THE INTEGRATION OF LAND USE AND PUBLIC TRANSPORT SYSTEM IN ADAMA CITY, OROMIA NATIONAL REGIONAL STATE, ETHIOPIA

Betelhem Daniel Getu

A Thesis Submitted to

The Department of Architecture

School of Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirement for the Degree of Master's in Urban Planning and Design

Office of Graduate Studies

Adama Science and Technology University

Adama, Ethiopia

May 2022

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Declaration

I hereby declare that this MSc Thesis entitled "**The integration of land use and public transport system in Adama city, Oromia national regional state Ethiopia.**" is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation

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Name of the student	Signature	Date

Recommendation

I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled "**The integration of land use and public transport system in Adama city, Oromia national regional state Ethiopia.**." prepared under my guidance by Betelhem Daniel Getu submitted in partial fulfillment of the requirements for the degree of Mater's of Science in Urban Planning and Design. Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

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Major Advisor	Signature	Date

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LIST OF ACRONYMS AND ABBRVIATIONS

AIT	Area Index of Trip
ALT	Alatalo Evenness Index
ENI	Entropy Index
FSM	Four Step Travel Model
HBW	Home Based Work Trip
HBNW	Home Based Non-Work Trip
LUTI	Land Use –Transportation Integration
NHB	Non-Home Based Trip
OD	Origin-Destination
PD	Population Density
PT	Public Transport
TAZ	Traffic Analysis Zone
TOD	Transit-Oriented Development

ABSTRACT

Public transport infrastructure in Adama city is not enough to meet the transport demand generated by the rapid growth of residential areas. As a result it generates vehicle trips leading to traffic congestion and costly roadway capacity improvements. Therefore, this research aims to understand the integration of land use and public transport system in Adama city. For identified public transport system analyses it uses international transport system evaluation standards, regression analysis, travel demand model, and local references by using questioners. Land use mix is calculated by measuring land use mix level using the Shannon diversity index and the extent of land use linking with travel using the Area index of a trip for each 8 traffic zone. Correlation analysis has been carried out to identify the relationship between the population density, land use mix level, and area index of the trip and understand the integration of land use and the public transport system. The research is mixed type research and was conducted using the deductive approach and descriptive in an explanatory manner. There are 13 public buses and 500 taxis (mini-bus) as a common public transport mode in Adama city. Public transport route covers 4.575% of total street network spatial coverage in Adama city, which is below standard according to the UN Inhabitants declaration in 2015. The travel demand model has been applied to 14 major 8 traffic zone which include 313 sub-8 traffic zones classified based on neighborhood block boundary and the result showed that there are 8 common trip generator 8 traffic zones and according to Utility Function and Multinomial Logit model, Public buses and taxis (mini-bus) had 95.6363% and 4.3636% of probability being chosen respectively. 8 traffic zone located nearby to the center of the city had a medium value of land use mix level ranging between 0.45 -0.65, while 6 8 traffic zone at a far distance from the city center and in the expansion area had a low value of land mix level below 0.45.The final analyses result showed land use mix level which indicate land use diversity and Area index of the trip which indicate travel behavior had a direct relation to each other. Generally it is recommended that, Adama city administration should include mixed-use development either or both vertical and horizontal methods and the transit oriented method in the city expansion strategy.

Key words: Adama, Integration, Land use, Public transport, System,

CHAPTER ONE

1. INTRODUCTION

The integration of urban land use and public transport systems addresses the development of strategies to increase economic efficiency, reduce excessive use of resources, and improve social aspects (Alourafi.et.al, 2020). Public transport and land use seem to function as separate worlds, with their institutions, disciplinary and cultural backgrounds, planning procedures, and concepts. If public transport and land-use integration are to be achieved, all of these institutional and substantive aspects need to be addressed (Straatemeier, 2019). Currently in most of developing countries, the issues of integrating public transport systems and land use are not considered through the planning process and there is a gap in studies on aligning transport infrastructure and services with land use in ways that reduce kilometers traveled and other issues. This results in different lack of an efficient public transport system, high commuting time, and travel hours. The land-use system is only one important component of measures required to achieve transport objectives. Improvements to public transport services such as pubic buses, taxis, etc... And addressing travel purpose, travel demand, and travel distance compatibility are very important factors for the city development (NSW Department of Urban Affairs and Planning, 2001)

