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Zone-based fare integration for public transport in the case of Addis Ababa city

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CERTIFICATE

This is certifying that the thesis entitled “Zone-based fare integration for public transport in the case of Addis Ababa city” is a personal work carried out by Toyiba Mohammed. This is the actual work done by Toyiba Mohammed for the partial fulfillment of the requirement of the award of Degree of Masters of Science in Railway Engineering (Civil infrastructure) from Addis Ababa university, Addis Ababa.

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Abstract

The most important technique to establish an efficient and modernized public transportation system is to conduct studies on it. In terms of economic and social growth, public transportation is essential. Furthermore, providing integrated fare systems is critical for creating effective public transportation that enables the pursuit of objectives such as maximization of demand, maximization of revenue, profit, and social welfare. The goal of this research is to propose a fare integration system of public transportation using a zone-based fare structure in the case of Addis Ababa city.

The study reviewed the current fare system, identify economic and social problems due to the lack of a fare integration system, examined the best zone partition and zone-based fare setting approaches, and proposed, identified, and verified the main benefits of the applying zone-based fare integration system of public transportation such as maximization of revenue, maximization of profit, reduction of fare, and minimization of passengers waiting time. In order to create the fare integration system, the zone is partitioned analytically using the value of the weighted mean travel distance of the ride in a city and the K-means clustering algorithm is employed to model the segmented zone and the zone-based fare also determined based on the principle distance- based expense.

Accordingly, the new proposed system for users' 16.66% reduction of fares, 32.33% minimization of passengers waiting time and for operators' maximization of revenue by 31.52% and maximization of profit by 75.77% against the existing system. And the result clarified using a numerical explanation with a graph.

Keywords: *Fare integration system, public transport, zone-based fare, and K-means clustering algorithm.*

Acronyms and Abbreviations

AA	Addis Ababa
AACPTA	Addis Ababa city public transport authority
AALRT	Addis Ababa light rail transit
DF	Distributed fare
IF	Integrated fare
KM	Kilometer
LRT	Light rail transit
PT	Public transport

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Public transport is one of the most important basic requirements for economic growth and social activities by creating network between service providers and users. This sector is used to provide an appealing chain of services in a "door to door" relationship, integrating various modes of public transportation, public and individual transportation, and transportation policy in terms of spatial planning and infrastructure investment (Mrnková et al. 2017). When it is possible to use a single travel document for which the price does not depend on the type of mode or the number of means used but only on the quantity of transportation purchased and passengers use different modes with its integrated journey. Users, operators, authorities, and the general public all benefit from public transport integration. When public transportation is integrated, it creates a more attractive system since people can use it with the concept of "one network, one timetable, one ticket, and one fare from door to door" (Integration et al. 1998).

Public transport integration system is concerned with best practices methodology, physical management, and operational abilities for improved performance in which each mode is integrated and the connection is completely unified including fare, ticket, and schedule. Integrated public transportation system address a lot of advantage for both users and operators such as supports free and healthy competitions while reducing unhealthy competitions, combines all modes of transportation into a single system to deliver transportation services, improve the efficiency of all modes of transportation when compared to operating each mode independently, cost minimization, reliability and safety, aims to meet the needs of customers (passengers) as quickly and efficiently as possible, and encourages co-operation and harmony among the transportation industries. And there are different choices of fare system on public transportation such as flat-rate fare, zone-based fare, and distance-based fare approach. All of those fare systems had their own fundamental goals, such as providing a simple and clear tariff system, a standardized ticket assortment, uniform tariff regulations, constant price differences between

zones (for zone tariff), price hike limitations at zone boundaries (for zone tariff), and linear tariff for single and multi-trip tickets. However, the goal of this study is to propose a zone-based fare integration system for public transport in the case Addis Ababa city. In general, implementing integrated fare system is one way to mitigate the current public transportation problem. Plus, applying zone-based fare structure offers its own set of advantages such as transparency and simplicity, customer orientation, the ability to cover a vast geographic region, ease of handling for operators, fairness for users and operators, reduction of fare and minimization of waiting time for users, and maximization of revenue as well as profit for service providers.

1.2 Problem statement

Due to the current fare structure, Addis Ababa city public transportation system is unable to provide the benefits of public transport. The existing unintegrated faring system in Addis Ababa city public transport causes a lot of problems like the reliance of system on goods and individuals, the high cost of ongoing staff training, the large number of staff required, the difficulty of easy management, and boldly observed traffic congestion, free riding, theft on passengers, poor revenue from tickets, long queues, manpower costs, wastage of time, and the ongoing increase in transportation fees. That is why, the current city public transportation service does not address the interest of users' as well as operators'. Instead, Public transport is responsible to satisfy society's interests by reducing traffic congestion, cost minimization, sharing different aspects of society's life by meeting new people, increasing mobility, and freeing up time. In order to minimize such kind of problems and to address public transportation benefits many scholars at different time proposed their solutions by applying different parameters to partition the zone and to set the zone-based fare. And they partitioned the zone using station network in Saarland, Germany and origin-destination of passengers in Zilina municipality, Solvokia and Haifa, Israel and the zone-based fare also set by means of stopping distance of passengers, trip frequency, and travel time approach respectively.

Nevertheless, the zone partition and the zone-based fare setting approaches of the reviewed scholars were applying either users or operators centric and it couldn't be applied directly for Addis Ababa city because of the two main reasons. First; the existing zone partition approaches such as station network and origin-destination of passengers due to the reason of city's

topography where the stations located and doesn't represent the ride distance of vehicles respectively and they couldn't accommodate the providing of fair benefit of the public transport service. Second; their zone-based fare also set by applied the methods stopping distance of passengers, trip frequency, and travel time are not suitable due to the reasons stopping distance of passengers doesn't represent the length of trip ride distance, the actual distance of each trip in a city has different length with their own different trip frequency, and to apply travel time based system the service providers should cover long distance with short travel time unless it couldn't be suitable and it contrast the current city traffic congestion.

1.3 Objective of the study

To answer the research questions correctly, the researcher has set the following general and specific objectives.

1.3.1 General objective

The general objective of the study is to propose a zone-based fare integration system on public transport in the case of Addis Ababa city.

1.3.2 Specific objectives

The study aims to propose a zone-based fare integration system based on the following specific objectives.

- 1.To identify the best zone partition and zone-based fare setting approaches for Addis Ababa city's public transport.
- 2.To examine economic and social impacts caused by the lack of a fare integration system of public transport in Addis Ababa city.
- 3.To propose zone-based fare integration system of public transport for Addis Ababa city.
- 4.To evaluate the proposed zone-based fare integration system.

1.4 Research questions

The study was conducted to answer the following research questions, which includes: -

- 1.What are the best zone partition and zone-based fare setting approaches for Addis Ababa city public transport system?
- 2.What are the economic and social impacts due to the lack of fare integration system of public transport in Addis Ababa city?

3. What are the improvement on users' and operators' side benefits due to the proposed zone-based fare integration system?

1.5 Significance of the Study

The research has the following contributions: -

- ✓ This research helps to create and develop an awareness for AACPTA and AALRT professionals, managers, and other concerned individuals on the benefits of the zone-based fare integration system of public transport in the case of Addis Ababa city.
- ✓ Presumably, the discipline of integrated public transportation system in all aspects like fare integration, ticket integration, timetable integration, and infrastructure integration are still not yet in our country and more research works are required in that regard. Therefore, this give chance for others who are interested in the fare integration systems and also helps as a reliable point of reference to make further studies on the subject adding values of knowledge and to practice the system in our country.
- ✓ The study also serves as an input for policy analyzers and decision makers of public transportation service provider firms.

1.6 Scope of the study

The scope of this research is limited to study on a zone-based fare integration system of public transport in the case of Addis Ababa city had been constructed.

1.7 Limitation of the study

While conducting the study, the researcher faced a limitation of lack of well-organized data in the selected firm and lack of related literatures. Furthermore, the data is collected through self-administered questionnaires, some questionnaires are not returned, and some questionnaires are not answered completely. However, the above mentioned problems were confronted, the researcher was used maximum effort to minimize the effect of those limitations on the result of the study through distributing more questionnaires greater than the required number of respondents by adding contingency questionnaires.

1.8 Definition of key terms

To understand what the researcher meant to express, terms utilized in this study must be operationalized in order to be familiar throughout the research. The study put the definition of

fare integration system, public transport, zone-based fare, and K-means clustering algorithm as follows.

Fare integration system - is a public transportation fare payment system in which users pay only once but can use two or more modes of public transit (Hulu and Kusuma 2020). It also facilitates payment among numerous modes of transportation and promotes non-congested transit.

Public transport - is also known as public mass transit or simply transit and is a mode of local transportation that allows a larger group of people to travel together and is available to the public (Rodrigues, Barros, and Oliveira 2019). It also contrasts with private transport, which is often operated on a timetable, operates on established routes, and costs a set fare for each journey.

Zone-based fare - is a fare calculated based on the origin and destination of zones and group transit stops or stations into geographic or political zones (Silva et al., n.d.). And the transit users pay according to the number of zones traveled within or through.

K-means clustering algorithm - is an approach for partitioning a dataset into K separate and non-overlapping sub-groups (clusters), each of which contains just one data point (Puntambekar and Verma, n.d.). It divides a set of N objects into K number of clusters using the input value of K and the similarity of clusters is quantified in terms of the object's mean value.

1.9 Organization of the study

The paper was organized in to five chapters. The first chapter deals with the introduction; including background of the study, statement of the problem, objective of the study which includes general and specific objectives, research questions, significance of the study, scope of the study, limitation of the study, and definition of key terms. The second chapter is concerned with the review of related literature in the wide sense of the research topic. The third chapter describes about research design and methodology employed while undertaking the study. The fourth chapter is about data presentation, analysis, and discussion and the final chapter is about summary of findings, conclusions, and recommendations based on the data presented, analyzed, and concluded. Finally, references and appendices are included.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The findings from various reviewed literatures are presented in this chapter on the subject of zone-based fare integration system, an overview of fare system, definition of fare integration, benefit of fare integration, classification of tariff system on public transportation service, and tried to summarize some related works with zone partition and zone-based fare integration system of public transport for the study has been discussed.

2.2 An overview of fare system on public transportation

Fare refers to the delivery of a service to the passengers based on the value of customers perceive to have been acquired from the product and what they are prepared to pay for it. In general, when fares are raised, patronage declines. The functional relationship between fares and patronage determines whether revenue increases or decreases as a result of a fare increase (Paulley et al., 2006). As the result, cities should aim to make the fare system appealing and simple to comprehend for all users in order to increase the usage of public transportation and meet user needs. The fare structure should be consistent and straight forward with a sufficient number of tickets to meet the needs of users.

Fare is a direct and flexible instrument to influence passengers' behavior and cost recovery of a public transportation system (Borndörfer et al., 2012). One of the most important elements to determine public mass transit ridership is fare level. Fare level can play an essential role in the operation of an urban transportation system when used as a lever to change transit trip demand and supply. To encourage people to use public transport rather than private car, the public transportation system must meet their needs and cities aim to make the fare system should be simple to understand for every public transport users and operators.

2.3 Defining fare integration system of public transport

Fare integration system is the integration of all transport services into a single ticket with one leg that is valid for any transport mode (Paulley et al. 2006). Particularly, in public transport journey is called integrated when it is possible to use a single travel document for which the price does

not depend on the type of mode or the number of the means used but only by the quantity of transport purchased and passengers use different transport modes and services. And this is crucial in order to promote an easy and attractive public transport system. Integrated fare system of public transportation makes the whole travelling experience simpler and easier. Travelers are able to obtain tickets without knowing the distribution of their trips with each mode, so they perceive the system as more reasonable and attractive way. And this integrated public transportation system allows for the better coordination of fare policy. An integrated fare system of public transportation seeks to combine fares for multi leg journeys into a single fare and besides network and timetable integration, a further important step in implementing an integrated public transportation system is the integration of zone-based fare (Douglas, Economics, and Farm 2017).

2.4 Benefits of fare integration system for public transportation

Fare integration system of public transportation is a service refers to the ability to use any public transportation service in a local or regional area regardless of modes type, transportation tariffs, schedules, or ticket systems (Errampalli, Patil, and Prasad 2020). It is also a system which required to enhance comfort, information, trip time, and cost to address the needs of users as well as operators from public transport. Integrated public transportation fare system attempt to maximize demand, income, profit, and social welfare (Koháni, 2015). The system used to address different benefits. First, that maximizes revenue based on specific customer interests or governmental goals. The second, the system has been adjusted to maximize profit while also including operational expenditures on the lines. The third, model tries to increase demand for the transportation service as much as possible and besides these approaches, the system has the social welfare maximization also.

And in order to construct a good tariff system, it is necessary improve and implement the practice of integrating fare system of public transportation pricing methodologies (Borndörfer et al., 2012). This refers to the total value of both suppliers' and users' advantages. However, non-integrated public transportation system tend to neglect operators ability related with the provided services and customer needs, which ultimately result in a decrease of ridership and follow different problems and inconveniences for the side of customers, operators, and authorities due

to travel time (where connection and timetables between public transport operators are not harmonized), comfort (more than one ticket is required for a single-trip ride), costs (in some traffic relations, parallel and competitive services exist), and information (the passengers faces a non-transparent system of tariffs). Public transport fare integration system is being practiced in the cities of some developed countries and the system had been indicated and minimize the critical problems and inconveniences by applying the fare integration system of the public transportation. Benefits vary according to the level of integration and an advanced integration level brings a wide range of benefits for the public, individuals, and for the company (Errampalli, Patil, and Prasad 2020). For the public, the ease and convenience of purchase provided by the new fare integration systems in a city should encourage more people to use public transportation, resulting in fewer private cars entering the city, and more customer satisfaction obtained. For individuals, a new fare integration system can benefit every public transportation user because the new system offers better customized to each person's needs and travel patterns. Passengers can save their money and time when public transportation is integrated because the best pricing for the journey is calculated. For companies, public transport companies benefit from this measure by an increased number of passengers generated by the service.

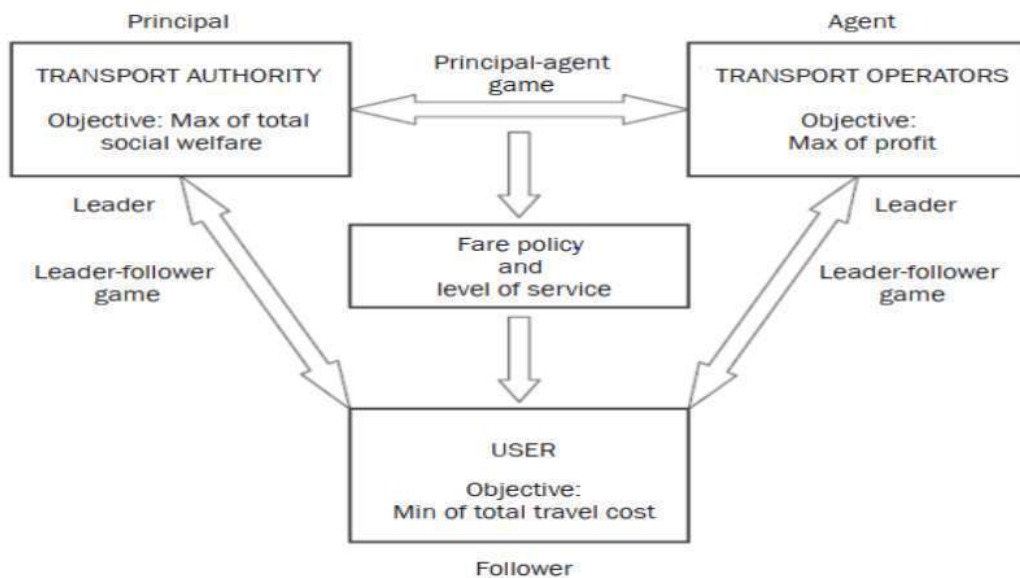


Figure 2.1 The relationship between parties when establishing a tariff system

2.5 Classification of tariff systems in public transportation

This complex real-world problem was brought our attention by public transportation company several years ago (Hamacher, Schöbel, and Hamacher 2004). While working on the design of tariff system in public transportation there are several possibilities of fare for defining ticket prices in public transportation as follows.

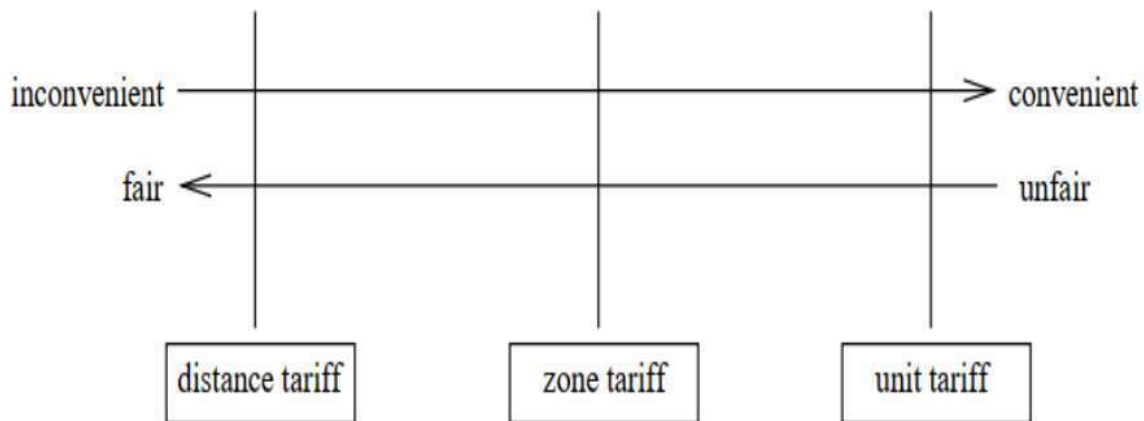


Figure 2.2 Comparison of different types of tariff systems

2.5.1 Distance-based tariff system

The cost of a trip is determined by its length. The higher the fare, for the longer the journey. This system is widely seen as equitable. The distance between two stations is needed to calculate ticket pricing. For both the public transportation service providers and the users, this makes a distance tariff inconvenient with limited transparency. However, it has its own advantages by providing easiness of use for operators and a high tariff yield.

2.5.2 Flat rate tariff system

In this situation, all journeys are the same price regardless of length. The flat rate applies the same fare for all trips and it is the most straight forward and cost-effective policy to implement. On the other hand, the flat rate fare is particularly unfair to short-distance travelers, who are charged the same as long-distance customers. In general, the public does not accept the flat rate fare (Hamacher et al., 2004).

2.5.3 Zone-based tariff system

This is a model that compares the two tariff schemes. The territory is divided into sub-regions in order to generate a zone tariff. On some specific routes or lines, several fare levels are available at varying quality levels. The primary goal of zone-based fare is to encourage car owners to leave their vehicles in favor of public transportation (Hamacher et al., 2004). Reliable, frequent, and high quality public transportation should be provided with the set of timetables can be used as a substitute for private car travel. This kind of tariff system has the advantages of transparency and simplicity, users' orientation, cover vast zones, and ease of handling for operators. In a zone tariff system, the price of a trip is determined only by the originating and ending of the zones. There are two main types of zone tariff, those are arbitrary and counting zone prices. Tariff system is called a zone tariff with arbitrary prices if the price for each pair of zones can be chosen arbitrarily.



Figure 2.3 Zone tariff system with arbitrary price

And the second most popular type of a zone tariff system is counting zone tariff system. To know this fare in this system a customer counts how many zones will pass and read the price assigned to the number of crossed zones.



Figure 2.4 Counting zone tariff system

2.6 Related works

For any research, it is better to include good practices and experiences related to the title of the study. Based on this, the study tried to take as the guidance the experience of different city practices on zone-based fare integration systems in order to be aware the way of how they partition the zone, set the zone-based fare to integrate the public transportation system, and to address their study gap. And the study reviewed some European cities which practice zone-based fare integration system of public transport such as, Saarland in Germany, Zilina municipality in Slovakia, and Haifa in Israel.

Saarland in Germany

Obviously, when unintegrated public transportation system replaced by zone-based fare integration the system is suitable for both operators and users by maximizing their revenue as well as profit and can obtain reduction of fare and minimization passengers waiting time respectively. This means that neither the public transportation company nor the customers will have major disadvantages when changing the current tariff system to a zone-based tariff system (Hamacher et al. 2004). Almost all tariff associations in Germany have previously implemented zone-based tariff schemes and Saarland also one of the German city and practice zone-based tariff system. Saarland principle station network model to partition the zone using the three different algorithms such as clustering theory algorithm, greedy algorithm, and spinning tree algorithm and divided the city into nine groups. The fare for the partitioned zone also was designed based on the stopping distance of passengers. However, those zone partition and zone-based fare setting approaches is difficult to implement directly for Addis Ababa city due to the difficulty of topography where the stations are located and stopping distance of passengers' based fare setting approach also doesn't represent the vehicles full trip ride distance.

Zilina municipality in Slovakia

Zilina municipality is the fourth largest city of the central European country of Slovakia. Zilina municipality is the city uses public transportation services and applied integrated zone-based fare system of public transport. In order to partition the zone, they principled origin-destination of passengers. The three different algorithms such as clustering theory algorithm, greedy algorithm, and spinning tree algorithm were used to partition the zone like Saarland. And the Zilina municipality public transport fare system was set by taking an assumption all of the existing line had equal trip frequency. Those zone partition and zone-based fare setting mechanisms are not suitable to apply directly for Addis Ababa city public transport due to the presence of two reasons. First, the applied zone partition approach doesn't represent the origin-destination of vehicles or the full trip length of the ride and it couldn't address operators side welfares. Second, applying trip frequency based zone fare setting mechanism by treating the fare equally for Addis Ababa city is not fair due to the reason of the actual trip distance in a city has different length

with their own different trip frequency between short and long distance and treat the fare equally on different trip has its own economic and social impacts on users as well as on operators.

