type X - Roughness 04		0.52	0.58		0.43	0.49		1.51	2.07		0.39	0.55
BX-05	Terrain B / Type X - Roughness 05		0.56	0.63		0.43	0.49		1.57	2.15		0.40	0.55
BX-06	Terrain B / Type X - Roughness 06		0.59	0.67		0.44	0.50		1.69	2.32		0.41	0.56
BX-07	Terrain B / Type X - Roughness 07		0.62	0.70		0.47	0.53		1.85	2.53		0.43	0.59
BX-08	Terrain B / Type X - Roughness 08		0.65	0.73		0.49	0.57		2.00	2.75		0.46	0.64

APPENDIX III-Interviews and Questionnaire

Interview check list questions to AACATA

The Interview questions listed below are guiding questions. There will be probing questions based on the answers that would be provided by the Interviewee to get more information associated with the study.

- What is the roll of AACATA in the public transportation sector?
- Is there a public transport policy driven and implemented?
    - Yes/no
    - If yes what are the policies, plans and goals of the public transportation?
- What are the pros and cons of the existing public transportation?
- What do you think the major cause of the existing problem?
- How do you address the existing problem?
- Who are the providers of public transportation?
    - Private Public Mixed
- Is there competition between the providers of public transportation?
    - Yes / no
    - If yes, what kind of competition?
- What is the share of each sector (i.e. private and public)?
- Is there a well-established operation and management system of public transportation?
- What are the main components of the operation and management system of the public transportation?
- How does the existing operational and managerial strategy affect the quality and reliability of the whole public transportation system?
- What are the challenges faced in providing operational and managerial strategies in public transportation?
- How can operational and managerial strategies be improved and implemented in the public transportation system?
- What are the future plans to improve the operational and managerial system?
- Is there a plan for an integration of an ITS in public transportation sector?

Interview check list questions to ACBSE

The Interview questions listed below are guiding questions. There will be probing questions based on the answers that would be provided by the Interviewee to get more information associated with the study.

- What are the strategic plans of your organization? (Vision, mission, goal)
- What is the fleet size? Both operational and non-operational
- What are the reasons for those not in operations?
- How many are under maintenance?
- How many are totally out of service?
- What types of vehicles are in operation?
- Capacity of the vehicles?
- What is the average number of passenger per vehicle per trip?
- What are the average vehicle-km and passenger-km?
- How many operational roots available?
- Distance of each root?
- How are the individual routes laid out? What are the factors taken in to consideration?
- What is the average distance of consecutive bus stops?
- How long is the working time of service?
- What is the frequency of service?
- Does this vary with different routes?
- Does this vary during morning/ night peak?
- If so, what are the factors in this variation?
- What are the average waiting time, and walking distance?
- Do you provide service on time according to the schedule?
- If not, how much delay is tolerated?
- What is the average travel time per trip?
- Staff ratio (administrative staff, maintenance Staff, operation staff: drivers and conductors)
- The route map of Anbessa bus?
- Cleaning, checking, and maintaining process….?

- How much revenue does it collect? Is it a self-sustaining system or does it get government subsidies?
- What are the operational and managerial strategies of the whole system?
- What look like the management system (management of: demand, fleet, parking ,finance, personnel, maintenance, communication and information)
- Do you conduct performance measure studies?
- If yes, what parameters are used to measure the performance?
- How does you rate the service offered by Anbessa?
- What is the future plan or proposal to make the system efficient?

Questionnaire used for ACBSE (bus service) customers

Dear respondents, I am a student of AAIT, studying on road and transport engineering Master's Program. The purpose of this questionnaire is to collect data for the study entitled "Analyzing Public Transportation Operations and Management in the City of Addis Ababa: A Case study of Anbessa City Bus Service Enterprise". To achieve the objective of the study your genuine, frank and timely response is vital. Therefore, you are kindly requested to read the questions carefully and give accurate data.

Note: The information you give is strictly for academic purposes and kept confidential.

Instruction:

- Please fill in the questionnaire by putting '√' on the blank boxes provided and write on the blank spaces.
- It is not necessary to write your name
- Kindly, do not hesitate to explain your true feeling

Thank you, in advance for your kind cooperation and timely response.

1. Demography information
   - Sex

     1) Male ☐ 2) Female ☐

   - Age

     1) 20 and Below ☐ 3) 20-35 ☐

2) 35-45 ☐ 4) 45 and above ☐

- Education Level

1) Grade 1-12 ☐ 3) Degree ☐

2) Diploma ☐ 4) above degree ☐

- Occupation

1) Student ☐ 3) Not employed ☐

2) Employed ☐ 4) Retired ☐

2. Questions related to the topic

- For how long have you been a customer of the enterprise?

1) Less than 1 year ☐ 3) 3 – 5 years ☐

2) 1- 2 years ☐ 4) More than 5 years ☐

- For what purpose do you mostly use public transport?

1) School ☐ 3) leisure ☐

2) Work ☐ 4) other ☐

- How long do you walk to and from bus stops?

1) up to 300m ☐ 3) 500m-1000m ☐

2) 300m-500m ☐ 4) above 1000m ☐

- How long do you spend for a journey (includes: walking time, waiting time and travelling time) on buses throughout the day?

1) less than an hour ☐ 3) 2 to 3 hours ☐

2) 1 to 1.5 hours ☐

- How long do you wait at the bus stop?

1) Less than 10 min ☐ 3) 15 to 30 min ☐

2) 10 to 15 min ☐ 4) more than 30 min ☐

- How do you rate your level of satisfaction regarding the safety and security of the Anbessa bus service?

1) strongly dissatisfied ☐ 3) average ☐ 5) strongly satisfied ☐

2) dissatisfied ☐ 4) satisfied ☐

- How do you rate your level of satisfaction regarding the comfort (regarding crowdedness, neat, good ventilation and availability of seats) in the bus?

  1) strongly dissatisfied ☐ 3) average ☐ 5) strongly satisfied ☐
  2) dissatisfied ☐ 4) satisfied ☐

- How do you rate your level of satisfaction on the availability of information and communication to Anbessa service providers regarding basic route line, travel delay and arrival time of buses, tariff, emergency situation and other information?

  1) strongly dissatisfied ☐ 3) average ☐ 5) strongly satisfied ☐
  2) dissatisfied ☐ 4) satisfied ☐

- How do you rate your level of satisfaction on customer care of the Anbessa bus service?

  1) strongly dissatisfied ☐ 3) average ☐ 5) strongly satisfied ☐
  2) dissatisfied ☐ 4) satisfied ☐

- How do you rate your level of satisfaction on the quality of the Anbessa transportation service overall?

  1) Strongly dissatisfied ☐ 4) Satisfied ☐
  2) Dissatisfied ☐ 5) Strongly satisfied ☐
  3) Averagely satisfied ☐

- What do you think the main reasons for your level of satisfaction in the previous question?

  _____

  _____

- What is your suggestion for Anbessa transportation service to improve its quality of service?

  _____

  _____