Ethiopia is a developing country with a low level of income accompanied by a high rate of population growth. Different reasons can be mentioned as constraints in the country's economic performance, among which the existing transport system takes part. This is because Transport is an important sector for facilitating different economic activities in the national economy (Dagnachew, 2007). These relations have not been without difficulties in Adama city, due to its strategic location, economic, and administrative importance as one of the fast-growing urban centers in Ethiopia. The city is serving as the gateway to overseas; and it is the main commercial, manufacturing, trade shows, Bazar, conference, and educational center in the region. The physical location of different activities influences the needs for travel and the choice of modality (G/Yesus, 2015).

It is also made clear that the existing public transport infrastructure in Adama city is not enough to satisfactorily meet the transport demand generated by the rapid growth of residential areas at the peripheries of the city in addition to this activities are not located to meet the needs of the economy and people's lifestyle choices due to the expansion of the city most of the residents are living an outskirts area of the city but working in the city center (G/Yesus, 2015).

Nowadays solution includes looking at ways of improving public transport to make it more flexible and responsive to user needs which includes expanding the road networks and/or increasing the public transport services (Dagnachew, 2007). But understanding the integration of land use and public transport system in Adama city to meet the mobility demand of residents is not taken under consideration before, due to this reason this research aims to study this subject.

This research aims to understand the integration of land use and public transport system in Adama city. After identifying existing public transport system efforts and the dominant mode of the public transport system, their route and street in integration with land use in the city, and data interpreted from a survey questionnaire collected from sample residents selected from 14 kebeles by identifying the trip production, attraction, and purpose, which can directly show trip production kebeles and trip attraction kebeles in Adama city, following this, land-use diversity or land mix is for trip production and trip attraction kebeles and identify land mix level and land use and public transport integration level. This research is conducted because no research has been perused on the selected topic in Adama city. For the future developments to be held on the expansion areas in Adama city, this research can be used as a reference for further investigation in the issue. The main research instrument, besides the literature study, are the observation, interview, questionnaire and secondary data. Such examination would give a superior feeling of the degree to which plans may be depended upon and, likewise, bits of knowledge with regards to how nearby arranging endeavors may be improved.

1.1. Background of the Study

The dominant post-war planning approach was premised almost exclusively on car-based mobility in case in Perth, Australia. However, since the 1990s, sustainable cities and sustainable transport have been promoted. (Goodwin et.al, 2012) Suggested a package approach to deliver sustainable transport, one element of which is the land use transport integration (LUTI). (Curtis, 2011) Nowadays, sustainable development is widely perceived as a development pattern that improves the quality of life while protecting and enhancing the natural environment. The public transport system is one of the basic components of sustainable development which integrates the economic, social, and environmental needs of a city. As a result, special attention is being given to public transport and land-use interaction as an instrument for sustainable development (Dagnachew, 2007).

Currently, the issues of integrating land use and public transport are not considered in developing countries through the planning process. This results in high travel time, long travel distance, and high commuting times. By and large, such an evaluation would contribute too to our comprehension of how well both nearby land-use arranging and transportation arranging represent the complementary connections between land use examples and transportation frameworks independently and how those undertakings may be better incorporated (Rodríguez, 2004). The importance of integrating land use and public transport study cannot be overstated. Thinking more strategically about land use-transportation relationships can lead to reduced vehicle miles of travel; improvements in air quality; increased levels of transit use; economic and community revitalization; and the preservation of neighborhood character – not to mention a more visually appealing landscape. Strategically the study aims to achieve integrated land use and public transport systems resulting in integrated developments in a city (Blanton, 2000).