Haifa in Israel

Haifa is one of the city which located in the north of Israel and it is the hub of the third-largest metropolitan area. The city has a population around 1 million and 50% of which live in the city itself (Sharaby and Shiftan 2012). Haifa principled origin-destination of passengers' movement to partition the zone like Zilina municipality. The new integrated fare policy changed the history of complex pre-boarding fare system divided into five zones with zone-based fare system by using free transfers and reducing fares. The city public transportation system created a zone-based fare structure in 2008 using travel time-based fare setting mechanism. Nevertheless, those zone partition and zone-based fare setting principles are not appropriate for Addis Ababa city public transportation. The reason behind origin-destination of passengers' approach to partition the zone is already mentioned before. And travel time-based fare setting principle, Israel facilitate large number of trip frequency per day and the system can be relatively fair for users as well as for service providers. However, in order to set the zone-based fare based on travel time for Addis Ababa city public transportation the service provides should be cover large distance with a short period of time and owing to the city traffic congestion, this system doesn't fit and couldn't obtained an appropriate benefit.

2.7 Summary

As the literature reviewed with different perspective, public transport is one of the most important basic requirements for country economic growth and social benefits. Transit system and ridership has grown dramatically as a result of coordinated policies to manage urban form and ensure balanced investment of Bus and Train transit system. Integrated system of public transport services is a system use single ticket with one leg that is valid for any transport mode. The experience of the cities had demonstrated that integrated public transportation fare system adopted strategies which give priority of mixed public transportation environment for both Bus and Train, gained user satisfaction, enhance comfort and sharing of information, minimize traveling time, make the whole travelling experience simpler and easier, supports further development of the transit system, and improved safety and operation of the service. Integrated

fare system of public transportation has its own benefit for public, individuals, and company. And it can be designed in different ways such as flat rate, distance-based, and zone-based fare system. Zone-based fare system is the fair tariff system for users and operators rather than flat and distance-based fare system. The study aims to propose zone-based fare integration system and tried to summarize three cities which practiced this system. The zone-based fare integration system practiced in the selected cities with their own different zone partition and zone-based fare setting mechanisms. As the reviewed indicate the cities obtained different benefits due to the applied fare integration system by taking the fare reduction mechanism as a principle in order to attract public transport users and reform the three important contributions: first, it encouraged travelers to shift from private cars or taxi to public transport. Second, avoid excessive crowded by increase trip frequency and can offering more opportunities for activity participation. Third, it increased travel options by allowing travelers to choose a better mode. And the three selected cities applied their own approaches to integrate the system as mentioned before. Meanwhile, the reviewed literatures tried to partition their zone based on different parameters for instance station network and origin-destination of passengers. And both of them zone partition approaches pleasing better consideration for users benefit rather than service provider sectors. However, public transport service providers also need some consideration and this study tried to fill the gap by applying an appropriate way of zone partition and zone fare setting in order to address both users' and operators' benefits. The users obtained fair transportation service and the service provider firms also gain fitting revenue. However, directly applying others scholars zone partition approaches are impossible for Addis Ababa city due to the difficulty of topography where the stations are located and the existing different origin-destination distance of passengers doesn't represent the length of full trip. And their zone-based fare setting mechanisms also doesn't fulfill both side welfare like stopping distance, due to the absence of equal origin-destination of passengers and vehicles. Second trip frequency, it also related with trip distance the longer the trip the low frequency and vice versa, and third, travel time it mainly depends on the travel distance coverage and in order to apply this principle the service providers should cover long distance with short time or high trip frequency should be exist and it couldn't suitable with the existing city traffic congestion.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter concerned with the description of the research methodology, which is used to carry out the research methodology in chronological order and explains the procedures and tasks to be completed the study. It describes research design, research approach, research methods, source of data, methods of data collection, and methods of data analysis. Finally, ethical considerations and summary of this chapter included.

3.2. Research design

Research design is the conceptual framework of the research and it is used to structure the research, to show how all of the major parts of the research, work together, and try to address the central research questions (Kitula,2010). It is also a master plan of the research that specifies the methods and procedures for measuring and analyzing the necessary information. This study is designed to propose a zone-based fare integration system of public transport for Addis Ababa city.

3.3. Research approach

3.3.1 Existing zone partition approaches

Approach A

Station network approach - it is one of the existing zone partition approach in Saarland, Germany. This zone partition approach applied directly by taking two, three, four, and five stations as one zone. In Saarland, Germany this zone partition approach practices, were focused for only users' side interest. And their tariff setting system was also relatively matched with their zone partition approach which was the stopping distance. However, when we come to Addis Ababa city public transport route, most of the route originates from similar place or station and most of the route doesn't intersect one another on a common station and some of the route share only roundabout. And this route behavior creates difficulty to implement this zone partitioning approach directly for Addis Ababa city due to the topography of the city where the stations are located and the existing of different route path. Due to those reasons this type of zone partition

approach is not possible to create easy, accessible, and fair zone for users and operators on Addis Ababa city public transport. And this city public transport route behavior specifies using figure as follows.

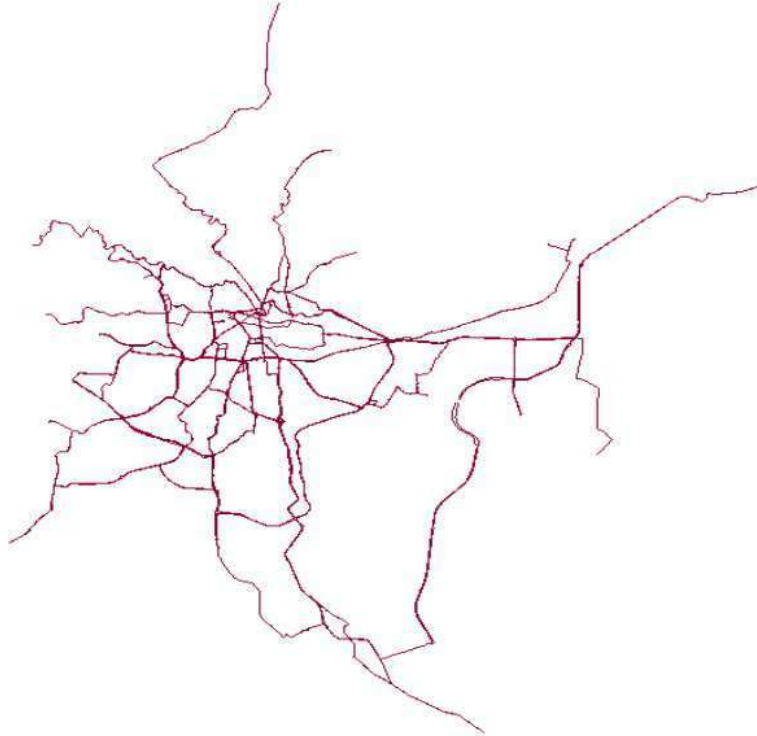


Figure 3.1 Addis Ababa city public transport route

Approach B

Origin-destination of passengers - it is the second zone partition approach which practiced in Haifa, Israel and Zilina Municipality, Solvakiya public transport. Origin-destination of passenger doesn't represent the origin-destination of vehicles or the full trip length of the ride. Due to the reason behind this zone partition approach taken more attention for users' benefits rather than the consideration of both side benefits like the first mentioned approach. The zone partition approach should be taken in to account about the vehicle origin-destination also in order to create an easy zone access to count the zone by users as well as by service providers. And the study was allowing for larger geographical distances to be traveled for the same fare and it doesn't include the price reduction principle for short distance travelers. This approach doesn't recognize the substantial network growth and the dynamic behavior of demand which mean cause some

disadvantages even users side also. Therefore, by applying this zone partition approach for Addis Ababa city public transport in the hope of addressing parallel benefit for users and service providers absolutely difficult.

3.3.2 Existing zone-based fare setting approaches

Approach A

Stopping distance of passengers'- this fare setting approach applied directly based on each trip stopping distance. The price for the trip is based on the distance between arrival and destination of the trip station. And all stopping distance are not equal and cause the fare value either increasing or decreasing. However, they were set the fare by taking an assumption of equal treatment for the fare variation. And this way of fare setting mechanisms couldn't address both side benefits even also has its own impacts on users according to the objective of using zone-based fare system. On top of that, this approach couldn't be match and applicable for Addis Ababa city public transport due to the reason of the existing un equal and different length of trips. And as the developing city public transportation firm, this equal price variation treatment causes its own economical as well as social problems on both users and operators side also. And this cause disadvantage either for users or operators and it will be impossible to fulfill and address both side benefits. And it is necessary to consider users as well as operators to find an impartial zone-based fare system. Service providers also need an appropriate concern in order to maximize the service providers' ability to fit the demand request of users by maximizing the numbers of vehicles and the users should have to pay an appropriate payment for the provided service.

Approach B

Trip frequency - it is the second fare setting approach which applied in Zilina Municipality. The fare was set based on trip frequency by taking an assumption of the existing line had equal trip frequency. And the aim was maximization of demand simply based on the principle the lower the cost the higher the demand, when the fare was setting. However, the demand change was only within 3% and not satisfied. Applying the method equal trip frequency assumption to set the zone-based fare in Addis Ababa city is not fair due to the reason of the actual distance of each trip in Addis Ababa city has their own different length. And the short distance route has high trip

frequency and long distance low trip frequency which mean there is inverse relationship between distance and trip frequency. When the number of trips high, the operating cost will be high and it doesn't fulfill the principle of create an impartial zone-based fare system. However, when we come to Addis Ababa city public transport service the city has a large demand rather than the ability of the operators' supply. And on top of that, there is congested traffic flow. As well as when the tariff set using trip frequency, the city traffic flow related with travel time should be taken in to account which mean the required number of trip to give service without any interruption related with time or other factor unless the price doesn't make equal benefits for both side.

Approach C

Travel time- it is the third fare setting approach, which practice in Haifa, Israel. In Haifa, the city public transportation had fast trip frequency like Train 2000 and Bus 6500 trips per day. Due to the reasons of this high trip frequency the researcher assumed travel time fare setting mechanism. And the result shows significant change on reduction of fare and annual revenue within 22.87% and 25% respectively. However, 42% of the respondents reported being happy or even very happy with the reform, 41% being in different about the reform, and 16% being unhappy with the reform. When those in the last group were asked why they were not happy, they complained about service characteristics unrelated to the price integration reform, such as bus frequency and crowdedness. The travel time cost tend to increase with variability, arrival uncertainty, and particularly high for unexpected delays during activities with strict schedules such as business travel and commuting. If the driver is usually able to catch up with the planned schedule during off-peak periods and maybe overcrowded or even more severely delayed during on-peak periods. And travel time based fare has its own impacts on service providers as well as users like activity of empty service to address exact time service, maximization of trip makes high operating cost, and increment of transportation fee. Due to those traffic congestions related problems travel time based zone fare setting approach doesn't suitable for Addis Ababa city public transport.

3.3.3 Zone partition approach for Addis Ababa city

The aim of the implementation of a zone-based fare integration system to be avoid excessive traffic crowded by sharing different mode, reduce transportation fee compare with non-integrated system, minimize passengers waiting time, and create easy transit system from the user point of view, and for maximization of the revenue and profit from the operator stand point of view. On a theoretical ground, those issues are settled and depend on the way of zone partition and on the value of the zone-based fare. This research tried to follow an appropriate methodological framework to partition the zone which is the weighted mean travel distance of the ride in a city based on research objectives with the consideration of both users' and operators' benefits. The main reason behind skip other scholars approach, they were mainly focused on users' side benefits. The weighted mean travel distance of the ride in a city had been taken as a diameter of the zone due to some reason like it is an appropriate approach to create proportional zone, easy for handling, suitable to create fair zone-based fare, to create a compatible zone with the transport network according to city topography, and to address fairness for both users and operators.

3.3.4 Zone-based fare setting approach for Addis Ababa city

Other countries applied different approaches to set a zone-based fare using either users or operators centric. However, this study applied distance-based expense approach to set the zone fare. When applied this method which is used to set the zone-based fare, it considers both users' as well as operators' centric to find an impartial zone-based fare system. Zone-based fare system is as close as possible to the distance-based fare, for the fares of the distance-based fare system are highly correlated with the actual distance of trips. Based on this reliable reason the study applied distance- based expense fare setting approach to fulfill the objectives of the study as well as to obtained an appropriate result in order to address the benefits of a zone-based fare system.

3.4 Research method

Research method is a systematic and scientific procedure of data collection, compilation, analysis, interpretation, and implication relating to any problem (Williams 2007). Research methods can be classified into several categories according to the study to be conducted. And in this study the researcher applied descriptive and explanatory research methods. Descriptive

research method helps to describe, compare, analyze, and interpret the events. Whereas explanatory research method helps to explain a social phenomenon by asking a question “Why?” and tried to answer the problem. In this case the researcher not only describing but also analyze and explain why or how ineffective current system examination, then it undertakes causes and reasons. Therefore, the researcher used both research methods.

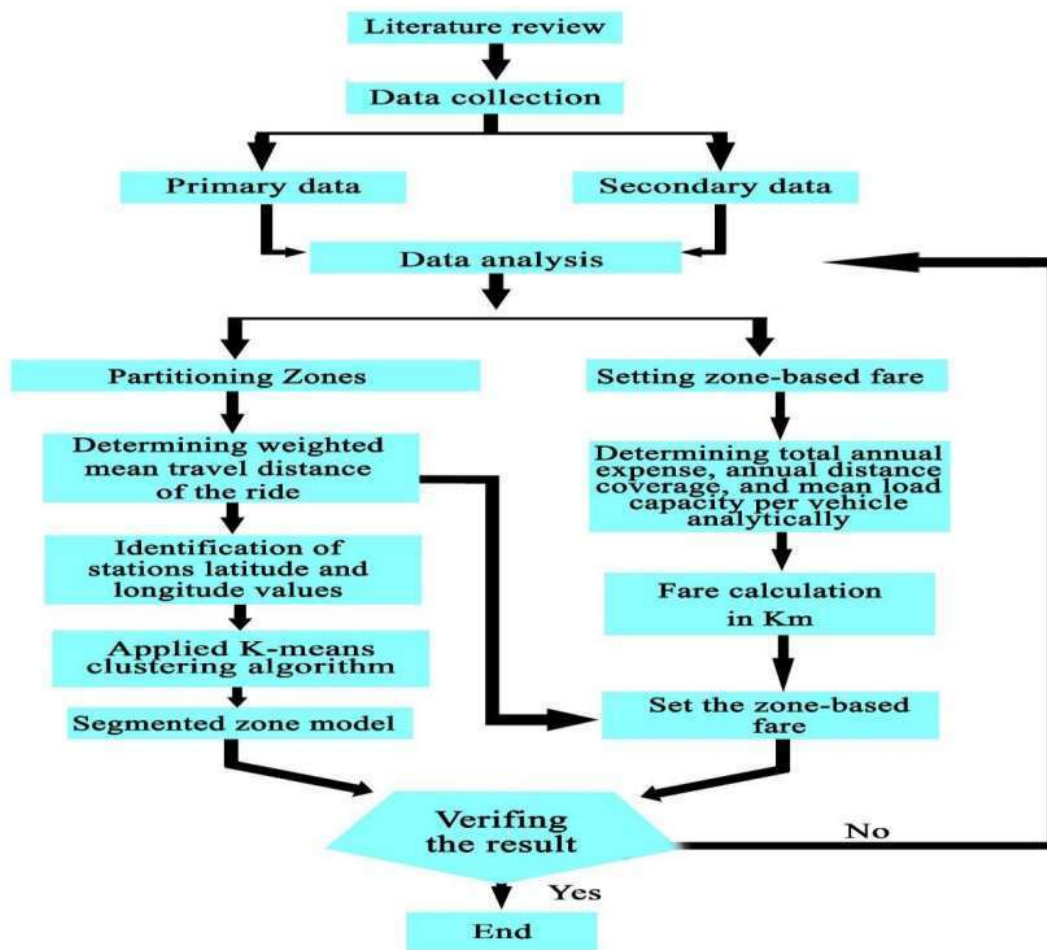


Figure 3.2 Research methodology flow chart

3.4.1 Sample size

Sampling is the process of selection depending upon the type of sample to be used. In order to collect the actual current waiting time of passengers, the target population consist average total

number of daily passengers. And the researcher used for this study 50% response rate and the remaining 50% non-response rate and the sample size determined by using Kothari 's (2004) formula in the following way.

$$n = \frac{z^2 \cdot p \cdot q \cdot N}{e^2(N-1) + z^2 \cdot p \cdot q}$$

Where, p = proportion of success = 50%, q = proportion of fail = 50%, n = sample size, z = confidence level = 1.96, e = standard error = 5%, and N= total number of target population = 258,762 to calculate the sample size by using the formula stated above. Therefore, the sample size was calculated from the number of 258,762 target populations in the following way.

$$n = \frac{z^2 \cdot p \cdot q \cdot N}{e^2(N-1) + z^2 \cdot p \cdot q}$$

$$n = \frac{(1.96)^2 (0.5)(0.5)(258,762)}{(0.05)^2(258,762-1) + (1.96)^2(0.5)(0.5)}$$

$$n = \frac{248,515}{647.8} = 383.6 \approx 384$$

Therefore, the minimum sample size required to represent the daily number of passengers was 384 number of respondents.

3.5 Sources of data

There are two source of data, namely primary and secondary data. Researcher might use either both or one of the types of data depends on the research type and data collect by researcher Saunders et.al, (2009). For this research, the researcher used both primary and secondary sources of data. Primary source of data are first hand data which come from the original sources and can control the design as well as data collection process. Whereas secondary source of data are studies made by others for their own purposes and they are relatively cheap as compared to primary source of data.

3.5.1 Primary sources of data

Primary data may be collected through different data collection mechanisms such as questioners, interviews, and observations. It is originated by a researcher for the specific purpose of addressing the problem at hand Malhotra and Birks, (2006). For this research purpose, primary

data was collected through open ended questionnaires, interviews, and observation. Those were the data collected by the researcher and used for the first time. This data provides raw form of information according to the needs of the study.

3.5.2 Secondary sources of data

Secondary data are the ones which are not collected or gathered by the researcher directly, the data had previously collected, analyzed, documented, and published by someone else for some other purpose. Books and periodicals, government sources, regional publications, commercial sources, media sources, and selected internet sites are some examples of secondary data sources (Saunders et al, 2009). This research used internal and external sources were used to collect secondary data related to public transport activities. Internal sources for this study were archival documentation collected from the concerned organizations and analyzed, which included information such as distance of each trip, annual expense and annual revenue of each firm, annual number of users, and other related variables. Reviewing various literature from several perspectives, public articles, journals, scientific research, and various fare integration books were used as an external sources of secondary data for this study.

3.6 Data collection instrument

Kothari (2008) suggested that, data collection has significant role in order to present a trustworthy research. The researcher depends on data collection method to achieve the research objective. For collecting the primary quantitative and qualitative data used a self-developed questionnaires containing self-assessment items through open-ended questions were distributed for the respondents, including a contingency to compensate invalid and uncollected questionnaires. And the researcher used the following data collection instruments.

i. Questionnaire

To collect necessary information from the selected organizations, open-ended questionnaires were prepared and distributed to the respondents. Open-ended questions allowed to the respondent to have a variety response options. The questionnaire had been prepared in English, because all the respondents can understand English in a simple way. Data collected from questionnaires were cross checked against those collected through interview, observation, and

document review. The researcher insured the reliability of data by receiving information only from reliable authoritative sources.

ii. Interview

The interview method of data collection allowed for the collection of reliable information from the respondents. It also allowed the interviewer and interviewees to interact more effectively, clarify issues, and learn more about the questions and answers. Applying interview also used to obtain the data which is related with collected by questionnaire in detail. And face-to-face interview is better than questionnaire due to the creation of reliable, explained, and clear information with direct interaction.

iii. Observation

The researcher was able to gather information through observation in which information could not easily be gathered with other methods and this technique chosen to collect data from the sources. And it allows the researcher to see practically the problem on the ground, enabling to raise more questions relating to the objective of the study, and had a room to verify the truth of the statements provided by the respondents through questionnaires and interviews.

3.7 Methods of data analysis

The data analysis procedure included the process of packaging the collected information and put in ordering and structuring its main components in a way that the findings can be communicated. The data analyzed by applying both descriptive and explanatory data analysis methods and the result presented using statistical tools like tables and figures.

3.7.1 Zone partition method

To partition the city into a number of zones, the first step had been collected all the target lines and their weighted parameter data of public transportation from AACPTA and AALRT. And based on the collected weighted parameters data, the weighted mean travel distance of the ride in a city had been determined and assigned the number of zone analytically. Second, in order to model the segmented zone by using code syntax identified all city public transportation stations latitude and longitude values and taken as input of an algorithm.

i. Determination of weighted mean travel distance of the ride in a city

In order to partition the zone, weighted parameters such as number of vehicles, mean capacity of vehicles, mean daily trip frequency of vehicles, and each trip distance for both Bus and Train were used. Applying those weighted parameters used as a track to address the benefits of both users' and operators'. And based on those parameters weighted mean travel distance of the ride in a city had been determined as follows.

$$\text{Weighted mean travel distance of the ride} = \frac{\text{Total travel length of the ride}}{\text{Total number of passengers}}$$

$$\mu_d = \sum_{i=1}^n \left(\frac{(L * N_b * C_b * F_b) + (L * N_t * C_t * F_t)}{(N_b * C_b * F_b) + (N_t * C_t * F_t)} \right) \quad \text{Equation 3.1}$$

Where:- μ_d - Mean travel distance of the ride

$N_{b/t}$ - Number of Bus/Train

$C_{b/t}$ - Mean capacity of Bus/Train

$F_{b/t}$ - Mean daily trip frequency of Bus/Train

L - Ride distance from origin to destination for each trip

ii. Identification of stations latitude and longitude values

Based on the routes of city public transport, all stations latitude and longitude values of both Buses and Trains had been collected using open street map. And in order to cluster the zone, all the collected stations latitude and longitude values had been taken as input of an algorithm.

iii. Code creation

The code creation had been done by applied K-means clustering algorithm using python programming language. There are reasons behind applying code creation to segmented the zone rather than using analytical partitioning technique only such as to obtained the centroids of the segmented zone without long and tedious process by professionals if it is required and to create good and an appropriate zone coverage area to address fairness for both users and service providers. And in order to partition the zone by applying K-means clustering algorithm with python programming language, the six different packages were imported.

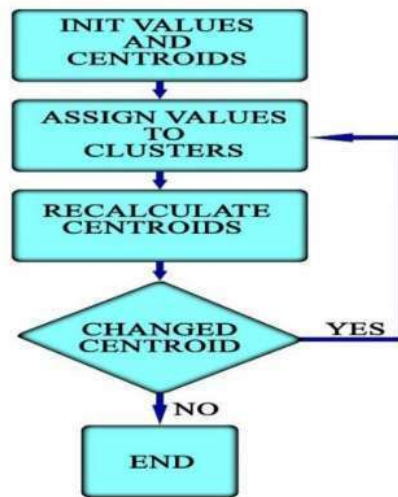


Figure 3.3 K-means clustering algorithm flow chart

First, Numpy is one of the fundamental library of python, used to perform scientific computing and calculations across arrays. Second, Pandas is used for manipulating numeric data and time series by importing data from Microsoft excel and it built on the Numpy library. Third, State models is allowing users to explore data, estimate statistical models, and perform statistical tests. Fourth, Matplotlib it is used for plotting graphs with the help of other libraries like Numpy and Pandas. Seaborn is the fifth Python library package used for plotting graphs with the help of Matplotlib, Pandas, and Nump. And Matplotlib and Seaborn depended each other. The Sklearn is the sixth required Python library package contains a lot of efficient tools for machine learning and statistical modeling including classification, regression, and clustering. After imported those required package, all the collected stations latitude and longitude values are taken as input of an algorithm and modeled the segmented zone based on the number of cluster.

3.7.2 Setting of zone-based fare

The research applied distance-based expense to set the zone-based fare using analytical calculation of data analysis method. And to set the zone-based fare the study tried to determined annual total expense per vehicle, annual distance coverage per vehicle, mean load capacity per vehicle, and fare per kilometer per seat had been determined orderly.

iii. Determination of mean load capacity per vehicle

The mean load capacity per vehicle determined based on the total number of vehicles and their capacity as follows.

$$\text{Mean load capacity} = \frac{\sum_{i=1}^n (\text{Number of vehicles in each route} * \text{Capacity of vehicles})}{\text{Total number of vehicles}}$$

$$M_{LC} = \frac{\sum_{i=1}^n ((N_A * C_A) + (N_S * C_S) + (N_T * C_T))}{N_{AT} + N_{ST} + N_{TT}} \quad \text{Equation 3.4}$$

Where:- N_A - Number of Anbesa bus C_A - Mean capacity of Anbesa bus
 N_S - Number of Sheger bus C_S - Mean capacity of Sheger bus
 N_T - Number of Train C_T - Mean capacity of Train
 N_{AT} - Total number of Anbesa bus N_{ST} - Total number of Sheger bus
 N_{TT} - Total number of Train

iv. Calculation of fare per kilometer per seat

$$\text{Fare per kilometer per seat} = \frac{\text{Total annual expense per vehicle}}{\text{Annual distance coverage per vehicle} * \text{Mean load capacity per vehicle}}$$

$$F_{KS} = \frac{A_{TE}}{A_{DC} * M_{LC}} \quad \text{Equation 3.5}$$

Where: - F_{KS} - Fare per kilometer per set
 A_{TE} - Total annual expense per vehicle
 A_{DC} - Annual distance coverage per vehicle
 M_{LC} - Mean load capacity per vehicle

v. Setting of zone-based fare per seat

Zone-based fare per seat = Fare in kilometer per seat * Mean travel distance of the ride in a city

$$F_{ZS} = F_{KS} * \mu_d \quad \text{Equation 3.6}$$

Where:- F_{ZS} - Zone-based fare per seat
 F_{KS} - Fare in kilometer per seat
 μ_d - Mean travel distance of the ride in a city

3.8 Fare distribution for each public transport firm

The integrated fare had been distributed for each public transport firm depending on their annual distance coverage. The total and each annual distance coverage of an enterprise structured as follows.

$$\text{Distributed fare for each firm} = \frac{\text{Each firm annual distance coverage}}{\text{Total annual distance coverage}} * \text{Integrated fare}$$

$$D_F = \frac{A_D}{T_{AD}} * I_F \quad \text{Equation 3.7}$$

Where:- D_F -Distributed fare

A_D -Annual distance coverage of each firm

I_F -Integrated fare

T_{AD} -Total annual distance coverage

3.9 Verifying the result

The data gathered from primary and secondary sources is organized and analyzed in a systematic manner using the methods used to partition the zone and to set the zone-based fare. And the interpretation had been done on the main benefits of the proposed zone-based fare integration system. And the result presented graphically.

3.10 Research ethical considerations

Each discipline should have its own ethical guidelines regarding the treatment of human research participants Vanderstoep and Johnston, (2009). Research ethics deal with how we treat those who participate in the studies and how can handle the data after he/she collected. And the researcher kept privacy of specific individuals from being known and keeps the information confidential. Accordingly, the questionnaires were distributed to voluntary participants and have a clear introduction and instruction parts regarding the purpose of the research and in this study the researcher was carefully considering honesty and confidentially. When questionnaires were distributed by the researcher informed them about its objectives and the respondents are filled the questionnaires by themselves on voluntary basis without any pressure. In terms of respondents' right to privacy, the study maintained the isolation of each

participant's identity. In all cases, names were kept confidential and instead collective names such as the respondents, the participants, the interviewees, etc., used in the study.

3.11 Summary

As the research methodology is the blueprint or plan of the research, this section has made detail explanations concerning on the research designs that the researcher has used. The mixed approach was used that both quantitative and qualitative data incorporated and research design was used to describe and explanatory cross section. In addition, primary data was collected by using self-developed open ended questionnaires, interviews, and observations and secondary sources of data also done. Furthermore, weighted mean travel distance of the ride in a city using K-means clustering algorithm with python programming language was applied to model the segmented zone and distance-based expense applied to set the zone-based fare. The next chapter deals about data presentation, analysis, and discussion of the study.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The main objective of this study is to propose a zone-based fare integration system for public transport in the case of Addis Ababa city in order to address the benefit of integrated fare system for public transport. In this regard, this chapter presents the results and discussion of the study based on the collected data and the result had been presented using tables and graph. The chapter covers response rate, data analysis, and results and discussion of the analysis. Finally, included the chapter summary.

4.2 Response rate

To propose integrated zone-based fare structure in the case of Addis Ababa city public transport, Addis Ababa city public transport authority (AACPTA) and Addis Ababa light rail transit (AALRT) were selected for questionnaires and interviews to acquire an appropriate data through effective conduct of the survey procedure. It is believed that reliable and clear information about the current fare system and their company future plan had obtained in Addis Ababa city. The primary data was obtained from concerned professionals and managers of AACPTA and AALRT based on purposive sampling questionnaires and interviews. And secondary data also collected from concerned organizations, books, and journals.

In order to collect the required data to partition the zone and to set the zone-based fare the study applied unstructured interviews with 5 professionals in AACPTA and 5 professionals and 1 manager in AALRT and a total number of 45 open-ended questionnaires with judgmental decide were distributed including 5 number of contingency questionnaires for both AACPTA and AALRT professionals and managers. During the survey, the questionnaires were distributed to the respondents which consists both qualitative and quantitative and found in AACPTA and AALRT usable questionnaires and some of the respondents were not willingness to respond the questionnaires and received only 35 out of 45 distributed questionnaires which represent 77.8% response rate.

According to Mugenda, (2003) a response rate from 50% - 60% is adequate, a response rate from 60% - 70% is good, and a response rate greater than 70% is very well. Thus, the response rate of 77.8% is very well and it is adequate to make the analysis. And the researcher had been collected the actual current waiting time of passengers' data also using interview based on the determined sample size on top transfer stations such as Megenagna, Piassa, Mexico, Stadium, Kality & Merkato. The data collected for 3 different days and the interview address 768 number of respondents on-peak hour and 384 respondents on off-peak hour on both Bus and Train. On top of that, observation also taken in addition to interview to validate the reliability of data which obtained from the respondent and to gather factual information and data on attitudes preferences, beliefs, predictions, behaviors, and experiences about the passengers.

4.3 Methodological framework to partition the zone

This study focused to propose integrated zone-based fare system in the case of Addis Ababa city public transport, where the users can travel through various zones being able to change lines and modes. The aim of this system implementation to reduce transportation fee compare with non-integrated system, reduce passengers waiting time, and create easy transit system from the user point of view and maximization of revenue and profit from the operator stand point of view. On a theoretical ground, those issues are settled and depend on the segmented zone and the value of the zone-based fare. And the study tried to follow an appropriate methodological framework to partition the zone based on research objective with the consideration of both users' and operators' benefits. In this case the weighted mean travel distance of the ride in a city taken as a diameter of the zone due to some reason like it is suitable approach to create proportional and fair zone-based fare, to create a compatible zone with the transport network according to city topography, and to address fairness for both users and operators. And when the study applied this principle, short distance walk taken as an assumption in order to accommodate parallel service for different types of mode sharing.

4.3.1 Determination of weighted mean travel distance of the ride

To partition the zone, determining the weighted mean travel distance of the ride in a city based on the collected weighted parameters data from AACPTA and AALRT for city Bus and Train respectively was the first step. The data include the number, mean load capacity, and mean daily

trip frequency of the vehicles, and line distance for each trip. Each vehicle capacity, trip frequency, and each trip distance have its own different coverage of the ride distance and those different trip distance must come into an appropriate mean value in order to make balancing between the minimum and maximum value of trip ride and to address fairness for both users and operators. However, the procedure of determining the weighted mean travel distance of the ride in a city was long, tedious, and includes the large number of data. And all the collected data and the analyzed results included the required steps attached on appendix A and the weighted mean value determined as follows.

$$\text{Weighted mean travel distance of the ride} = \frac{\text{Total travel length of the ride}}{\text{Total number of passengers}}$$

$$\mu_d = \sum_{i=1}^n \left(\frac{(L \cdot N_b \cdot C_b \cdot F_b) + (L \cdot N_t \cdot C_t \cdot F_t)}{(N_b \cdot C_b \cdot F_b) + (N_t \cdot C_t \cdot F_t)} \right) \quad \text{Equation 4.1}$$

$$\mu_d = \frac{8,061,054 + 1,679,339}{669,616 + 97,636}$$

$$= 12.7 \approx 13 \text{ km}$$

4.3.2 Identification of stations latitude and longitude values

Based on the applied principle, which is the weighted mean travel distance of the ride the city grouped into five zones analytically by taking an assumption the top terminals as the centroid of the zone in order to measure the zone coverage distance using an open street map. After analytically setting the number of zones, Bus and Train stations latitude and longitude values were collected. Then, the collected stations latitude and longitude values were prearranged and taken as input of an algorithm. And the zone segmentation had been created by employed k-means clustering algorithm with python programming language. Stations latitude and longitude values had been organized as follows.

Table 4.1 Stations latitude and longitude values of Addis Ababa city public transportation

Name of stops	Latitude	Longitude	Name of stops	Latitude	Longitude	Name of stops	Latitude	Longitude
Furi	8.9557	38.69847	Gulelie fan school	9.05846	38.706131	Fluha park	8.95979	38.836
Jemo 2	8.961	38.71201	Kojjii food complex	9.05947	38.70424	Goragora	8.92976	38.82
Jemo michel	8.9688	38.72183	Friam church	9.06367	38.69859	Tulidimtu	8.87445	38.82
Michel bridge	8.9658	38.72735	Asco progress academy	9.06576	38.69712	Emperial	9.00246	38.8
Jermen	8.9656	38.73287	Tikur abay shoe factory	9.06497	38.69195	Bole	8.98756	38.792
Mekanisa	8.9733	38.73166	Alesco hotel	9.06582	38.69017	Bole michel	8.97967	38.772
Zebra	8.9796	38.73444	Asco gebrel church	9.06772	38.6898	Yosief	8.9702	38.767
Abo	8.9824	38.73434	Sansusi	9.07096	38.68904	Kadisco	8.96471	38.767
Abadr	8.9862	38.73781	Ethio shekla	9.0748	38.68363	Saris abo	8.94525	38.769
Sarbet	8.9923	38.73831	Ejersa	9.07138	38.68174	Yeka sub city	9.02201	38.801
Africa union	8.9995	38.73969	Kete	9.07036	38.68055	Yeka menafesha	9.02444	38.796
Mexico	9.0095	38.74435	Asosa bar	9.07185	38.67956	Beljim embassy	9.03231	38.783
Bherawi	9.0149	38.75099	Unity trading	9.07582	38.67674	Kokobtsebah school	9.03473	38.78
Cherchel	9.0177	38.75259	Gefersa way	9.07689	38.67368	Minilik hospital	9.03805	38.774
Tewdros round about	9.0272	38.75166	Rift vally	9.07302	38.668462	Yared school	9.04329	38.763
Piassa round about	9.0359	38.75237	Asko bus	9.06754	38.69347	6 Killo	9.04384	38.759
Piassa	9.0333	38.75222	Legetafo bus station	9.07472	38.89857	Afnchober	9.04522	38.752
Akaki kalitiy	8.8565	38.80306	Legetafo adebabay	9.05683	38.87865	Signal	9.02229	38.786
Akakai noc	8.8614	38.80116	Ayat adebabay	9.02136	38.875734	Adewa dldy	9.0233	38.78
Mini market	8.8668	38.79891	Meri	9.0206	38.86037	Siasie	9.02755	38.775
Akaki woreda 1	8.8744	38.7949	CMC adebabay	9.02089	38.85222	4killo adebaby	9.0329	38.763
Meshualkiya	8.8766	38.78633	Michael	9.02127	38.84166	4 killo menafesha	9.0347	38.76

Zone-based fare integration for public transport in the case of Addis Ababa city 2021/22

Akaki textile	8.8799	38.77954	Civil service	9.02094	38.82827	Gulele sub-city	9.03604	38.758
Selam tower	8.8842	38.77694	Saltmehirt adebabay	9.01988	38.825867	Ampir cinema	9.03364	38.755
Akaki stadium	8.889	38.77602	Gurd shola 1	9.01962	38.81673	St.peter referral hospital	9.07435	38.759
Bherawi school	8.8936	38.77404	Gurd shola 2	9.02009	38.81029	Silase church	9.07003	38.761
Kality bus station	8.8987	38.76911	Lem hotel	9.01717	38.79302	Medhanialm	9.04986	38.762
Kality telecom	8.9017	38.76731	22 adebabay	9.01586	38.78741	6 killo campus	9.04528	38.761
Cheralia	8.93449	38.76539	Gatefam hotel	9.01486	38.78319	5killo	9.04037	38.762
K.prism house	8.915	38.76322	Urael	9.01079	38.77525	4 killo	9.03457	38.763
Sheger dabo	8.9212	38.76384	Babis	9.01034	38.76875	Ambasader	9.03051	38.764
Kality werda 10/11	8.9271	38.76722	Estifanos	9.01963	38.80162	Wedajinet park	9.02643	38.762
Kality Masetegna	8.904971	38.766268	Stadium bus stop	9.01211	38.75631	Next to wedajnet park	9.02141	38.764
Kality train station	8.9382	38.76307	Stadium rasmekonon aviation	9.01152	38.75154	Stadium	9.01121	38.761
Adey Ababa	8.9449	38.76632	Mexico adebabay	9.01039	38.74444	6 killo	9.04426	38.764
Dama hotel	8.9522	38.76336	Lideta	9.01122	38.73612	Ferensay embassy	9.05099	38.771
Saris gebeya	8.9569	38.76385	Coca-cola	9.01203	38.7292	Ferensay adebabay	9.05712	38.777
Nifas silk	8.9658	38.76294	Abebechigobena hospital	9.02192	38.8899	Ferensaybus station	9.06227	38.788
Gottera 2	8.9734	38.76073	Ayat tsebel condominium	9.01788	38.89451	Piassa	9.04802	38.72701
Agona	8.9779	38.7599	Nibu Michel adebabay	9.00224	38.87629	Federal maremiyabet	9.04278	38.75
Gottera 1	8.9906	38.75919	Arabsa road	8.99733	38.88538	Shewadabo	9.04813	38.746
Lancha	8.9956	38.75977	Bole arabsa	8.98047	38.88506	Dilber secondary school	9.05691	38.74
Riche	9.0007	38.75855	Bole arabsa condominium	8.99804	38.894612	Kenema pharmacy	9.05984	38.732

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Meshualkia	9.0049	38.75881	Yeruqtam	8.96976	38.883992	Addisugebya adebabay	9.06276	38.734
Stadium	9.0123	38.7594	Yeruqtam condominium	8.96006	38.883828	Nurhussen messjid	9.0666	38.734
Posta	9.0208	38.75212	Christ embassy bole arabsa	8.98152	38.89184	Sheger radio	9.07257	38.738
Karakore	8.9778	38.68445	Bole arabsa chergos square	8.97238	38.89087	Filamingo restorant	9.00856	38.765
Beteseb acadamy	8.9821	38.68969	49 mazoria	9.01064	38.89467	Dembel	9.00336	38.768
Ayertena	8.9847	38.69642	CMC to summit route	9.01909	38.85278	City plaza	8.99893	38.771
Zenebework	9.01180	38.72140	Fyel bet	9.01055	38.85203	Median cafe	8.99433	38.774
3kutr mazoria	8.9933	38.71707	Pepsi	9.00424	38.8521	Aferica aveation	8.99242	38.779
Torhailoch	8.98774	38.38.7084	Summit condominium	8.98383	38.85485	Freindship	8.99022	38.785
Anphomeda	9.0215	38.67743	Megenagna bus station	9.02044	38.80238	Skylight	8.98804	38.791
Keranio	9.0233	38.68954	Asmera road	9.02148	38.809859	Ethiopia revenue & customs authority	9.00941	38.775
Yeshi deblie bus station	9.0191	38.69698	Lamberet	9.02387	38.81826	Axum building	9.00727	38.776
Qeranio round about	9.0182	38.70204	Federal college	9.02541	38.82532	Market place	9.00522	38.778
Holland bus stop	9.0171	38.71754	Hillside school	9.02802	38.83231	Dat tower	9.00003	38.784
Abnet	9.0163	38.73453	Wesen	9.0302	38.838156	Ednamol	8.9972	38.787
Sebategna	9.0212	38.73333	Abem	9.03582	38.85371	Enat bank	8.99402	38.79
Merkato	9.034	38.73286	Kara	9.04071	38.86452	Brass	8.98989	38.793
Autobus tera	9.0346	38.73202	Zobl park	9.05266	38.871695	Maseltegna	8.93111	38.76
Atklt tera	9.0347	38.73835	Tafo route	9.06421	38.87359	Hanamariam	8.93234	38.751
Abunpetros adebabay	9.0354	38.74948	Yekabado	9.06981	38.876158	Robel computer	8.9365	38.74

			condominium					
Adewa adebebey	9.0378	38.7221	Yekabado bus station	9.06644	38.86495	Haile garment adebabay	8.93673	38.729
Arbegnoch street	9.041	38.74659	Kotebie bretabret	9.03404	38.823447	Roba car sales	8.92852	38.734
Arbegnoch street	9.0434	38.74491	Wetatoch maekel	9.03698	38.833908	Sefera adebabay	8.92422	38.734
Rasdesta hotel	9.0474	38.7421	Kotebie metropolitain	9.03766	38.83972	Zemen buliding	8.91995	38.735
Egg factory	9.0482	38.73734	Eka kotebie general hospital	9.03877	38.853603	Sefanit pharmacy	8.94055	38.735
Paster	9.0466	38.73263	Totot	9.00702	38.8061	Lebu crossing	8.94621	38.734
Paulos	9.03586	38.75237	Mebrat haile	9.00307	38.79941	Mebrathail	8.94938	38.733
Medhanialm school	9.0516	38.72178	Jakros	9.00397	38.8165	Tabot maderiya	8.95479	38.732
Loli bar	9.0557	38.71703	Yerer	8.99966	38.82065	Lemariam building	8.95812	38.733
Winget	9.0566	38.7135	Goro adebabay	8.99093	38.829879	Germen adebabay	8.9644	38.733
Nib candy factory	9.0567	38.70988	St.kidanmihret church	8.97982	38.829578	CBE tulmidtu	8.8594	38.811
Apdca school & Engineering	8.8961	38.77198	Megenagna	9.01099	38.7633	Entotoamba school	9.0635	38.761

Source - Online google map

4.3.3 Code syntax to model the segmented zone

The collected stations latitude and longitude values had been taken as input of an algorithm and modeled the segmented zone. The code syntax attached on appendix B and the network map shown as follows.