In Ethiopia, urban areas are expanding spatially to accommodate the increasing population resulting from natural growth and in-migration. As a result, residents living in the sprawled residential settlements at the fringes call for affordable and efficient public transport to accommodate travel to jobs, markets, health centers, and other socio-economic activities. This development trend stretched public transport to its limits; hence, it became an earnest matter that solicits resolute action to sustain the development where work requires a substantial journey (Dagnachew, 2007).

Due to its strategic location, economic and administrative importance, Adama city is one of the fast-growing urban centers in Ethiopia. Respectively Adama city is also serving as a distribution center for the surrounding areas. So, all this contributes to making Adama city an ever-warm and busy town, especially at the main road [from Addis Ababa to Harer] due to the agglomeration of different land-use functions that attract the public. For the reason Adama city is expanding horizontally to accommodate the increase in population as a result of natural population growth and in-migration from surrounding areas, the public transport system failed to reach the increasing demand generated from the sprawled settlement at the peripheries (G/Yesus, 2015).

1.2. Statement of the problem

Land use and public transport system integration has a key role to play in delivering social, economic, and environmental sustainability. For many reasons integrated land use and public transport system has not proceeded as fast or as far as some would have expected. not the least of which is that the domain is intensely controversial, it involves many institutional and non-institutional stakeholders with divergent values and mandates, and the sheer complexity of the issues and interdependencies is high in addition to this appropriate concern is not given for the integration system regarding emerging expansion site due to population growth (Waddell, 2011).

Spatial sprawl and increasing transport demand are concurrent trends that need the integration of land use and the public transport system. Lack of diversity or the mix of land uses and disintegrated networks of streets in Adama city results in impacts on the effectiveness and efficiency of manpower activities which directly affects Adama city developments effectiveness and efficiency. Long travel distances for HBW, NBHW, and NHB trips and lack of nearby services in Adama city are results of a lack of integration of land use and public transport system specifically Public bus and taxi.

To solve the problem of transport system regarding public transport system, many research stated by such as (Wegener a. F., 2009), (Pujinda, 2006), (Wee, 2000) and others aims only by planning procedures, analyzing the road width, assessing the traffic system and several public transport modes available. This research fills the analytical and methodological gaps to extend the conceptualization and implementation of land use and public transport integration in Adama city as a major tool for solving transport problems by identifying and mapping the dominant mode of public transport and their route (OD) with their level of route integration using space syntax analysis method and then also measure land use mix level and link of land use with travel of Adama city using Shannon Entropy land use mix index and Area index of trip calculation respectively. This research using the methodological analysis will identify areas in which land use and public transport system are integrated, less integrated, and unintegrated in Adama city. In the end, the research can be a reference for a further research study.

1.3. Objective of the Study

1.3.1. ***General objective***

To understand the integration of land use and public transport system in Adama city, Ethiopia.

1.3.2. ***Specific Objective***

1. To identify the exiting public transport system in integrating with land use in Adama city.
2. To measure the land use mix level of Adama city.

1.4. Research questions

1. What is the current status of public transport system in Adama city?
2. To what extent land use of Adama city is mixed or diverse?
3. How land use and public transport system are integrated in Adama city?

1.5. Scope of the research

This study covers the current judiciary boundary of Adama city, Ethiopia. The research focus on understanding the integration of land use and public transport system in Adama city, Ethiopia, specifically only public bus, taxi, and their users.

1.6. Limitation of the study

The limitation of this study was that the study does not cover issues such as traffic flow, traffic congestion and traffic accident assessment due to the time schedule given for the research and the financial resource provided was not efficient to cover these issues. But it is much recommended for the future study to include these issues to strengthen the result of the study.

1.6. Significance of the study

This study helped to understand the integration of land use and public transport system by identifying the existing public transport system and the land use mix level in Adama city, Ethiopia. The result of the measurement is also used for existing local research input for deep study. In this research traffic flow, traffic congestion, and traffic accident assessment were not covered; this helps other researchers to explore in more depth depending on this current gap, which is how the traffic flow system is affected by the disintegration of land use and public transport and cause a traffic accident and congestion.