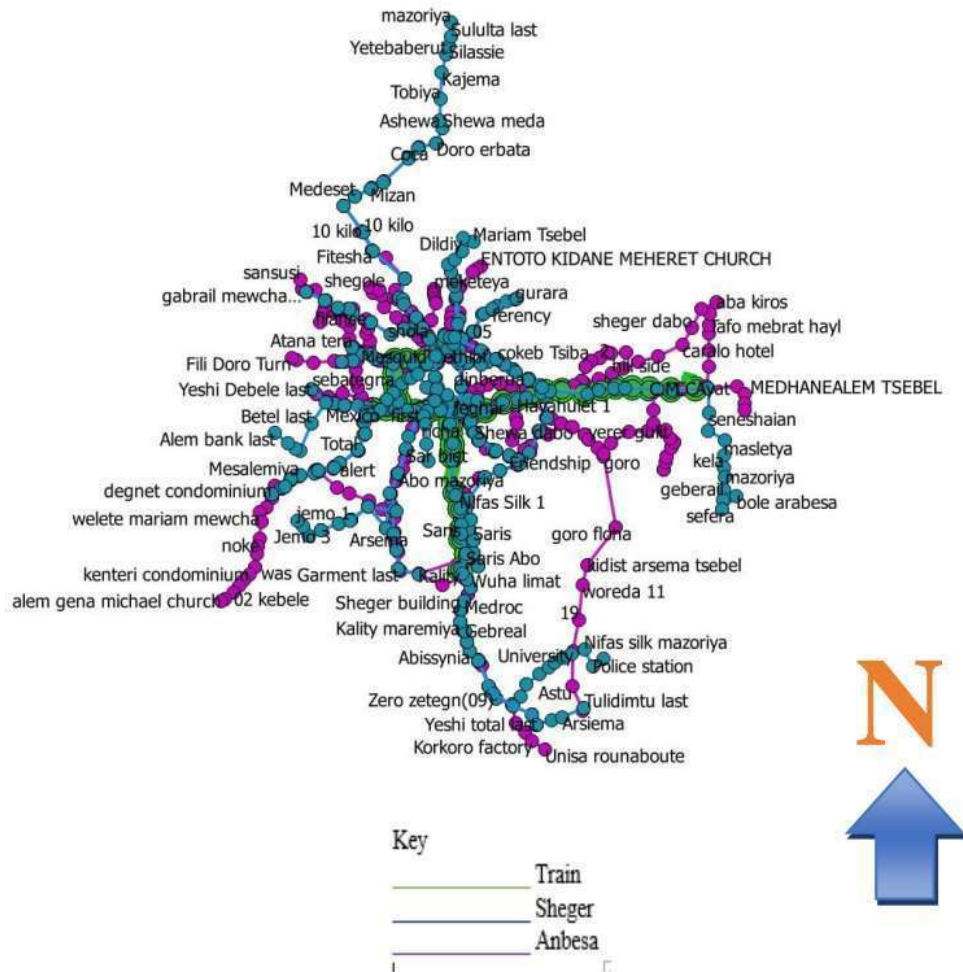


Figure 4.1 Addis Ababa city public transport network map

4.4 Setting of zone-based fare

Fare setting mechanisms are vary but in general, they represent the value that ensures the coverage of transportation enterprises' gains and expenditures as well as the economic and financial balance based on fare rates (Rodrigues, Barros, and Oliveira 2019). And when come up

with zone-based public transport fare system, it is creating a consistent fare review system that takes into account the actual costs of the transport service providers, the cost to the users, and to reduce the gap in kilometers fare. The zone-based fare system has its own benefit from the perspective of passengers as well as enterprises such as for users' reduction of transportation fee, minimization of passengers waiting time, and being simple and easy to accept by passengers for easy mode sharing. For an enterprise, it makes a simple and easy fare system to use and maintain certain significant relationships between passengers' transportation requests and the scope of the transportation system by maximize the annual revenue and profit of the service providers.

4.4.1 Annual financial performance of mass transport service enterprise

Financial performance is a measure of a company's capacity to gather and allocate funds over a period of time, as measured by capital adequacy, efficiency, and profitability (Fatihudin, Jusni, and Mochklas 2018) . The company's ability to manage and control its own resources is measured by its financial performance. The annual financial performance related to the annual expense and their historical background of Addis Ababa city public mass transport service enterprises such as Anbesa city bus, Sheger city bus, and Addis Ababa light rail transit are presented as follows.

i. Anbesa city bus service enterprise

Anbesa city bus had its first corridor implemented in 1942. It is the major road-based bus transit operator in the city. The company is administered by Addis Ababa city public transport authority (AACPTA) and its network is completely inserted within the city of Addis Ababa. Anbesa city bus enterprise cover large city area with the large number of passengers' movement rather than Sheger Bus and Train. The company has 647 number of buses. Anbesa city bus service enterprise is known to have different types of buses based on their age and capacity of the buses such as 140 number of bus with the age of 20 years 100 passengers, bishoftu artulethed 188 number of bus with 7 years 135 passengers, double-decker 147 number of bus with 1 year 95 passengers, and recent incoming 172 number of buses 70 passengers. Because of their load capacity varies, the Bus performance also varies. Furthermore, the data related to their annual distance coverage and their mean load capacity attached on appendix A and the collected annual company expenses has listed below.

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Table 4.2 Annual expenses of Anbesa Bus mass transport service enterprise

It.no	Particulars	Expenses	Amount of expense in birr
1	Overhead cost	Insurance	22,000,000
		Stationary and cleaning service	2,145,942
		Other overhead cost and publication	12,400,577
2	Operational cost	Oil , grease, and fuel for bus	150,363,296
		Employ salary	188,344,793
		Overtime payment	42,550,500
		Other allowance and bones	32,846,100
		Cost of ticket	6,720,417
		Safety materials	8,267,014
3	Spare part and maintenance cost	Tire and inner rubber	6,642,452
		Garage materials	44,416,353
		Total expense	516,697,444

Source - Anbesa mass transport service enterprise annual expense recorded data April, 2020

ii. Sheger mass transport service enterprise

Sheger mass transport service enterprise began in 2015. It is administered by Addis Ababa city public transport authority (AACPTA) and its network is completely inserted within the city of Addis Ababa like Anbesa city bus. Sheger mass transport service enterprise institute has a total number of 321 vehicles for regular transport services and the buses have different capacities such as the number of 306 with a capacity of 70 passengers and the remaining 15 are overlapping vehicles with a capacity of 90 passengers. In addition, the data related to the annual distance coverage and their mean load capacity are attached on appendix A and the total annual company expenses are listed below.

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Table 4.3 Annual expenses of Sheger mass transport service enterprise

It.no	Particulars	Expenses	Amount of expense in birr
1	Overhead cost	Insurance	20,606,601.40
		Office materials	1,605,581.55
		Stationary and cleaning service	3,003,098.76
		Other overhead cost and publication	15,163,687
2	Operational cost	Oil, grease, and fuel for bus	72,909,662.53
		Employ salary	102,781,277.57
		Overtime payment	10,935,408.36
		Other allowance and bones	254,792.84
		Cost of ticket	4,554,469.85
		Safety materials	1,677,505.00
3	Spare part and maintenance cost	Bus spare part	14,098,623.33
		Tire and inner rubber	10,000,000.00
		Maintenance and repair	560,741.23
		Garage materials	1,188,261.57
		Total expense	259,339,712

Source – Sheger mass transport service enterprise annual expense survey May, 2020

iii. Addis Ababa light rail transit

Addis Ababa light rail transit started its operation in 2015. Addis Ababa light rail transit project has two lines known as east-west and north-south lines with 5 overlapping stations at the two lines. And there are a total of 39 stations with different level such as 29 on the surface, 9 above, and 1 underground. When compared to other stations, those 5 communal stations are located in the city core and have a higher number of passengers (Obsie, Woldeamanuel, and Woldetensae 2020). Both lines have nearly the same distance and equal number of stations. The E–W corridor covers 17.5km distance and has 22 stations including the 5 communal stations. The line connects

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residential areas of the eastern part of Addis Ababa to the center, while the N–S corridor covers 16.9 km distance and 22 stations it also including the 5 communal stations. This line connects the city center's commercial areas to the south's residential and industrial areas. Both lines are nearly identical in length and have similar number of stations. AALRT began with the number of 41 Trains, but now the functional Trains are 31 and the remaining 10 Trains are detained. Out of those 31 functional Trains 2 couple and 18 single with a total of 20 Trains are available for regular daily service and 11 Trains are used as a stand by. The N- S line has 10 Train with 15 minute average waiting time, while the E–W line also has 10 Train with 12 minute average waiting time. As well, the data related to the annual distance coverage and the mean load capacity attached on appendix A. And the total annual company expenses of Addis Ababa light rail transit listed below.

Table 4.4 Annual expenses of Addis Ababa light rail transit

It.no	Particulars	Expenses	Amount of expense in birr
1	Overhead cost	Insurance	1,914,205.25
		Stationary, cleaning , and security services	12,320,095.70
		Utility expense	11,930,617.79
		Canteen Expense	10,888,964.33
		Advertisement expense for tender and vacancy announcement	500,578.46
2	Operational cost	Employee salary & related expense	128,988,745.47
		Training and education	115,679.62
		Cost of ticket	5,006,883.00
		Communications	7,819.78
		Vehicle running expense	1,525.95
		Safety materials	2,076,798.43
3	Spare part and maintenance cost	Spare part, maintenance, and other garage materials cost	20,103,084.74
		Total expense	193,854,999

4.4.2 Determination of the total annual expense per vehicle

In order to set the fare, the total annual expense per vehicle also considered as follows. And it includes an expense which is related with operation and maintenance costs in all public transport service provider firms.

$$\text{Total annual expense per vehicle} = \frac{\text{The sum of total annual expense}}{\text{Total number of vehicles}}$$

$$A_{TE} = \frac{\sum_{i=1}^n ((O_{EA} + M_{EA} + OH_{EA}) + (O_{ES} + M_{ES} + OH_{ES}) + (O_{ET} + M_{ET} + OH_{ET}))}{(N_{AT} + N_{ST} + N_{TT})} \quad \text{Equation 4.2}$$

$$A_{TE} = \frac{516697444 + 259339711.62 + 193854998.56}{647 + 321 + 31}$$

$$= \frac{969,892,154.2}{999}$$

$$= 970,863.01 \text{ birr per vehicle}$$

4.4.3 Determination of annual distance coverage per vehicle

The annual distance coverage per vehicle determined based on each trip distance, number of vehicle in each trip, mean daily trip frequency, and annual working days and combined as follows.

$$\text{Annual distance coverage per vehicle} = \frac{\text{The sum of total annual distance coverage}}{\text{Total number of vehicles}}$$

$$A_{DC} = \frac{\sum_{i=1}^n ((D_{CA} * N_A * F_A * A_{Wdays}) + (D_{CS} * N_S * F_S * A_{Wdays}) + (D_{CT} * N_T * F_T * A_{Wdays}))}{(N_{AT} + N_{ST} + N_{TT})} \quad \text{Equation 4.3}$$

$$A_{DC} = \frac{16978950 + 12336534 + 1757840}{647 + 321 + 31}$$

$$= \frac{33677736}{999}$$

$$= 31,104 \text{ km per vehicle}$$

4.4.4 Determination of mean load capacity per vehicle

$$\text{Mean load capacity} = \frac{\sum_{i=1}^n (\text{Number of vehicles in each route} * \text{Capacity})}{\text{Total number of vehicles}}$$

$$M_{LC} = \frac{\sum_{i=1}^n ((N_A * C_A) + (N_S * C_S) + (N_T * C_T))}{N_{AT} + N_{ST} + N_{TT}} \quad \text{Equation 4.4}$$

$$M_{LC} = \frac{55247 + 18970 + 6974}{647 + 321 + 31}$$

$$= \frac{78945}{999}$$

=81 Person per vehicle

4.4.5 Determination of fare per kilometer per seat

The fare per kilometer per seat = $\frac{\text{Total annual expense per vehicle}}{\text{Annual distance coverage per vehicle} * \text{Mean load capacity per vehicle}}$

$$K_{FS} = \frac{ATE}{ADC * M_{LC}} \quad \text{Equation 4.5}$$

$$= \frac{970863.01}{31,104 * 81}$$

=0.38 birr per km

4.4.6 Determination of zone-based fare per seat

Due to the reason of the applied weighted mean travel distance of the ride in a city to partition the zone, the zone-based fare had been determined by multiplying the fare per kilometer per seat with the value of the weighted mean travel distance of the ride.

The zone-based fare per seat = Fare in kilometer per seat * Mean travel distance of the ride

$$Z_{FS} = K_{FS} * \mu_d \quad \text{Equation 4.6}$$

$$= 0.38 \text{ birr/km} * 13 \text{ km}$$

$$= 4.94 \approx 5 \text{ birr per zone}$$

The study sought to collect financial and operational audited data on city's public transport route distance coverage and tariff rates. According to the collected data, a tariff of 6 birr been set for a 13-kilometer distance trip. And the proposed zone-based integrated fare decreased by 16.66% compared to the existing system. And the current practical km division and the applicable fare data attached on appendix E.

Table 4.5 Zone-based fare in birr per one-way trip

Zone	1	2	3	4	5
1	5				
2	10	5			
3	15	10	5		
4	20	15	10	5	
5	25	20	15	10	5

4.5 Zone fare distribution for each public transport firm

The study focused to propose a zone-based fare integration system of public transport. However, the organization of the public transportation services enterprises also not integrated. Due to this reason, the proposed integrated zone-based fare had been distributed for each public transport firm. And in order to distribute the integrated fare, the annual distance coverage of each firm and the total annual distance coverage of all enterprise had been organized and the zone fare distributed for each public transport service provider firms as follows.

$$\text{Zone fare distribution} = \frac{\text{Each firm annual distance coverage}}{\text{Total annual distance coverage}} * \text{Integrated zone fare}$$

$$D_F = \frac{AD}{TAD} * I_F \quad \text{Equation 4.7.}$$

$$\text{i. Anbesa Bus} = \frac{16,978,950}{31,073,324} * 5$$

$$= 2.7 \text{ birr}$$

$$\text{ii. Sheger Bus} = \frac{12,336,534}{31,073,324} * 5$$

$$= 2 \text{ birr}$$

$$\text{iii. Train} = \frac{1,757,840}{31,073,324} * 5$$

$$= 0.3 \text{ birr}$$

4.6 Economic and social impacts due to the lack of fare integration system

Public transport is one of the key factors for the development of every society. Public transport is not a goal itself, but it is a means of economic development and opportunity for achieving social cohesion by improving employment access, increasing business and freight movement efficiency, reducing mounting traffic congestion constraints, and can boost overall economic production (Now and Network 2014). In both economic and social terms public transport is essential. Some identified economic and social advantages of public transportation over individual forms of transportation such as lower community costs, less urban area required, lower energy consumption, safest mode, improved employment accessibility, and mobility for all. Furthermore, when public transport uses a fare integration system it can provide better opportunities and access to use and gain PT benefits such as attractive fare for customers, better service, full multimodal integration, high taxes and car use restrictions, it saves money and improves reliability, safety, social welfares, aims to meet the needs of customers as quickly and efficiently as possible, minimization of passengers waiting time, and fair improvement of revenue and profit for service providers. However, In Addis Ababa city public transportation system context couldn't fulfill those benefits rather than facing different obstacles. And the study used interview and direct observation data collection instruments to collect the data related with economic and social impact of the existing unintegrated transport system. Non-integrated public transportation system is difficult and create different economic and social impacts for users as well as for service providers. And Addis Ababa city public transportation system also faces different obstacles like absence of long-term economic development and prosperity productivity by making transportation bottlenecks for people and goods, minimizing opportunities for individuals, decrease income and asset value for service providers, consumption of travel time due to the absence of harmonized timetables and connections between operators, absence of comfort and safety means for a single trip ride is needed more than one ticket, long period passengers transit and waiting time, absence of transparent system of fare information, and increment of transportation fee for users due to the existing of some parallel competitive services. And those problem boldly observed due to the current unintegrated system and gradually create huge challenges for passengers, service providers, and authority also.

4.7 Some improvements due to the proposed zone-based fare integration system

The current public transportation system in Addis Ababa city is unintegrated and doesn't address the interests of users plus operators and lots of problems have been observed such as traffic congestion, free riding, theft on passengers, poor revenue from ticket, long queues, manpower costs, wastage of time, and the ongoing increase in transportation fee. Accordingly, it is difficult to provide suitable transportation services and improve the quality of life in cities that lack of modernized and integrated transportation system. Provide fare integration system of public transport using zone-based fare structure had been taken as a solution in this research. The reduction of fare and minimization of passengers waiting time for users and maximization of revenue and profit for operators used as the measuring parameters owing to the proposed system. And the results explained using graph in addition to a numerical presentation.

i. Maximization of revenue

Maximization of annual revenue is one of the main benefits of providing zone-based fare integration system of public transport. So, in order to maximize the annual revenue of an enterprise, proposing zone-based fare integration system is taken as an option in this study. The data related to the current annual revenue of public transport enterprises is collected from AACPTA and AALRT. And the annual revenue of the public transport enterprises owing to the new proposed zone-based fare system determined by using the annual number of passengers with the zone-based fare as follows.

$$R_a = \sum_{i=1}^n P_{\text{annual}} * Z_{\text{fare}} \quad \text{Equation 4.8}$$

When the current city public transportation faring system replaced by integrated zone-based fare, the annual revenue of Anbesa city bus from 730,173,600 to 880,821,000, Sheger 289,554,720 to 423,259,200, Train 117,439,682 to 356,371,400, and the total annual revenue of all firms from 1,137,168,002 to 1,660,451,600 birr. Therefore, the proposed system is absolutely obtained maximization of annual revenue by 31.52%. Then, maximization of the annual revenue aims at improving the profitability of a public transportation and provide the chance of operators to solve their problems. Then, the firms can be creating standardized and modernized public transportation service in the city by making an appropriate supply of vehicles for users without

much difficulty situation and maximize their daily trip frequency in order to address users demand request by maximize ability of the service providers.

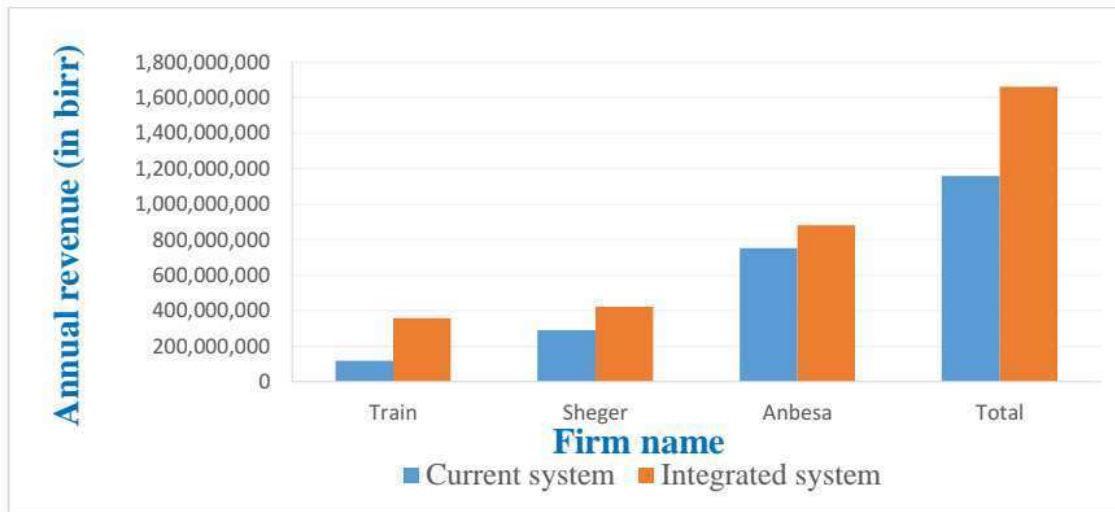


Figure 4.2 Maximization of revenue

ii. Maximization of profit

Public transportation is not a for-profit institution. However, this research looks at the profit in some extent taking into account the general problems with the public transportation service providers and users. The annual revenue maximizing quantity choice would also represent the profit maximizing choice. In order to have a better grasp of this condition, it is possible to define the equations for total revenue and profit as a function of quantity. Now express the maximization of profit, revenue minus expense costs. And it is usual that the costs for transporting passengers in public transport are higher than the revenue arising from selling tickets (Borndörfer, Karbstein, and Pfetsch 2012). However, the new proposed zone-based fare integration system can change this condition by providing fair increment on the annual revenue. The annual profit increment of each public transport firm is mentioned by applied the profit function as follows.

$$\text{Profit} = \text{Revenue} - \text{Expense} \qquad \text{Equation 4.9}$$

Based on the collected data, the study had been organized all the annual expenses of each public transport firm Anbesa city bus 516,697,444, Sheger city bus 259,339,711, and Train 193,854,998 birr. And using the new integrated zone-based fare system the annual revenue was also

determined and its procedure attached in the appendix D. The annual public transport firm profit had been also determined using the above function and the profit variation occurred between the current and the new proposed system like Anbesa from 213,475,558 to 364,123,556, Sheger 30,215,008 to 163,919,489, Train -76,415,316 to 162,516,401, and total profit from 167,275,250 to 690,559,446 birr. This change indicates the total annual profit increase by 75.77%. As the result show the amount of annual profit which obtained on train due to the new proposed system is highest rather than Anbesa and Sheger due to the reason of the changed current flat rate fare system in to integrated zone-based fare. This annual change of profit for public transportation companies is not taken as a direct deposit profit. However, it creates a makeweight with the government subsidy in order to increase the number of vehicles in the firm to address the users demand request.

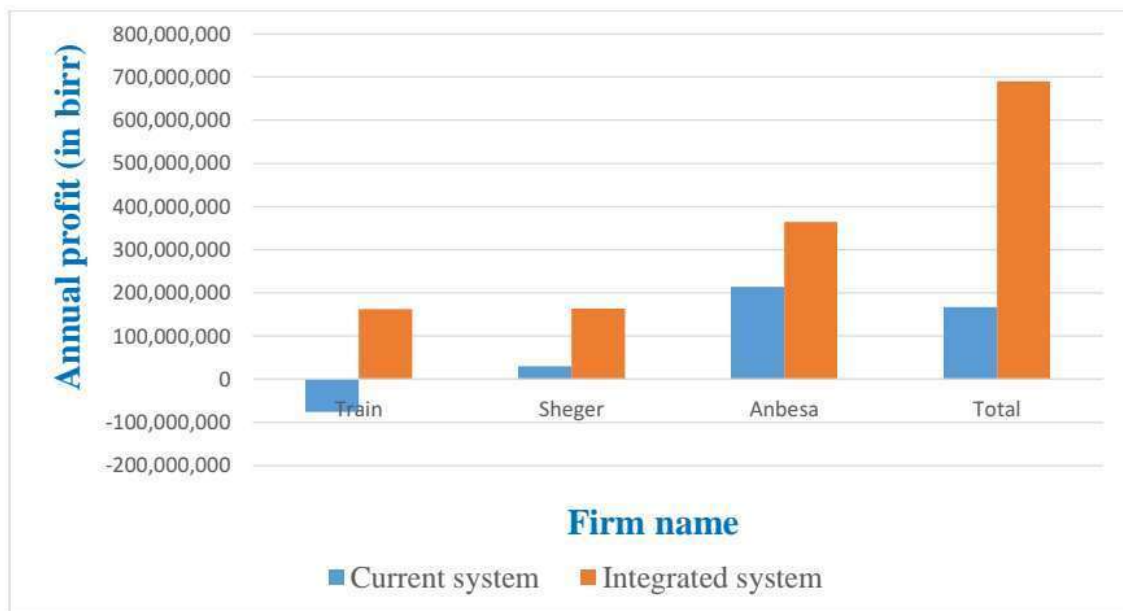


Figure 4.3 Maximization of profit

iii. Minimization of passengers waiting time

From the view point of passengers, waiting time has a far larger value on the counterparts of users such as in vehicle time and access time. Expected waiting time of passengers used as a primary performance indicator for public transportation. And it depends on vehicle headways, vehicle delay due to congestion, location of stops and ticket office, schedule, behavior of users,

and time period. In Addis Ababa city public transport service, passengers waiting time is very high due to the reason of high traffic congestion, long transfer distance, searching of transportation service to change the mode and to transit, long distance between stops and ticket office, and less number of vehicles compare with users' demand request. And the actual current passengers waiting time collected by using primary data collection instrument and organized as follows.

Table 4.6 Actual current on-peak and off-peak hour passengers waiting time at different transfer stations

Station ID	On-peak hour			Off-peak hour		
	Maximum	Minimum	Average	Maximum	Minimum	Average
S1	47.6	34.8	41.5	14.5	9.5	12
S2	45.5	32.5	39	17.5	12.5	15
S3	33.5	27.5	30.5	16.5	11.5	14
S4	40	30	35	18.75	13.75	16.25
S5	41.25	31.25	36.25	18.25	11.25	14.75
S6	47.5	35	41.25	31	22.5	26.75

Passengers waiting time is the time which represented by the summation of standing time to access vehicle and transit time. Transit time depends on the layout of the interchange, on the present faring system, orientation time which is the time required to collect information about the location and the departure times of connecting vehicles, walking time to purchase the ticket and to search the mode to transit, and the time required to pay fares. Therefore, when passengers need to transfer they must spend additional effort and time and both of them reduce the attractiveness and competitiveness of public transportation service. Passengers transit either from Train to Bus or from Bus to Train. And the study tried to collect the data which used to represent the transit time on the selected transfer stations on both on-peak and off-peak hour. However, there are some variables used to minimize passengers waiting time owing to the proposed zone-based fare integration system like passengers' information on travel decision, apply one leg payment system, transportation choice with single ticket and passengers will have different mode choice, minimizing transit time at transfer point, and traveler experience for different zone line.

And based on those variables and the collected data passengers waiting time due to zone based system presented as follows.

Table 4.7 Zone-based system on-peak and off-peak hour passengers waiting time at different transfer stations

Station ID	Current system		Zone-based system			
	On-peak hour	Off-peak hour	On-peak hour reduced time	Off-peak hour reduced time	On-peak hour	Off-peak hour
S1	41.5	12	13	8	28.5	4
S2	39	15	11	6.5	28	8.5
S3	30.5	14	8	5	22.5	9
S4	35	16.25	10	6	25	10.25
S5	36.25	14.75	10.2	7	26.05	7.75
S6	41.25	26.75	12	7.5	29.25	19.25

Based on the variables which obtained due to the proposed system on-peak and off-peak hour average waiting time of passengers minimize by 32.33 % and presented graphically as follows.

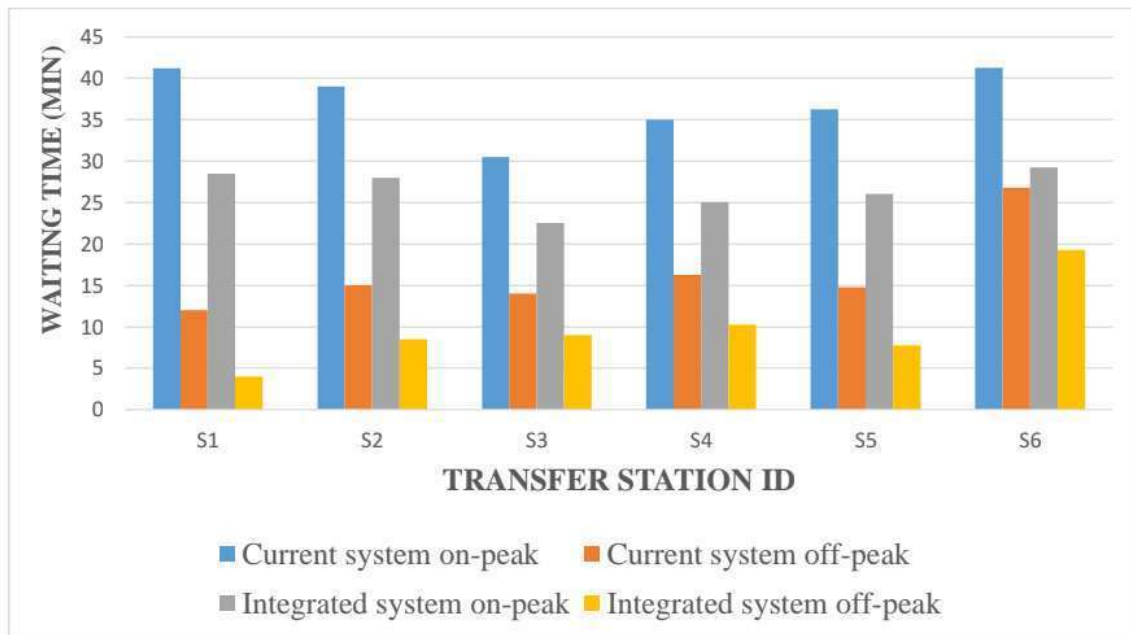


Fig 4.4 Passengers waiting time before and after zone-based fare system

4.8 Zone-based fare using travel time

The main problem to set the zone-based fare using travel time for Addis Ababa city, there is no any written paper which used to indicate the cost of time. As many scholars presented, different countries set their own labor cost standard to estimate the cost of time on public transportation using hourly income of the users, value of trip purpose, types of mode, and type of users like business, employee, student, young, and old passengers. However, in Addis Ababa city there is no any standard which used to set the time cost value of the public transportation system. Then, in order to set zone-based fare using travel time approach for Addis Ababa city the study consider two main parameters. First; the total time taken which required to cover the zone. Second; single trip expense per zone based on the total time taken to cover the zone. As the collected data indicate, kilometer coverage per hour Train 17km, Anbesa 13km, Sheger 10km, and the mean distance coverage per hour had been 13km. On top of that, this 13km mean distance coverage equal with one zone single trip. Single trip expense per hour for each type of vehicle determined based on the total annual expense. And the zone-based fare using travel time had been set as follows.

Single trip expense per hour = Total annual expenses / Total number of vehicles / Annual working days / Total daily operating hours

$$\begin{aligned} \text{Fare} &= \sum_{i=1}^n \left(\frac{\text{Single trip expense per hour}}{\text{Mean number of passengers per trip}} \right) && \text{Equation 4.11} \\ &= \frac{1223+273+276}{349+101+70} \\ &= 3.4 \approx 3.00 \text{ birr/hr./zone} \end{aligned}$$

Using travel time based fare, tried to make analysis and determined the annual revenue. As the result shows like Anbesa from 730,173,600 to 532,407,360, Sheger from 289,554,720 to 255,583,440, train from 117,439,682 to 213,822,840, and the total annual revenue from 1,137,168,002 to 1,001,813,640. The annual revenue which obtained on train due to the new proposed system is not decreased due to the reason of the changed current flat rate fare system in to integrated zone fare structure. As tried to mentioned the reason formerly travel time based fare is not suitable and doesn't fulfill both side benefits for Addis Ababa city public transport and

reduction of fare by 33.34% and decrement of the annual revenue for operators' side by 11.91%. And in order to obtain an appropriate operators side benefit, the long distance trip should cover within a short travel time unless time based fare setting mechanism is not suitable for operators. Due to the reason of the existing high traffic congestion this principle couldn't be suitable and applicable in Addis Ababa city context. For users also cause maximization of time cost due to the reasons of improper collection of passengers and maximization of speed and trip frequency of vehicles cause increment of operating cost.

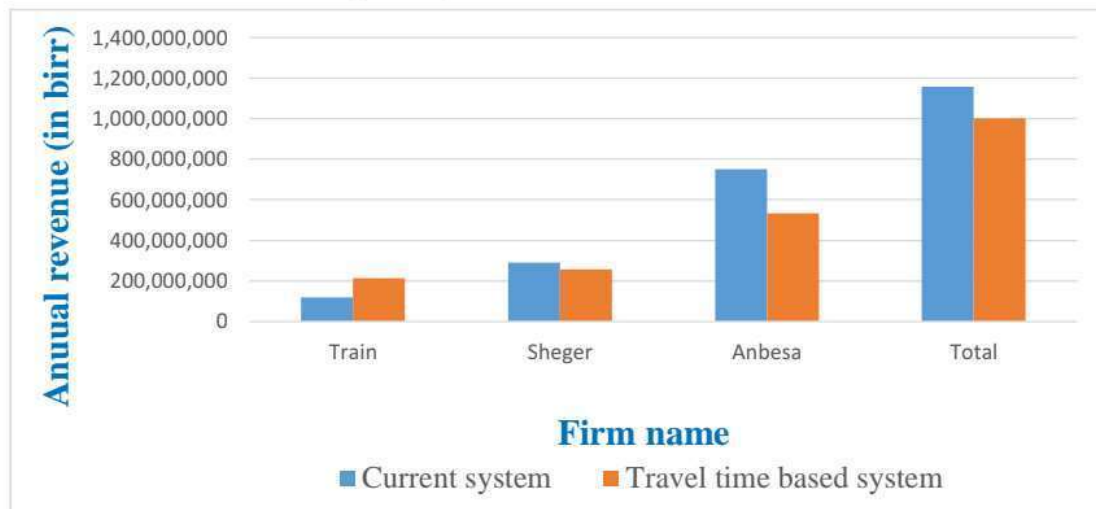


Fig 4.5 Decrement of annual revenue

4.10 Comparison between the three fare systems

In addition to previously mentioned problem and issues, there are many important factors with major influence on the solution of the zone-based fare design. There are important factors which has major influence on demand in public transport are price, travel time, waiting time, information about transport, safety, comfort, and availability. On the third chapter in the research approach part, tried to mentioned the existing different zone-based fare setting approaches like stopping distance, trip frequency, and travel time. And also the paper explained the reasons behind why they couldn't be applicable for Addis Ababa city. In this section the study strained to set the zone-based fare using distance-based expense and travel time. And make comparison between the current fare system, the distance-based expense, and travel time based fare using fare for users' centric and annual revenue for operators' centric benefit. The current public

transport fare system has a total annual revenue 1,137,168,002 birr, the proposed integrated zone-based fare set using distance-based expense 1,660,451,600, and using travel time based obtained annual revenue 1,001,813,640 birr. As the result indicate the distance-based fare setting approach obtained both side benefits like 16.67% reduction of fare for users and 31.52% annual revenue maximization for operators. Second, as tried to mentioned the reason behind travel time based fare the result indicates the reduction of fare 33.34% and decrement of annual revenue by11.91%.



Fig 4.6 Comparison of annual revenue

4.9 Summary

In this chapter, the collected data had been analyzed and interpret based on the guidance of the research methodology. The study was distributed purposive sampling 45 open-ended questionnaires and based on the determined sample size interview also done. And from the distributed questionnaires returned 35 number of respondents it indicates 78.78 % response rate and based on the required sample size interview based collected data also analyzed. It was very well to made analysis by making a combination with the data collected by interview, observation, and secondary source. And based on the returned questionnaires, interviews, observations, and secondary sources of data the chapter deals about data presentation, analysis, and discussion of the study had been done on the proposed methods. Finally, based on the analysis result comparison between the current and the new proposed systems had been drawn.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter is organized in to three sections. The first section highlighted summary of the main findings, the second section discussed about conclusions based on the research objectives, and the last section presented recommendations for the improvement of the public transportation system by applying the new proposed system and highlight suggestions for further study by other researchers in the future. It also indicated that the implications for further research and contribution of the study.

5.2 Summary of main Findings

The study intended to proposed a zone-based fare integration system of public transport based on detailed analysis and discussions were made in chapter four. And the main findings of this study summarized and presented in this chapter.

5.3 Conclusions

The study carried out to propose zone-based fare integration system of public transport in the case of Addis Ababa city. The research objectives and questions were answered and the findings of this study presented as follows.

- ✓ Weighted mean travel distance of the ride in a city to partition the zone and distance-based expense to set the zone-based fare were the best approaches for Addis Ababa city Public transportation.
- ✓ The current Addis Ababa city public transport faring system is unintegrated and it affects users and operators due to the resultant of economic and social consequence such as absence of long-term economic development and prosperity productivity by making productivity bottlenecks, minimizing opportunities for individuals, decrease income and asset value for service providers, consumption of travel time, absence of comfort and safety, maximization of passengers' transit and waiting time, absence of transparent system of fare information, and costly of transportation fee.

- ✓ Number of improvements obtained on Addis Ababa city public transportation system owing to the new proposed zone-based fare integration like reduction of fare 16.66% and minimization of passengers waiting time by 32.33% for users and maximization of revenue 31.52% and profit also improved by 75.77% for service providers.

5.4 Recommendations

In order to improve the effectiveness of public transport system in a city, the researcher suggest the following possible recommendations based on the results of the study obtained from the findings and conclusions.

5.4.1 Recommendations for practices

Based on the findings and conclusions of the study drawn in line with the study objectives, the following points are suggested by the researcher in order to improve the public transportation system.

- ✓ The AACPTA, AALRT, or any other related governmental bodies with Addis Ababa city public transportation service should place a high priority on developing a long-term plan for the city's fare integration system in order to reduce economic and social related losses.
- ✓ The integration practice of the responsible public transport institution is absolutely weak compared with other countries. So, emphasis should be given to creating and developing awareness about the benefits of integration in all aspects like fare, ticket, timetable, and infrastructure integration.
- ✓ According to the findings of this study, there is a constraint of qualified and experienced professionals to integrate the public transportation fare system. And AACPTA and AALRT should take steps to acquire well-trained and experienced experts through local or international training.

5.4.2 Recommendations for further studies

An interesting finding may come up by conducting studies national or country wide by incorporating other variables. The following points are recommended for further researchers depending on this study's comprehension.

- ✓ Integrate the ticketing system shall be done and create a rational organizational structure to facilitate an integrated and sustainable public transportation system in a city.

- ✓ According to the consideration of safety, reliability, and operator efficiency of public transportation service, the zone fare distribution shall be set again by additional further study.
- ✓ Identifying the losses and advantages associated with the absence or presence of zone-based fare integration system in detail.

5.5 Contribution and implication of the study

Public transport is backbone of the country's economic and social activities by creating a network between users and service providers. Therefore, this research helps for public transport service providers and users to look backward and forward to learn more and to decide on future activities based on the information obtained regarding the system. The study creates and develop an awareness for AACPTA and AALRT professionals, managers, and other concerned individuals on the benefits of fare integration system of public transport, give the chance for others who are interested in the fare integration systems and also helps as a reliable point of reference to make further studies on the subject adding values of knowledge, to practice the system in our country, and used as input for decision-makers and policy analyzers.

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Appendix A

Data analyzed in order to determine the weighted mean travel distance of the ride in a city, annual distance coverage, and mean load capacity per vehicle in Addis Ababa city public transport presented as follows.

Origin	Passing line	Destination	Name of vehicle	Line distance in km	No.of vehicle	Average capacity of vehicle	Average daily trip frequency	Total number of daily passengers	Total daily travel length of ride in km	Annual working days	Annual distance cover	Mean Load capacity
Megenagna	Lamberet	kara	Anbesa	7.7	17	101	8	13736	105767.2	323	338246	1717
Megenagna	CMC	Chefe Ayat	Anbesa	11	6	101	8	4848	53328	323	170544	606
Megenagna	6 killo	Gurara	Anbesa	9.5	5	101	8	4040	38380	323	122740	505
Megenagna	Saris abo	Gelan	Anbesa	18	5	101	8	4040	73528	323	235144	505
Megenagna	6killo	Shromeda	Anbesa	7.2	4	101	8	3232	23270.4	323	74419	404
Megenagna	Bole michael	Bole bulbula	Anbesa	15	4	101	8	3232	49126.4	323	157107	404
Megenagna	Abakiros	Legetafo	Anbesa	16	5	101	8	4040	63832	323	204136	505
Megenagna	meri	Abakirose	Anbesa	12	5	101	8	4040	48480	323	155040	505
Megenagna	goro	Koyefeché	Anbesa	8.1	9	101	8	7272	58903.2	323	188374	909
Megenagna	CMC	Summit condominium	Anbesa	14	4	101	8	3232	44278.4	323	141603	404
Megenagna	goro	kilinto	Anbesa	12	6	101	8	4848	58660.8	323	187598	606
Megenagna	Gerji	Tuludimtu	Anbesa	26	21	101	8	16968	441168	323	1E+06	2121
Megenagna	Kazanchis	Mexico	Sheger	6.6	1	70	12	840	5544	323	25582	70
Megenagna	CMC	Bole arabsa	Sheger	14	15	70	12	12600	173880	323	802332	1050
Megenagna	CMC	Summit	Sheger	10	4	70	12	3360	33600	323	155040	280
Megenagna	Bole michael	Bole saris	Sheger	12	2	70	12	1680	19656	323	90698	140

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Megenagna	wesen	Yekabado	Sheger	12	38	70	12	31920	383040	323	2E+06	2660
Megenagna	4killo	Piassa	Sheger	7.5	5	70	12	4200	31500	323	145350	350
Megenagna	CMC	Tafo	Sheger	11	4	70	12	3360	37632	323	173645	280
Megenagna	4 killo	Merkato	Anbesa	10	4	101	8	3232	33612.8	323	107494	404
Merkato	Tegbard	Mekanisa-kore	Anbesa	11	4	101	8	3232	35875.2	323	114730	404
Merkato	Tegbard-qera	kality	Anbesa	19	1	101	8	808	15675.2	323	50130	101
Merkato	Wabishabele	Mekanisa-qore	anbesa	13	4	101	8	3232	41046.4	323	131267	404
Merkato	Semen hotel	Qechene	Anbesa	9.4	4	101	8	3232	30380.8	323	97158	404
Merkato	6killo	Gurara	Anbesa	9.9	7	101	8	5656	55994.4	323	179071	707
Merkato	4 killo	Talian embassy	Anbesa	9.9	3	101	8	2424	23997.6	323	76745	303
Merkato	Afnchober	kidanmhret	Anbesa	7.9	6	101	8	4848	38299.2	323	122482	606
Merkato	5killo	kusquam	Anbesa	9.1	3	101	8	2424	22058.4	323	70543	303
Merkato	18 mazoria	qeraniyo	anbesa	7.3	5	101	8	4040	29492	323	94316	505
Merkato	Rufael	Dlber	Anbesa	8.6	5	101	8	4040	34744	323	11112	505
Merkato	18mazoriya	Filidoro	Anbesa	8.6	5	101	8	4040	34744	323	11112	505
Merkato	6 killo	Lamberet	Anbesa	12	5	101	8	4040	48480	323	155040	505
Merkato	Asco-teachers school	Dire solia	Anbesa	16	1	101	8	808	12847.2	323	41086	101
Merkato	Asco-teachers school	Asco-sansusi	Anbesa	11	3	101	8	2424	26906.4	323	86047	303
Merkato	Legehar	Addis sefer gebrel	Anbesa	13	12	101	8	9696	123139.2	323	393802	1212
Merkato	Tegbard	Jemo r/about	Anbesa	9.8	4	101	8	3232	31673.6	323	101293	404
Merkato	Lafto	Jemo 1	Anbesa	15	3	101	8	2424	36360	323	116280	303
Merkato	4 killo	Bole-school	Anbesa	9.6	3	101	8	2424	23270.4	323	74419	303
Merkato	4 killo lamberet	Karalo	Anbesa	18	3	101	8	2424	43389.6	323	138761	303
Merkato	4killo	Eyesus	Anbesa	8.5	3	101	8	2424	20604	323	65892	303

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Merkato	Paster	Yenegewsew school	Anbesa	6	2	101	8	1616	9696	323	31008	202
Merkato	Torhailoch	Betel	Anbesa	11	4	101	8	3232	35228.8	323	112662	404
Merkato	Sunshine immigration	Gergi	Anbesa	14	6	101	8	4848	68356.8	323	218606	606
Merkato	18mazoria	Mikililand	Anbesa	9.1	2	101	8	1616	14705.6	323	47029	202
Merkato	Torhailoch	Alembank	Anbesa	11	6	101	8	4848	53328	323	170544	606
Merkato	Torhailochi	Karakori	Anbesa	11	6	101	8	4848	50904	323	162792	606
Merkato	Gion urael	Summit condominium	Anbesa	18	5	101	8	4040	71912	323	229976	505
Merkato	Dessie hotel	Jemo	Anbesa	15	5	101	8	4040	58580	323	187340	505
Merkato	18 mazoriya	Tateq /kela/	Anbesa	18	2	101	8	1616	29088	323	93024	202
Autobus tera	Ldeta	Saris abo	Sheger	9.3	1	70	12	840	7812	323	36047	70
Autobus tera	Anfo	Kela	Sheger	25	3	70	12	2520	63504	323	293026	210
Autobus tera	Torhailochi	Alembank	Sheger	11	5	70	12	4200	46200	323	213180	350
Autobus tera	Mexico	Saris	Sheger	14	2	70	12	1680	22848	323	105427	140
Autobus tera	Lkuanda	Anfo	Sheger	10	2	70	12	1680	17472	323	80621	140
Autobus tera	Zenebe worq	Karaqori	Sheger	12	2	70	12	1680	19320	323	89148	140
Autobus tera	Zenebeworq	Ayertena	Sheger	9.6	4	70	12	3360	32256	323	148838	280
Autobustera	Yekatit12 hospital	Spain embassy	Sheger	6	1	70	12	840	5040	323	23256	70
Autobus tera	Michael r/about	Jemo	Sheger	15	2	70	12	1680	24360	323	112404	140
Piassa	Kazanchis	Bras clinic	Anbesa	11	3	101	8	2424	25452	323	81396	303
Piassa	Shola gebeya	Kotebe college	Anbesa	13	6	101	8	4848	61569.6	323	196901	606
Piassa	Stadium	Bole bulbula	Anbesa	12	5	101	8	4040	49692	323	158916	505
Piassa	Asco teachers schhol	Asco sansusi	Anbesa	13	38	101	8	30704	393011.2	323	1E+06	3838
Piassa	Asco teachers school	Mikisiland	Anbesa	9.9	2	101	8	1616	15998.4	323	51163	202

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Piassa	Sansusi	Driesoliana	Anbesa	17	3	101	8	2424	40238.4	323	128683	303
Piassa	Ambassador	Saris	Sheger	11	16	70	12	13440	151872	323	700781	1120
Piassa	Mexico	Jemo	Sheger	13	5	70	12	4200	53760	323	248064	350
Piassa	Bulgariya	Kera mebrathal	Sheger	11	7	70	12	5880	64680	323	298452	490
Piassa	Tkuranbesa	Bole	Sheger	8.7	6	70	12	5040	43848	323	202327	420
Piassa	Torhailochi	Betel	Sheger	9.4	4	70	12	3360	31584	323	145738	280
Piassa	Janmeda	Ferensay	Sheger	6.3	4	70	12	3360	21168	323	97675	280
Piassa	4killo	Megenagna	Sheger	7.5	5	70	12	4200	31500	323	145350	350
Piassa	Semen hotel	Dlber	Sheger	5	4	70	12	3360	16800	323	77520	280
Piassa	Mexico	Jemo	Sheger	12	6	70	12	5040	61992	323	286049	420
Piassa	Mexico	Ayertena	Sheger	13	2	70	12	1680	21840	323	100776	140
Giorgis	Sarbet	Jemo	Anbesa	12	6	101	8	4848	59145.6	323	189149	606
Giorgis	Wabeshebele	Ayertena	Anbesa	11	9	101	8	7272	78537.6	323	777.6	909
Giorgis	Wabeshebel	Keranio	Anbesa	12	3	101	8	2424	29088	323	93024	303
Giorgis	Coca fabrica	Betel hospital	Anbesa	12	6	101	8	4848	55752	323	178296	606
Stadium	Megenagna-cmc	Summit condominium	Anbesa	14	4	101	8	3232	46217.6	323	147805	404
Stadium	Gotera-saris-kality	Akaki	Anbesa	19	10	101	8	8080	153520	323	490960	1010
Stadium	4 killo	Shromeda	Anbesa	7.4	3	101	8	2424	17937.6	323	57365	303
Stadium	Megenagna	Hanamariam	Anbesa	11	2	101	8	1616	17129.6	323	54781	202
Stadium	Torhailochi	Karakori	Anbesa	12	4	101	8	3232	37814.4	323	120931	404
Stadium	Kelemework school	Dlber	Anbesa	8.6	3	101	8	2424	20846.4	323	66667	303
Stadium	4 killo	Gurara	Anbesa	9.5	4	101	8	3232	30704	323	98192	404
Stadium	Torhailochi	Alembank	Anbesa	12	2	101	8	1616	19392	323	62016	202
Stadium	Sarbet	Jemo	Anbesa	11	4	101	8	3232	34259.2	323	109562	404

Stadium	Torhailochi	Winget school	Anbesa	10	5	101	8	4040	41208	323	131784	505
Stadium	Coca-fabrica	Kolfe efoyta	Anbesa	9.5	2	101	8	1616	15352	323	49096	202
Stadium	Torhailochi	Betel hospital	Anbesa	10	5	101	8	4040	40400	323	129200	505
Stadium	Megenagna	Kara	Anbesa	14	5	101	8	4040	55348	323	177004	505
Stadium	Torhailoch	Anfomeda	Anbesa	12	4	101	8	3232	38784	323	124032	404
Stadium	Gotera-saris-kality	Gelan	Anbesa	7.9	5	101	8	4040	31916	323	102068	505
Stadium	Megenagna-cmc	Aayat condominium	Anbesa	18	8	101	8	6464	116352	323	372096	808
Mexico	Sefera	Gelan	Anbesa	15	10	101	8	8080	120392	323	385016	1010
Mexico	Bsrte gebrel	Karakori	Anbesa	10	3	101	8	2424	24240	323	77520	303
Mexico	Kera	Lafto	Anbesa	7.5	5	101	8	4040	30300	323	96900	505
Mexico	Bsrte gebrel	Alem bank	Anbesa	10	3	101	8	2424	24240	323	77520	303
Mexico	Sarbet	Sefera	Anbesa	9.4	8	101	8	6464	60761.6	323	194317	808
Mexico	Sarbet	Hailegarment	Anbesa	9.2	12	101	8	9696	89203.2	323	285274	1212
Mexico	Hailegarment	Tuludimtu	Anbesa	10	14	101	8	11312	113120	323	361760	1414
Mexico	Sarbet-mekanisa	Jemo 1	Sheger	9	17	70	12	14280	128520	323	593028	1190
Mexico	Sarbet-mekanisa	Jemo 2	Sheger	12	14	70	12	11760	141120	323	651168	980
Mexico	Sarbet-mekanisa	Jemo 3	Sheger	10	4	70	12	3360	33600	323	155040	280
Mexico	Zenbeworq	Alembank	Sheger	10	3	70	12	2520	25704	323	118606	210
Mexico	Sarbet	Ayertena	Sheger	8	4	70	12	3360	26880	323	124032	280
Mexico	Estifanos	Shromeda	Sheger	8.7	12	70	12	10080	87696	323	404654	840
Mexico	Kera	Lafto	Sheger	7.5	5	70	12	4200	31500	323	145350	350
Mexico	6 killo	Ferensay	Sheger	9	2	70	12	1680	15120	323	69768	140
Adisugebeya	Giorgis	Kera	Anbesa	9.9	8	101	8	6464	63993.6	323	204653	808
Balcha hospital	Hayahulet	Goro r/about	Anbesa	15	10	101	8	8080	117968	323	377264	1010

Balcha hospital	Mekanisa	Hanamariam	Anbesa	9.6	2	101	8	1616	15513.6	323	49613	202
4 killo	Megenagna	Kotebe gebrel	Anbesa	11	5	101	8	4040	46056	323	147288	505
4 killo	Hayahulet	Gerji	Anbesa	11	4	101	8	3232	36198.4	323	115763	404
4 killo	Megenagna	Summit condominium	Anbesa	15	2	101	8	1616	23755.2	323	75970	202
4killo	Adisugebeya	Etotomariam	Anbesa	17	2	101	8	1616	26825.6	323	85789	202
6 kilo	Tkuranbesa	Jemo 3	Anbesa	11	4	101	8	3232	35552	323	113696	404
6 kilo	Olompia	kera	Anbesa	10	6	101	8	4848	50419.2	323	161242	606
6 killo	Megenagna-cmc	Chefe-ayat condominium	Anbesa	18	5	101	8	4040	72720	323	232560	505
Bole bora	Gerjiroba	Summit comdominium	Anbesa	12	2	101	8	1616	19392	323	62016	202
Bole michael	Sunshine	Adisugebeya	Anbesa	16	6	101	8	4848	76598.4	323	244963	606
Bole michael	Gbigebrel	Shiromeda	Anbesa	12	8	101	8	6464	74336	323	237728	808
Bole michael	Piassa	Sansusi	Anbesa	22	4	101	8	3232	69488	323	222224	404
Ayertena	Tegbared	Aware r/about	Anbesa	12	2	101	8	1616	19392	323	62016	202
Ayertena	Bisrat gebrel	Qera	Anbesa	5	4	101	8	3232	16160	323	51680	404
Ayertena	Garment	Sarisabo	Anbesa	12	6	101	8	4848	59630.4	323	190699	606
Ayertena	Torhailoch	Winget school	Anbesa	11	7	101	8	5656	59388	323	189924	707
Saris abo	Gbi geberel	Shromeda	Anbesa	14	6	101	8	4848	68841.6	323	220157	606
Saris abo	Dama hotel	Hanamariam	Anbesa	4.9	4	101	8	3232	15836.8	323	50646	404
Saris abo	Kality	Akaki korkoro	Anbesa	11	3	101	8	2424	27633.6	323	88373	303
Saris abo	Kality	Tuludimtu	Anbesa	12	3	101	8	2424	29088	323	93024	303
Kality	Yosef	Kera	Anbesa	8.3	3	101	8	2424	20119.2	323	64342	303
Torhailoch	Ayertena	Kenteri	Anbesa	12	6	101	8	4848	58176	323	186048	606
Torhailoch	Gbigebrel	Minilik hospital	Anbesa	10	4	101	8	3232	32966.4	323	105427	404
Kolfe efoyta	Giorgis	Minilik hospital	Anbesa	10	4	101	8	3232	32320	323	103360	404

Jemo 2	Jemo	Mekanisa-michael	Anbesa	5.6	4	101	8	3232	18099.2	323	57882	404
Yeka abado	4 killo	Piassa	Sheger	21	9	70	12	7560	154980	323	715122	630
Yeka abado	Wesen	Megenagna	Sheger	19	6	70	12	5040	95760	323	441864	420
Bole arabsa	Megenagna	Legehar	Sheger	24	2	70	12	1680	40404	323	186436	140
Bole arabsa	Megenagna-4 killo	piassa	Sheger	24	2	70	12	1680	40824	323	188374	140
Ayat r/about	Noh realstate	Arabsa	Sheger	7	2	70	12	1680	11760	323	54264	140
Tafo	Ayat r/about	Arabsa	Sheger	8	1	70	12	840	6720	323	31008	70
Adisugebeya	6 killo	Mgenagna	Sheger	10	9	70	12	7560	75600	323	348840	630
Merab hotel	Betel	Alembank	Sheger	11	2	70	12	1680	18480	323	85272	140
Ayertena	Germen	Saris abo	Sheger	13	1	70	12	840	11088	323	51163	70
Jemo 2	Gofa-kerkos-legehar	Megenagna	Sheger	20	4	70	12	3360	67200	323	310080	280
Jemo	Mexico	6 killo	Sheger	15	6	70	12	5040	75600	323	348840	420
Shromeda	4 killo	Bole	Sheger	11	3	70	12	2520	27720	323	127908	210
4 killo	Shewadabo	Bole	Sheger	8	2	70	12	1680	13440	323	62016	140
Shromeda	Lancha	Saris	Sheger	15	3	70	12	2520	37296	323	172094	210
4 killo	6 killo	Ferensay	Sheger	5.3	2	70	12	1680	8904	323	41086	140
Ayertena	Lideta bar	Stadium	Sheger	9	1	70	12	840	7560	323	34884	70
6 killo	Gbigebrel	Kazanchis	Sheger	5.8	1	70	12	840	4872	323	22481	70
Yekabado	Mgenagna	Mexico	Sheger	19	4	70	12	3360	62496	323	288374	280
Sum								669616	8061054		29315482	74217
East	Megenagna	West	Single train	18	9	317	14	39942	698985	365	804825	2853
East	Megenagna	West	Double train	18	1	634	14	8876	155330	365	89425	634

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North	Stadium	South	Single train	17	9	317	14	39942	675019.8	365	777231	2853
North	Stadium	South	Couple train	17	1	634	14	8876	150004.4	365	86359	634
Sum								97636	1679339		1757840	6974

Appendix B

Code syntax to model the segmented zone

```
In:  Import numpy as np
      Import pandas as pd
      Import statsmodels.api as sm
      Import matplotlib.pyplot as plt
      Import seaborn as sns; sns.set ()
      From sklearn.cluster import KMeans
      data = pd.read_csv('cc.csv')
      data
```

```
Out: Latitude Longitude
      0 8.95566 38.69847
      1 8.96097 38.71201
      2 8.96878 38.72183
      3 8.96580 38.72735
      4 8.96564 38.73287
      ... ..
      230 8.94621 38.73420
      231 8.94938 38.73326
      232 8.95479 38.73246
      233 8.95812 38.73260
```

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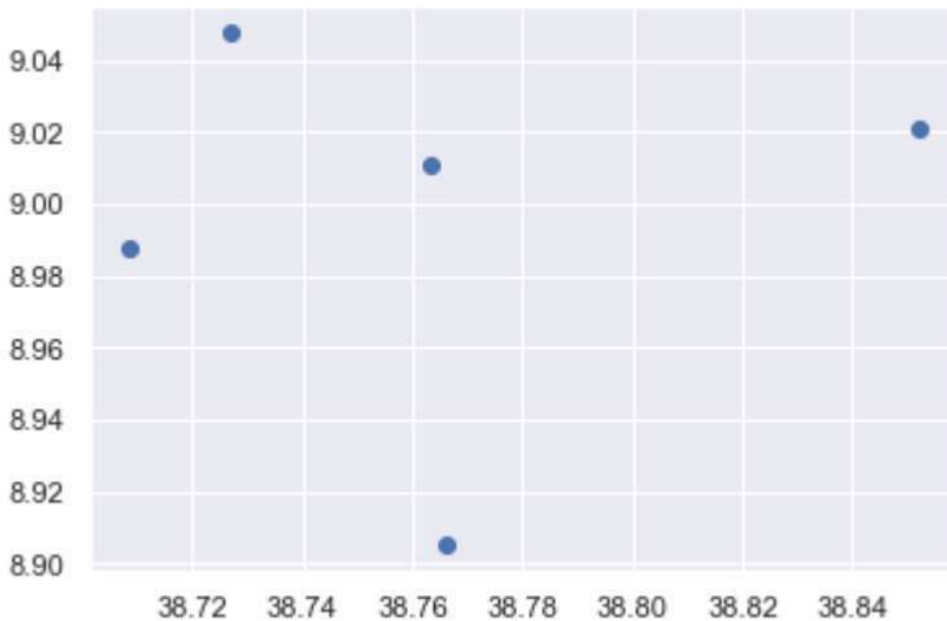
```
234 8.96440 38.73265
```

```
235 rows × 2 columns
```

```
In: y= [9.02089, 9.01099, 9.04802, 8.98774, 8.904971];
```

```
x= [38.85222, 38.7633, 38.72701, 38.70840, 38.766268];
```

```
Out: <matplotlib.collections.PathCollection at 0x1f953f26fd0>
```



```
In: x = data.iloc[:,0:3] # 1st for rows and second for columns x
```

```
X
```

```
Out: Latitude Longitude
```

```
0 8.95566 38.69847
```

```
1 8.96097 38.71201
```

```
2 8.96878 38.72183
```

```
3 8.96580 38.72735
```

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4 8.96564 38.73287

... ..

230 8.94621 38.73420

231 8.94938 38.73326

232 8.95479 38.73246

233 8.95812 38.73260

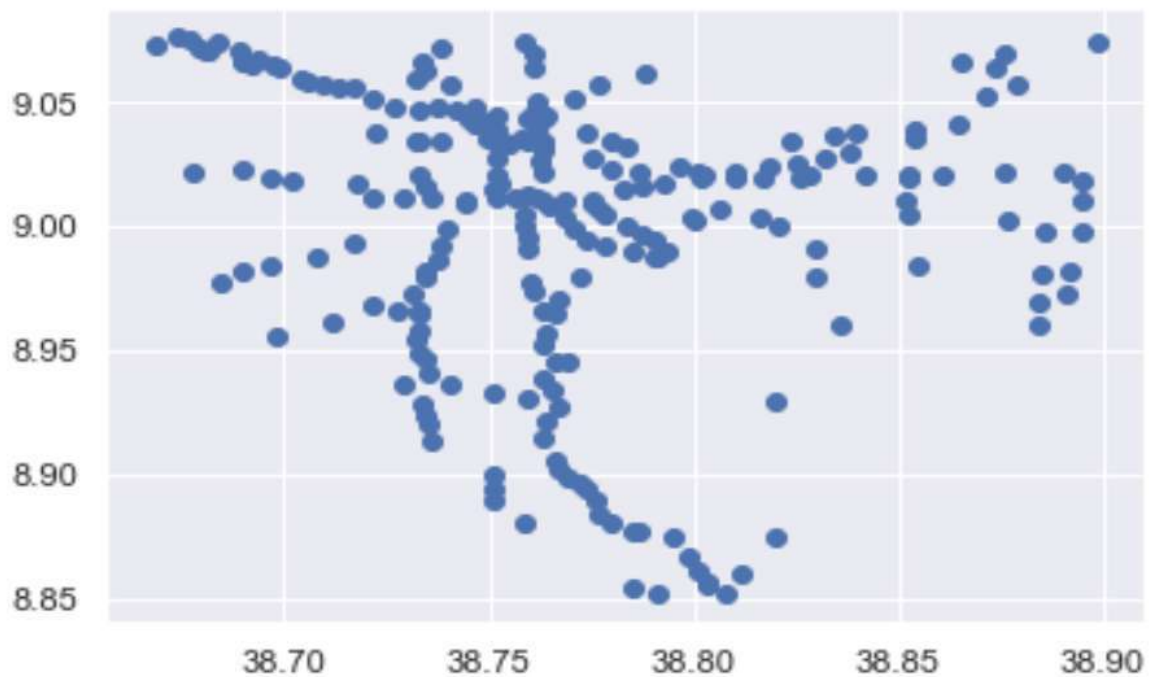
234 8.96440 38.73265

235 rows × 2 columns

In: `plt.scatter(data['Longitude'],data['Latitude'])`

`plt.show()`

Out



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```
In: Kmeans = Kmeans (5)

kmeans.fit(x)

Identified_clusters = kmeans.fit_predict(x)

Data_with_clusters = data.copy()

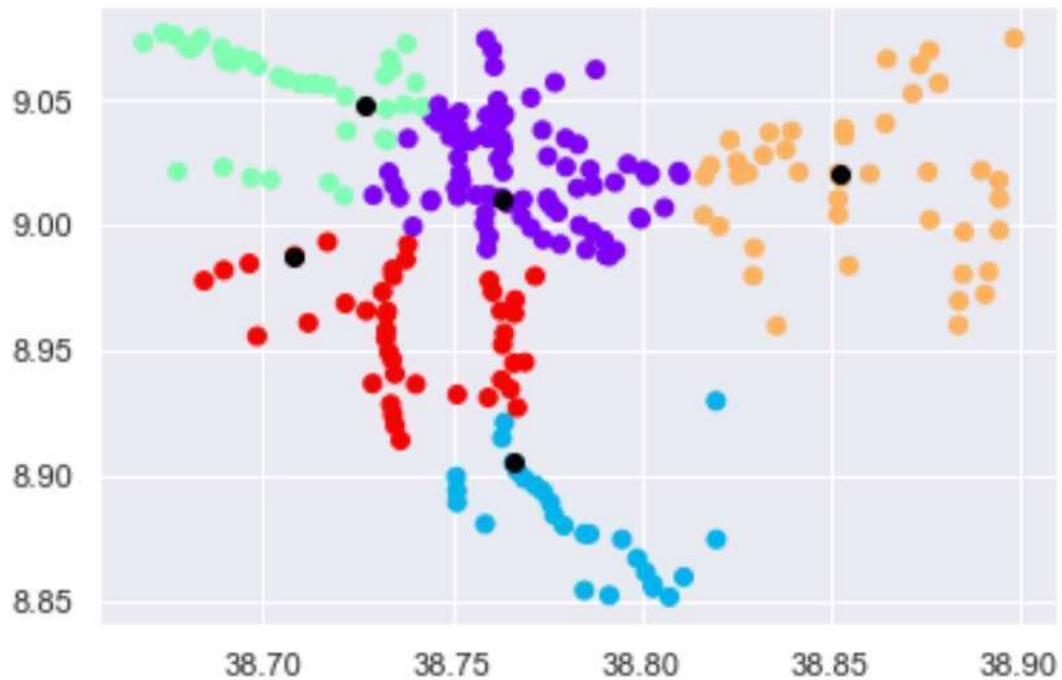
Data_with_clusters['Clusters'] = identified_clusters

Plt. scatter(data_with_clusters['Longitude'], data_with_clusters['Latitude'], c=data-
with_clusters['Clusters'], cmap='rainbow')

Y = [9.04802,8.904971,8.98774,9.02089,9.01099];
x = [38.72701,38.766286,38.70840,38.85222,38.7633];

Plt.scatter(x,y,color='black')
```

Out: <matplotlib.collections.PathCollection at 0x185345b5880>



Zone-based fare integration for public transport in the case of Addis Ababa city

2021/22

```
In: kmeans = KMeans (5)

kmeans.fit(x)

Identified_clusters = kmeans.fit_predict(x)

Data_with_clusters = data.copy()

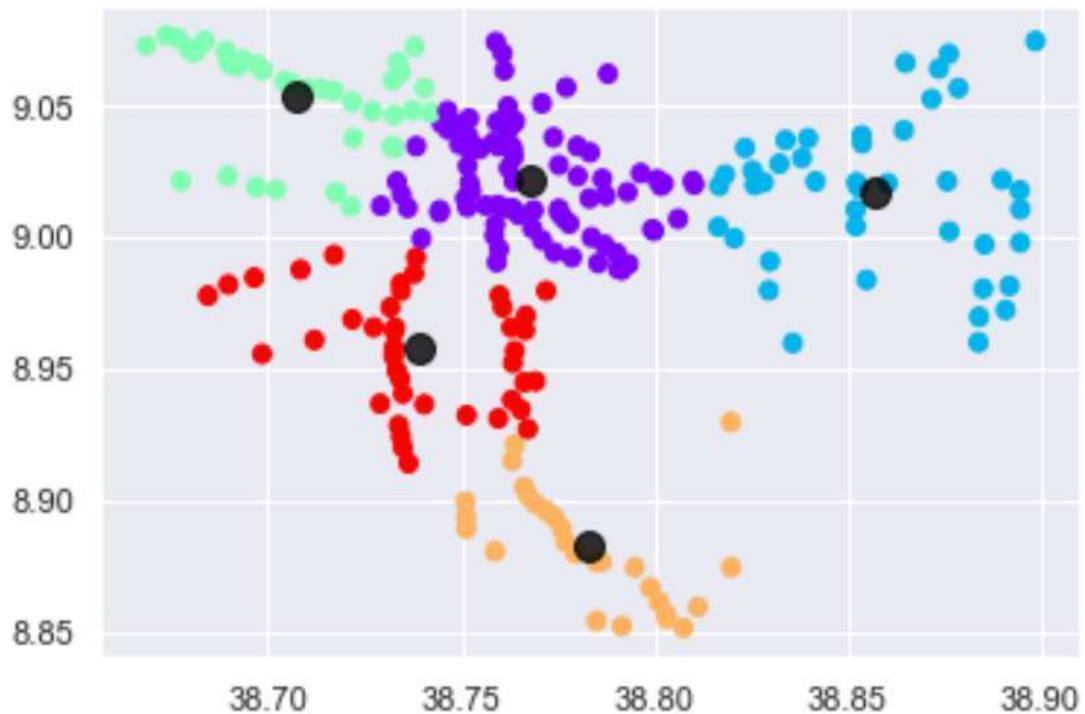
Data_with_clusters['Clusters'] = identified_clusters

Plt. scatter(data_with_clusters['Longitude'], data_with_clusters['Latitude'], c=data-
with_clusters['Clusters'], cmap='rainbow')

Centers = kmeans.cluster_centers_

Plt.scatter(centers [: 1], centers [: 0], color='black',s=100,alpha=0.8)
```

Out: <matplotlib.collections.PathCollection at 0x1718346b2b0>



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In: centers = kmeans.cluster_centers_ # Coordinates of cluster centers.

 centers

Out: array ([[9.05382837, 38.70728045],
 [8.88280996, 38.78251885],
 [8.95771133, 38.73886148],
 [9.02186487, 38.76799692],
 [9.01685635, 38.85726781]])

Appendix C

Analyzed data of the annual revenue due to the new proposed zone-based fare presented as follows.

Origin	Passing line	Destination	Name of vehicle	Line distance in km	No. of vehicle	Average capacity of vehicle	Average daily single trip frequency	Total number of daily passengers	Total number of pass. /year	Zone based fare	Annual revenue /veh/year
Megenagna	Lamberet	kara	Anbesa	7.7	17	101	8	13736	4436728	5	22183640
Megenagna	CMC	Chefe Ayat	Anbesa	11	6	101	8	4848	1565904	5	7829520
Megenagna	6 killo	Gurara	Anbesa	9.5	5	101	8	4040	1304920	5	6524600
Megenagna	Saris abo	Gelan	Anbesa	18.2	5	101	8	4040	1304920	10	13049200
Megenagna	6killo	Shromeda	Anbesa	7.2	4	101	8	3232	1043936	5	5219680
Megenagna	Bole michael	Bole bulbula	Anbesa	15.2	4	101	8	3232	1043936	10	10439360
Megenagna	Abakiros	Legetafo	Anbesa	15.8	5	101	8	4040	1304920	10	13049200
Megenagna	meri	Abakirose	Anbesa	12	5	101	8	4040	1304920	5	6524600
Megenagna	goro	Koyefeche	Anbesa	8.1	9	101	8	7272	2348856	5	11744280
Megenagna	CMC	Summit condominium	Anbesa	13.7	4	101	8	3232	1043936	5	5219680
Megenagna	goro	kilinto	Anbesa	12.1	6	101	8	4848	1565904	5	7829520
Megenagna	Gerji	Tuludimtu	Anbesa	26	21	101	8	16968	5480664	10	54806640
Megenagna	4 killo	Merkato	Anbesa	10.4	4	101	8	3232	1043936	5	5219680
Merkato	Tegbard	Mekanisa-kore	Anbesa	11.1	4	101	8	3232	1043936	5	5219680
Merkato	Tegbard-qera	kality	Anbesa	19.4	1	101	8	808	260984	10	2609840
Merkato	Wabishbele	Mekanisa-qore	anbesa	12.7	4	101	8	3232	1043936	5	41046.4

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Merkato	Semen hotel	Qechene	Anbesa	9.4	4	101	8	3232	1043936	5	5219680
Merkato	6killo	Gurara	Anbesa	9.9	7	101	8	5656	1826888	5	9134440
Merkato	4 killo	Talian embassy	Anbesa	9.9	3	101	8	2424	782952	5	3914760
Merkato	Afnchober	kidanmhret	Anbesa	7.9	6	101	8	4848	1565904	5	7829520
Merkato	5killo	kusquam	Anbesa	9.1	3	101	8	2424	782952	5	3914760
Merkato	18 mazoría	qeraniyo	anbesa	7.3	5	101	8	4040	1304920	5	6524600
Merkato	Rufael	Dlber	Anbesa	8.6	5	101	8	4040	1304920	5	6524600
Merkato	18mazoriya	Filidoro	Anbesa	8.6	5	101	8	4040	1304920	5	6524600
Merkato	6 killo	Lamberet	Anbesa	12	5	101	8	4040	1304920	5	6524600
Merkato	Asco-teachers school	Dire solia	Anbesa	15.9	1	101	8	808	260984	10	1304920
Merkato	Asco-teachers school	Asco-sansusi	Anbesa	11.1	3	101	8	2424	782952	5	3914760
Merkato	Legehar	Addis sefer gebrel	Anbesa	12.7	12	101	8	9696	3131808	5	15659040
Merkato	Tegbard	Jemo r/about	Anbesa	9.8	4	101	8	3232	1043936	5	5219680
Merkato	Lafto	Jemo 1	Anbesa	15	3	101	8	2424	782952	10	7829520
Merkato	4 killo	Bole-school	Anbesa	9.6	3	101	8	2424	782952	5	3914760
Merkato	4 killo lamberet	Karalo	Anbesa	17.9	3	101	8	2424	782952	10	7829520
Merkato	4killo	Eyesus	Anbesa	8.5	3	101	8	2424	782952	5	3914760
Merkato	Paster	Yenegewsew school	Anbesa	6	2	101	8	1616	521968	5	2609840
Merkato	Torhailoch	Betel	Anbesa	10.9	4	101	8	3232	1043936	5	5219680
Merkato	Sunshine imigration	Gergi	Anbesa	14.1	6	101	8	4848	1565904	10	15659040
Merkato	18mazoria	Mikililand	Anbesa	9.1	2	101	8	1616	521968	5	2609840

Zone-based fare integration for public transport in the case of Addis Ababa city 2021/22

Merkato	Torhailoch	Alembank	Anbesa	11	6	101	8	4848	1565904	5	7829520
Merkato	Torhailochi	Karakori	Anbesa	10.5	6	101	8	4848	1565904	5	7829520
Merkato	Gion urael	Summit condomin.	Anbesa	17.8	5	101	8	4040	1304920	10	13049200
Merkato	Dessie hotel	Jemo	Anbesa	14.5	5	101	8	4040	1304920	10	13049200
Merkato	18 mazoriya	Tateq /kela/	Anbesa	18	2	101	8	1616	521968	10	5219680
Piassa	Kazanchis	Bras clinic	Anbesa	10.5	3	101	8	2424	782952	5	3914760
Piassa	Shola gebeya	Kotebe college	Anbesa	12.7	6	101	8	4848	1565904	5	7829520
Piassa	Stadium	Bole bulbula	Anbesa	12.3	5	101	8	4040	1304920	5	6524600
Piassa	Asco teachers school	Asco sansusi	Anbesa	12.8	38	101	8	30704	9917392	5	49586960
Piassa	Asco teachers school	Mikisiland	Anbesa	9.9	2	101	8	1616	521968	5	2609840
Piassa	Sansusi	Driesoliana	Anbesa	16.6	3	101	8	2424	782952	10	7829520
Giorgis	Sarbet	Jemo	Anbesa	12.2	6	101	8	4848	1565904	5	7829520
Giorgis	Wabesheble	Ayertena	Anbesa	10.8	9	101	8	7272	2348856	5	11744280
Giorgis	Wabeshebel	Keranio	Anbesa	12	3	101	8	2424	782952	5	3914760
Giorgis	Coca fabrica	Betel hospital	Anbesa	11.5	6	101	8	4848	1565904	5	7829520
Stadium	Megenagna- cmc	Summit condominium	Anbesa	14.3	4	101	8	3232	1043936	10	10439360
Stadium	Gotera-saris- kality	Akaki	Anbesa	19	10	101	8	8080	2609840	10	26098400
Stadium	4 killo	Shromeda	Anbesa	7.4	3	101	8	2424	782952	5	3914760
Stadium	Megenagna	Hanamariam	Anbesa	10.6	2	101	8	1616	521968	5	2609840
Stadium	Torhailochi	Karakori	Anbesa	11.7	4	101	8	3232	1043936	5	5219680
Stadium	Kelemework school	DIber	Anbesa	8.6	3	101	8	2424	782952	5	3914760

Zone-based fare integration for public transport in the case of Addis Ababa city 2021/22

Stadium	4 killo	Gurara	Anbesa	9.5	4	101	8	3232	1043936	5	5219680
Stadium	Torhailochi	Alembank	Anbesa	12	2	101	8	1616	521968	5	2609840
Stadium	Sarbet	Jemo	Anbesa	10.6	4	101	8	3232	1043936	5	5219680
Stadium	Torhailochi	Winget school	Anbesa	10.2	5	101	8	4040	1304920	5	6524600
Stadium	Coca-fabrica	Kolfe efoyta	Anbesa	9.5	2	101	8	1616	521968	5	2609840
Stadium	Torhailochi	Betel hospital	Anbesa	10	5	101	8	4040	1304920	5	6524600
Stadium	Megenagna	Kara	Anbesa	13.7	5	101	8	4040	1304920	5	6524600
Stadium	Torhailoch	Anfomeda	Anbesa	12	4	101	8	3232	1043936	5	5219680
Stadium	Gotera-saris-kality	Gelan	Anbesa	7.9	5	101	8	4040	1304920	5	6524600
Stadium	Megenagna-cmc	Ayat condominium	Anbesa	18	8	101	8	6464	2087872	10	20878720
Mexico	Sefera	Gelan	Anbesa	14.9	10	101	8	8080	2609840	10	26098400
Mexico	Bstrate gebrel	Karakori	Anbesa	10	3	101	8	2424	782952	5	3914760
Mexico	Kera	Lafto	Anbesa	7.5	5	101	8	4040	1304920	5	6524600
Mexico	Bstrate gebrel	Alem bank	Anbesa	10	3	101	8	2424	782952	5	3914760
Mexico	Sarbet	Sefera	Anbesa	9.4	8	101	8	6464	2087872	5	10439360
Mexico	Sarbet	Hailegarment	Anbesa	9.2	12	101	8	9696	3131808	5	15659040
Mexico	Hailegarmnt	Tuludimtu	Anbesa	10	14	101	8	11312	3653776	5	18268880
Addisu gebeya	Giorgis	Kera	Anbesa	9.9	8	101	8	6464	2087872	5	10439360
Balcha hospital	Hayahult	Goro r/about	Anbesa	14.6	10	101	8	8080	2609840	10	13049200
Balcha hospital	Mekanisa	Hanamariam	Anbesa	9.6	2	101	8	1616	521968	5	2609840
4 killo	Megenagna	Kotebe gebrel	Anbesa	11.4	5	101	8	4040	1304920	5	6524600
4 killo	Hayahult	Gerji	Anbesa	11.2	4	101	8	3232	1043936	5	5219680

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4 killo	Megenagna	Summit condominium	Anbesa	14.7	2	101	8	1616	521968	10	5219680
4killo	Adisugebya	Etotomariam	Anbesa	16.6	2	101	8	1616	521968	10	5219680
6 kilo	Tkuranbesa	Jemo 3	Anbesa	11	4	101	8	3232	1043936	5	5219680
6 kilo	Olompia	kera	Anbesa	10.4	6	101	8	4848	1565904	5	7829520
6 killo	Megenagna-cmc	Chefe-ayat condominium	Anbesa	18	5	101	8	4040	1304920	10	13049200
Bole bora	Gerjiroba	Summit comdominium	Anbesa	12	2	101	8	1616	521968	5	2609840
Bole michael	Sunshine	Adisugebeya	Anbesa	15.8	6	101	8	4848	1565904	10	15659040
Bole michael	Gbigebrel	Shiromeda	Anbesa	11.5	8	101	8	6464	2087872	5	20878720
Bole michael	Piassa	Sansusi	Anbesa	21.5	4	101	8	3232	1043936	10	10439360
Ayertena	Tegbared	Aware r/about	Anbesa	12	2	101	8	1616	521968	5	2609840
Ayertena	Bisrat gebrel	Qera	Anbesa	5	4	101	8	3232	1043936	5	5219680
Ayertena	Garment	Sarisabo	Anbesa	12.3	6	101	8	4848	1565904	5	7829520
Ayertena	Torhailoch	Winget school	Anbesa	10.5	7	101	8	5656	1826888	5	9134440
Saris abo	Gbi geberel	Shromeda	Anbesa	14.2	6	101	8	4848	1565904	10	15659040
Saris abo	Dama hotel	Hanamariam	Anbesa	4.9	4	101	8	3232	1043936	5	5219680
Saris abo	Kality	Akaki korkoro	Anbesa	11.4	3	101	8	2424	782952	5	3914760
Saris abo	Kality	Tuludimtu	Anbesa	12	3	101	8	2424	782952	5	3914760
Kality	Yosef	Kera	Anbesa	8.3	3	101	8	2424	782952	5	3914760
Torhailoch	Ayertena	Kenteri	Anbesa	12	6	101	8	4848	1565904	5	7829520
Torhailoch	Gbigebrel	Minilik hospital	Anbesa	10.2	4	101	8	3232	1043936	5	5219680
Kolfe efoyta	Giorgis	Minilik hospital	Anbesa	10	4	101	8	3232	1043936	5	5219680

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Jemo 2	Jemo	Mekanisa-michael	Anbesa	5.6	4	101	8	3232	1043936	5	5219680
Sum										880821000	
Megenagna	Kazanchis	Mexico	Sheger	6.6	1	70	12	840	271320	5	1356600
Megenagna	CMC	Bole arabsa	Sheger	13.8	15	70	12	12600	4069800	5	20349000
Megenagna	CMC	Summit	Sheger	10	4	70	12	3360	1085280	5	5426400
Megenagna	Bole michael	Bolesaris	Sheger	11.7	2	70	12	1680	542640	5	2713200
Megenagna	wesen	Yekabado	Sheger	12	38	70	12	31920	10310160	5	51550800
Megenagna	4killo	Piassa	Sheger	7.5	5	70	12	4200	1356600	5	6783000
Megenagna	CMC	Tafo	Sheger	11.2	4	70	12	3360	1085280	5	5426400
Autobus tera	Ldeta	Saris abo	Sheger	9.3	1	70	12	840	271320	5	1356600
Autobus tera	Anfo	Kela	Sheger	25.2	3	70	12	2520	813960	10	8139600
Autobus tera	Torhailochi	Alembank	Sheger	11	5	70	12	4200	1356600	5	6783000
Autobus tera	Mexico	Saris	Sheger	13.6	2	70	12	1680	542640	5	2713200
Autobus tera	Lkuanda	Anfo	Sheger	10.4	2	70	12	1680	542640	5	2713200
Autobus tera	Zenebe worq	Karaqori	Sheger	11.5	2	70	12	1680	542640	5	2713200
Autobus tera	Zenebeworq	Ayertena	Sheger	9.6	4	70	12	3360	1085280	5	5426400
Autobstera	Yekatit12 hospital	Spain embassy	Sheger	6	1	70	12	840	271320	5	1356600
Autobus tera	Michael r/about	Jemo	Sheger	14.5	2	70	12	1680	542640	10	5426400
Piassa	Ambassador	Saris	Sheger	11.3	16	70	12	13440	4341120	5	21705600
Piassa	Mexico	Jemo	Sheger	12.8	5	70	12	4200	1356600	5	6783000
Piassa	Bulgariya	Kera mebrathal	Sheger	11	7	70	12	5880	1899240	5	9496200

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Piassa	Tkuranbesa	Bole	Sheger	8.7	6	70	12	5040	1627920	5	8139600
Piassa	Torhailochi	Betel	Sheger	9.4	4	70	12	3360	1085280	5	5426400
Piassa	Janmeda	Ferensay	Sheger	6.3	4	70	12	3360	1085280	5	5426400
Piassa	4killo	Megenagna	Sheger	7.5	5	70	12	4200	1356600	5	6783000
Piassa	Semen hotel	Dlber	Sheger	5	4	70	12	3360	1085280	5	5426400
Piassa	Mexico	Jemo	Sheger	12.3	6	70	12	5040	1627920	5	8139600
Piassa	Mexico	Ayertena	Sheger	13	2	70	12	1680	542640	5	2713200
Mexico	Sarnbet-mekanisa	Jemo 1	Sheger	9	17	70	12	14280	4612440	5	23062200
Mexico	Sarbet-mekanisa	Jemo 2	Sheger	12	14	70	12	11760	3798480	5	18992400
Mexico	Sarbet-mekanisa	Jemo 3	Sheger	10	4	70	12	3360	1085280	5	5426400
Mexico	Zenbeworq	Alembank	Sheger	10.2	3	70	12	2520	813960	5	4069800
Mexico	Sarbet	Ayertena	Sheger	8	4	70	12	3360	1085280	5	5426400
Mexico	Estifanos	Shromeda	Sheger	8.7	12	70	12	10080	3255840	5	16279200
Mexico	Kera	Lafto	Sheger	7.5	5	70	12	4200	1356600	5	6783000
Mexico	6 killo	Ferensay	Sheger	9	2	70	12	1680	542640	5	2713200
Yeka abado	4 killo	Piassa	Sheger	20.5	9	70	12	7560	2441880	10	24418800
Yeka abado	Wesen	Megenagna	Sheger	19	6	70	12	5040	1627920	10	16279200
Bole arabsa	Megenagna	Legehar	Sheger	24.1	2	70	12	1680	542640	10	5426400
Bole arabsa	Megenagna-4 killo	piassa	Sheger	24.3	2	70	12	1680	542640	10	5426400
Ayat r/about	Noh realstate	Arabsa	Sheger	7	2	70	12	1680	542640	5	2713200
Tafo	Ayat r/about	Arabsa	Sheger	8	1	70	12	840	271320	5	1356600
Addisu gebeya	6 killo	Mgenagna	Sheger	10	9	70	12	7560	2441880	5	12209400
Merab	Betel	Alembank	Sheger	11	2	70	12	1680	542640	5	2713200

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hotel											
Ayertena	Germen	Saris abo	Sheger	13.2	1	70	12	840	271320	5	1356600
Jemo 2	Gofa- kerkos- legehar	Megenagna	Sheger	20	4	70	12	3360	1085280	10	10852800
Jemo	Mexico	6 killo	Sheger	15	6	70	12	5040	1627920	10	16279200
Shromeda	4 killo	Bole	Sheger	11	3	70	12	2520	813960	5	4069800
4 killo	Shewadabo	Bole	Sheger	8	2	70	12	1680	542640	5	2713200
Shromeda	Lancha	Saris	Sheger	14.8	3	70	12	2520	813960	10	8139600
4 killo	6 killo	Ferensay	Sheger	5.3	2	70	12	1680	542640	5	2713200
Ayertena	Lideta bar	Stadium	Sheger	9	1	70	12	840	271320	5	1356600
6 killo	Gbigebrel	Kazanchis	Sheger	5.8	1	70	12	840	271320	5	1356600
Yekabado	Mgenagna	Mexico	Sheger	18.6	4	70	12	3360	1085280	10	10852800
Sum											423259200
East	Megenagna	West	Single train	17.5	9	317	14	39942	14578830	10	145788300
East	Megenagna	West	Double train	17.5	1	634	14	8876	3239740	10	32397400
North	Stadium	South	Single train	16.9	9	317	14	39942	14578830	10	145788300
North	Stadium	South	Couple train	16.9	1	634	14	8876	3239740	10	32397400
Sum											356371400

Appendix D

Questionnaires and interviews for AACPTA and AALRT official professionals and managers.

1. What is the type of the current fare system of PT in your company?
2. How design and set the current fare system analytically?
3. What are the primary consideration to design the current fare system related with demand, revenue, and profit?
4. What are the weakness and strengths of the current fare system of PT in your company?
5. What are the problems boldly observed on PT due to the current fare system?
6. What are economic and social impacts due to the current public transportation fare system in a city?
7. Is there any recorded data about the number of passengers per day, per month, per year, and number of vehicles which give daily, monthly, and yearly PT service?
8. If there is, is it satisfying users request /demand/?
9. How many people use the Buses/Trains/?
10. Is there any topography that may increase the travel time? If there is, which area?

11. Is there any recorded data about each trip distance and its fare, frequency, and capacity of each type of Buses and Trains?
12. How many of the routes cross each other on a common station?
13. Is your office estimated and tried to minimize the current PT problem? How much? If not, why?
14. Is there any future plan in your company for the implementation of the fare integration system of PT?
15. If there is a plan, which type of system plan to implement in your company?
16. If there is a plan, is there enough preparation to hand over the system in?
17. If you have future plan, what is your expectation from the implementation of fare integration system of PT?
18. Is there any possibility or future plan that AACPTA and AALRT public transport system can be under the management of unit office?
19. What is your personal perspective, if the current fare system replaces by zone-based fare integration system?
20. Do you have any important ideas regarding the issue?

Appendix E

Anbesa / Sheger public transport kilometer distribution and service charge, (03/04/2012 E.C)

It.no.	The practical km division	The applicable tariff
1	4	2
2	4.1 - 6	2.50
3	6.1 - 8.0	3.00
4	8.1 - 9.0	3.50
5	9.1 - 10.0	4.00
6	10.1 - 12.0	4.50
7	12.1 - 13.0	6.00
8	13.1 - 15.0	7.00
9	15.1 - 17.0	8.00
10	17.1 - 20.0	9.00
11	20.1 - 23.0	10.00
12	23.1 - 26.0	11.00
13	26.1 - 30.0	12.00
14	30.1 - 35.0	14.00

Source - Addis Ababa city public transport office

Appendix F

አንበሳ ባስ የብዙሃን ትራንስፖርት አገልግሎት ድርጅት ስታንዳርድን መሰረት አድርጎ የተሰበሰበ አመታዊ ገቢ

ገ.ቁ	የቆይታ ቁጥር	የጉባዔ መለኪያዎች					የአድራሻ (Av.Fare/K.m)	የገቢ መለኪያዎች		
		የጉባዔ ቁጥር (Av.Trip/Veh/day)	የጉባዔ ቁጥር (Av.Trp/Veh/month)	የጉባዔ ቁጥር (Av.Pass/day)	የጉባዔ ቁጥር (Av.Pass/Veh/month)	የጉባዔ ቁጥር (Av.Pass/Veh/year)		የጉባዔ ቁጥር (Av.Rev/Veh/day)	የጉባዔ ቁጥር (Tot.Rev/Veh/month)	የጉባዔ ቁጥር (Tot.Rev/Veh/year)
1	4	10	1,040	3,000	78,000	936,000	3	9,000	234,000	2,808,000
2	8	12	2,496	7,200	187,200	2,246,400	3	21,600	561,600	6,739,200
3	4	11	1,144	3,300	85,800	1,029,600	4	13,200	343,200	4,118,400
4	8	12	2,496	7,200	187,200	2,246,400	3	21,600	561,600	6,739,200
5	3	8	624	1,800	46,800	561,600	13	23,400	608,400	7,300,800
6	3	14	1,092	3,150	81,900	982,800	3	9,450	245,700	2,948,400
7	6	12	1,872	5,400	140,400	1,684,800	3	16,200	421,200	5,054,400
8	7	12	2,184	6,300	163,800	1,965,600	3	18,900	491,400	5,896,800
9	3	14	1,092	3,150	81,900	982,800	3	9,450	245,700	2,948,400
10	6	5	780	2,250	58,500	702,000	5	11,250	292,500	3,510,000
11	4	8	832	2,400	62,400	748,800	3	7,200	187,200	2,246,400
12	6	14	2,184	6,300	163,800	1,965,600	2	12,600	327,600	3,931,200
13	6	12	1,872	5,400	140,400	1,684,800	3	16,200	421,200	5,054,400
14	6	16	2,496	7,200	187,200	2,246,400	2	14,400	374,400	4,492,800
15	38	16	15,808	45,600	1,185,600	14,227,200	3	136,800	3,556,800	42,681,600
16	4	10	1,040	3,000	78,000	936,000	3	9,000	234,000	2,808,000

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17	6	12	1,872	5,400	140,400	1,684,800	2	10,800	280,800	3,369,600
18	6	13	2,028	5,850	152,100	1,825,200	5	29,250	760,500	9,126,000
19	5	12	1,560	4,500	117,000	1,404,000	3	13,500	351,000	4,212,000
20	4	12	1,248	3,600	93,600	1,123,200	5	18,000	468,000	5,616,000
21	4	8	832	2,400	62,400	748,800	5	12,000	312,000	3,744,000
22	10	12	3,120	9,000	234,000	2,808,000	5	45,000	1,170,000	14,040,000
23	6	12	1,872	5,400	140,400	1,684,800	4	21,600	561,600	6,739,200
24	4	10	1,040	3,000	78,000	936,000	5	15,000	390,000	4,680,000
25	10	14	3,640	10,500	273,000	3,276,000	2	21,000	546,000	6,552,000
26	6	12	1,872	5,400	140,400	1,684,800	3	16,200	421,200	5,054,400
27	10	12	3,120	9,000	234,000	2,808,000	3	27,000	702,000	8,424,000
28	4	12	1,248	3,600	93,600	1,123,200	4	14,400	374,400	4,492,800
29	5	10	1,300	3,750	97,500	1,170,000	4	15,000	390,000	4,680,000
30	4	8	832	2,400	62,400	748,800	3	7,200	187,200	2,246,400
31	4	12	1,248	3,600	93,600	1,123,200	3	10,800	280,800	3,369,600
32	4	10	1,040	3,000	78,000	936,000	4	12,000	312,000	3,744,000
33	3	12	936	2,700	70,200	842,400	3	8,100	210,600	2,527,200
34	4	10	1,040	3,000	78,000	936,000	5	15,000	390,000	4,680,000
35	4	14	1,456	4,200	109,200	1,310,400	2	8,400	218,400	2,620,800
36	4	10	1,040	3,000	78,000	936,000	4	12,000	312,000	3,744,000
37	4	8	832	2,400	62,400	748,800	5	12,000	312,000	3,744,000
38	15	10	3,900	11,250	292,500	3,510,000	5	56,250	1,462,500	17,550,000
39	3	14	1,092	3,150	81,900	982,800	3	9,450	245,700	2,948,400
40	4	12	1,248	3,600	93,600	1,123,200	3	10,800	280,800	3,369,600
41	3	10	780	2,250	58,500	702,000	3	6,750	175,500	2,106,000

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42	4	10	1,040	3,000	78,000	936,000	5	15,000	390,000	4,680,000
43	4	12	1,248	3,600	93,600	1,123,200	3	10,800	280,800	3,369,600
44	6	8	1,248	3,600	93,600	1,123,200	5	18,000	468,000	5,616,000
45	6	12	1,872	5,400	140,400	1,684,800	3	16,200	421,200	5,054,400
46	6	10	1,560	4,500	117,000	1,404,000	5	22,500	585,000	7,020,000
47	6	12	1,872	5,400	140,400	1,684,800	4	21,600	561,600	6,739,200
48	4	12	1,248	3,600	93,600	1,123,200	3	10,800	280,800	3,369,600
49	6	12	1,872	5,400	140,400	1,684,800	3	16,200	421,200	5,054,400
50	5	12	1,560	4,500	117,000	1,404,000	4	18,000	468,000	5,616,000
51	6	10	1,560	4,500	117,000	1,404,000	3	13,500	351,000	4,212,000
52	6	12	1,872	5,400	140,400	1,684,800	3	16,200	421,200	5,054,400
53	9	8	1,872	5,400	140,400	1,684,800	20	108,000	2,808,000	33,696,000
54	8	12	2,496	7,200	187,200	2,246,400	5	36,000	936,000	11,232,000
55	4	8	832	2,400	62,400	748,800	5	12,000	312,000	3,744,000
56	3	14	1,092	3,150	81,900	982,800	3	9,450	245,700	2,948,400
57	6	12	1,872	5,400	140,400	1,684,800	3	16,200	421,200	5,054,400
58	6	12	1,872	5,400	140,400	1,684,800	3	16,200	421,200	5,054,400
59	6	12	1,872	5,400	140,400	1,684,800	3	16,200	421,200	5,054,400
60	6	10	1,560	4,500	117,000	1,404,000	3	13,500	351,000	4,212,000
61	4	12	1,248	3,600	93,600	1,123,200	3	10,800	280,800	3,369,600
62	2	8	416	1,200	31,200	374,400	6	7,200	187,200	2,246,400
63	6	10	1,560	4,500	117,000	1,404,000	4	18,000	468,000	5,616,000
64	3	10	780	2,250	58,500	702,000	3	6,750	175,500	2,106,000
65	4	18	1,872	5,400	140,400	1,684,800	3	16,200	421,200	5,054,400
66	6	10	1,560	4,500	117,000	1,404,000	3	13,500	351,000	4,212,000

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67	6	9	1,404	4,050	105,300	1,263,600	5	20,250	526,500	6,318,000
67	4	12	1,248	3,600	93,600	1,123,200	3	10,800	280,800	3,369,600
68	6	8	1,248	3,600	93,600	1,123,200	6	21,600	561,600	6,739,200
69	4	18	1,872	5,400	140,400	1,684,800	2	10,800	280,800	3,369,600
70	2	12	624	1,800	46,800	561,600	4	7,200	187,200	2,246,400
71	4	10	1,040	3,000	78,000	936,000	3	9,000	234,000	2,808,000
72	6	12	1,872	5,400	140,400	1,684,800	3	16,200	421,200	5,054,400
73	6	8	1,248	3,600	93,600	1,123,200	6	21,600	561,600	6,739,200
74	10	16	4,160	12,000	312,000	3,744,000	2	24,000	624,000	7,488,000
75	6	12	1,872	5,400	140,400	1,684,800	4	21,600	561,600	6,739,200
76	2	12	624	1,800	46,800	561,600	3	5,400	140,400	1,684,800
77	4	8	832	2,400	62,400	748,800	15	36,000	936,000	11,232,000
78	5	12	1,560	4,500	117,000	1,404,000	4	18,000	468,000	5,616,000
79	6	10	1,560	4,500	117,000	1,404,000	3	13,500	351,000	4,212,000
80	4	7	728	2,100	54,600	655,200	15	31,500	819,000	9,828,000
81	3	8	624	1,800	46,800	561,600	15	27,000	702,000	8,424,000
82	6	12	1,872	5,400	140,400	1,684,800	3	16,200	421,200	5,054,400
83	2	3	156	450	11,700	140,400	20	9,000	234,000	2,808,000
84	3	12	936	2,700	70,200	842,400	3	8,100	210,600	2,527,200
85	4	12	1,248	3,600	93,600	1,123,200	4	14,400	374,400	4,492,800
86	3	12	936	2,700	70,200	842,400	3	8,100	210,600	2,527,200
87	4	7	728	2,100	54,600	655,200	15	31,500	819,000	9,828,000
88	6	12	1,872	5,400	140,400	1,684,800	4	21,600	561,600	6,739,200
89	4	10	1,040	3,000	78,000	936,000	5	15,000	390,000	4,680,000
90	6	10	1,560	4,500	117,000	1,404,000	5	22,500	585,000	7,020,000

Zone-based fare integration for public transport in the case of Addis Ababa city 2021/22

91	6	12	1,872	5,400	140,400	1,684,800	4	21,600	561,600	6,739,200
92	6	12	1,872	5,400	140,400	1,684,800	3	16,200	421,200	5,054,400
93	6	10	1,560	4,500	117,000	1,404,000	4	18,000	468,000	5,616,000
94	6	10	1,560	4,500	117,000	1,404,000	4	18,000	468,000	5,616,000
95	6	12	1,872	5,400	140,400	1,684,800	3	16,200	421,200	5,054,400
96	2	8	416	1,200	31,200	374,400	8	9,600	249,600	2,995,200
97	4	12	1,248	3,600	93,600	1,123,200	3	10,800	280,800	3,369,600
98	4	12	1,248	3,600	93,600	1,123,200	4	14,400	374,400	4,492,800
99	4	10	1,040	3,000	78,000	936,000	6	18,000	468,000	5,616,000
100	6	10	1,560	4,500	117,000	1,404,000	4	18,000	468,000	5,616,000
101	12	12	3,744	10,800	280,800	3,369,600	6	64,800	1,684,800	20,217,600
102	4	10	1,040	3,000	78,000	936,000	4	12,000	312,000	3,744,000
103	10	12	3,120	9,000	234,000	2,808,000	5	45,000	1,170,000	14,040,000
104	2	12	624	1,800	46,800	561,600	3	5,400	140,400	1,684,800
105	6	12	1,872	5,400	140,400	1,684,800	4	21,600	561,600	6,739,200
106	6	10	1,560	4,500	117,000	1,404,000	5	22,500	585,000	7,020,000
107	4	12	1,248	3,600	93,600	1,123,200	4	14,400	374,400	4,492,800
108	6	12	1,872	5,400	140,400	1,684,800	6	32,400	842,400	10,108,800
109	14	13	4,732	13,650	354,900	4,258,800	6	81,900	2,129,400	25,552,800
110	4	14	1,456	4,200	109,200	1,310,400	5	21,000	546,000	6,552,000
111	6	12	1,872	5,400	140,400	1,684,800	4	21,600	561,600	6,739,200
112	17	14	6,188	17,850	464,100	5,569,200	6	107,100	2,784,600	33,415,200
113	6	12	1,872	5,400	140,400	1,684,800	6	32,400	842,400	10,108,800
ጠቅላይ									730,173,600	

Source - Anbesa mass transport service enterprise annual revenue recorded data April, 2020

ሸገር ባስ የብዙሃን ትራንስፖርት አገልግሎት ድርጅት ስታንዳርድን መሰረት አድርጎ የተሰበሰበ አመታዊ ገቢ

ገ.ቁ	የሰዓት ቁጥር	የጉዞ መለኪያዎች					የአማካኝ ወጪ (Av.Fare/K.m)	የገቢ መለኪያዎች		
		የአማካኝ ጉዞ (Av.Trip/Veh/day)	የአማካኝ ጉዞ/ወር (Av.Trp/Veh/month)	የአማካኝ ጉዞ/ቀን (Av.Pass/day)	የአማካኝ ጉዞ/ወር (Av.Pass/Veh/month)	የአማካኝ ጉዞ/ዓመት (Av.Pass/Veh/year)		የአማካኝ ገቢ/ወር (Av.Rev/Veh/day)	የአማካኝ ገቢ/ወር (Tot.Rev/Veh/month)	የአማካኝ ገቢ/ዓመት (Tot.Rev/Veh/year)
1	38	16	45,600	1,185,600	14,227,200	170726400	4	182,400	4,742,400	56908800
2	16	12	14,400	374,400	4,492,800	53913600	5	72,000	1,872,000	22464000
3	4	12	3,600	93,600	1,123,200	13478400	6	21,600	561,600	6739200
4	3	8	1,800	46,800	561,600	6739200	6	10,800	280,800	3369600
5	4	12	3,600	93,600	1,123,200	13478400	6	21,600	561,600	6739200
6	2	8	1,200	31,200	374,400	4492800	2	2,400	62,400	748800
7	2	12	1,800	46,800	561,600	6739200	3	5,400	140,400	1684800
8	4	12	3,600	93,600	1,123,200	13478400	3	10,800	280,800	3369600
9	5	8	3,000	78,000	936,000	11232000	4	12,000	312,000	3744000
10	5	12	4,500	117,000	1,404,000	16848000	4	18,000	468,000	5616000
11	8	8	4,800	124,800	1,497,600	17971200	6	28,800	748,800	8985600
12	2	8	1,200	31,200	374,400	4492800	6	7,200	187,200	2246400
13	15	16	18,000	468,000	5,616,000	67392000	3	54,000	1,404,000	16848000
14	14	14	14,700	382,200	4,586,400	55036800	4	58,800	1,528,800	18345600
15	4	16	4,800	124,800	1,497,600	17971200	4	19,200	499,200	5990400
16	4	8	2,400	62,400	748,800	8985600	6	14,400	374,400	4492800
17	2	8	1,200	31,200	374,400	4492800	6	7,200	187,200	2246400
18	3	16	3,600	93,600	1,123,200	13478400	4	14,400	374,400	4492800

Zone-based fare integration for public transport in the case of Addis Ababa city 2021/22

19	3	16	3,600	93,600	1,123,200	13478400	4	14,400	374,400	4492800
20	2	8	1,200	31,200	374,400	4492800	4	4,800	124,800	1497600
21	16	8	9,600	249,600	2,995,200	35942400	4	38,400	998,400	11980800
22	6	10	4,500	117,000	1,404,000	16848000	4	18,000	468,000	5616000
23	3	12	2,700	70,200	842,400	10108800	5	13,500	351,000	4212000
24	2	10	1,500	39,000	468,000	5616000	6	9,000	234,000	2808000
25	4	16	4,800	124,800	1,497,600	17971200	3	14,400	374,400	4492800
26	3	8	1,800	46,800	561,600	6739200	5	9,000	234,000	2808000
27	3	8	1,800	46,800	561,600	6739200	3	5,400	140,400	1684800
28	2	10	1,500	39,000	468,000	5616000	4	6,000	156,000	1872000
29	3	8	1,800	46,800	561,600	6739200	4	7,200	187,200	2246400
30	14	12	12,600	327,600	3,931,200	47174400	3	37,800	982,800	11793600
31	6	12	5,400	140,400	1,684,800	20217600	3	16,200	421,200	5054400
32	8	12	7,200	187,200	2,246,400	26956800	3	21,600	561,600	6739200
33	2	10	1,500	39,000	468,000	5616000	4	6,000	156,000	1872000
34	2	10	1,500	39,000	468,000	5616000	3	4,500	117,000	1404000
35	2	10	1,500	39,000	468,000	5616000	4	6,000	156,000	1872000
36	4	12	3,600	93,600	1,123,200	13478400	2	7,200	187,200	2246400
37	4	16	4,800	124,800	1,497,600	17971200	2	9,600	249,600	2995200
38	4	16	4,800	124,800	1,497,600	17971200	2	9,600	249,600	2995200
39	9	12	8,100	210,600	2,527,200	30326400	3	24,300	631,800	7581600
40	3	8	1,800	46,800	561,600	6739200	6	10,800	280,800	3369600
41	4	10	3,000	78,000	936,000	11232000	3	9,000	234,000	2808000
42	4	10	3,000	78,000	936,000	11232000	3	9,000	234,000	2808000
43	2	12	1,800	46,800	561,600	6739200	4	7,200	187,200	2246400
44	5	8	2,800	72,800	873,600	10483200	4	11,200	291,200	3494400
45	4	8	2,240	58,240	698,880	8386560	2	4,480	116,480	1397760

Zone-based fare integration for public transport in the case of Addis Ababa city 2021/22

46	4	12	3,360	87,360	1,048,320	12579840	5	16,800	436,800	5241600
47	4	8	2,240	58,240	698,880	8386560	4	8,960	232,960	2795520
48	4	8	2,240	58,240	698,880	8386560	3	6,720	174,720	2096640
ድምር										289554720

Source – Sheger mass transport service enterprise annual revenue survey May, 2020

በኢትዮጵያ ምድር ባቡር የአዲስ አበባ ቀላል ባቡር ትራንዚት አገልግሎት አፈጻጸም ሪፖርት

ተ.ቁ	የአፕራሽን መግለጫ	2012 ዓ.ም
1	ገቢ	
1.1	የትኬት ገቢ	117,439,682.00
1.2	ጠቅላላ ገቢ	117,439,682.00

Source - AALRT comprehensive annual revenue June, 2020