In addition to this, since Adama city is on the path of expansion development due to high population growth this study identified and clearly showed the area with a high spatial concentration of activity which is the core area, In addition, it can be used as a reference giving direction for the Adama city land administration office to diversify activities from the CBD to expansion zones. Generally, it gave a better understanding of the integration of land use and public transport system and also served as a partial fulfillment requirement for the MSc in Urban Planning and Design.

1.7. Organization of the Research

The thesis is organized into five chapters. Each chapter systematically and effectively examines the content and data of the study accordingly. The fundamental chapter in the thesis is further demonstrated as follows.

Chapter One: Introduction to the study introduces the thesis by lighting the main topic of the study, research problems, objectives, questions, significance, scope, and description of the study area, limitation, and organization.

Chapter Two: Literature Review is a chapter that discusses key definitions of Land use and Public transport concepts, land use mix, best practices for the measurement of land use mix, a common problem, travel demand, the method of investigation, and measurements. It also includes both empirical and theoretical frameworks about the integration of land use and the public transport system.

Chapter Three: Research Methodology is a chapter that discusses the methodology of the research. The chapter explains the methods used for the study and the process of data collection and analysis in detail.

Chapter Four: Result and Discussion is a chapter that discusses the results of qualitative and quantitative data findings. The subjective quantitative data are gotten from field observation. The qualitative data are analyzed based on a questionnaire survey, field observation notes, and printed documents.

Chapter Five: Conclusion and recommendation is the concluding part of the research. The chapter made a conclusion based on the findings from the measurements, the integration of land use and public transport system level based on the collected data, the study concludes the results and discussion as well as it stated recommendations.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Introduction

This chapter is to give a general theoretical framework and empirical review of the integration of land use and public transport system; related to this, it also presents facts, definitions, arguments, debates, and about the concept that has been researched. In addition, it explains general methodological approaches and empirical concepts that show how land use and public transport integration can be integrated, calculation of land use mix index, street integration, travel demand model, trip purpose, and public transport demand. Finally, it summarizes gaps and debates that have been seen and analyzed, and interpret effectively.

2.2. Theoretical Review

2.2.1. ***Definition and categories***

2.2.1.1. *Land use*

According to (Balcombe et.al, 2003), in "Land use Transport Interaction", the term land use is characterized as a run of human activities, the state of the built environment, conjointly to a few perspectives of the characteristic environment. Having this definition, Land-use is of significance to transport for at slightest three reasons, Arrive using activities and the interaction between them create the requests for transport. Those activities and intuitive are to a more noteworthy or lesser degree impacted by the accessibility of transport, and the linkages between transport and activities may be critical to the examination of transport strategies- especially when attempting to consider whether the transport framework is impacted by the land use activities. In talking of land use, travel request modelers frequently are utilizing this term as a shorthand expression for the zonal populace and work conveyances that they require as inputs to their models. More formally, land use alludes to how land is used, in terms of the buildings built upon the arrival (houses, stores, schools, manufacturing plants, etc.) and the exercises housed inside these buildings (in-home exercises, shopping, instruction, work, generation of goods and administrations, etc.) (Goulias, 2003)**.**

As such, land use is essentially synonymous with urban form, which is a term often used by geographers and regional scientists. Given that it is the participation in out-of-home activities that gives rise to the need for travel, transportation system analysts often speak of the urban activity system, which consists of both the physical built form and the spatial-temporal distribution of activities that occur within this built form (Goulias, 2003).

2.2.1.2. *Urban Land use*

The urban form was defined on different levels of complexity (Batty, 2009), to begin with, microscopically, in terms of detailed areas of employment, homes, commercial zones, entertainment regions, and empty-urban land, with pacific consideration to the area of overwhelming contaminating offices (control stations). Moment, at a better level of generalization, the urban frame can be indicated in terms of density of activities and components, partitioned of employments, sort and structure of transportation arrange, and time measurement of the utilization of its space. Third, at the foremost generalized level urban shape may be drawn closer in terms of spatial setups: compact versus scattered, single cores versus multi-nuclei, and shapes that adjust to development, or those which have foreordained measure.(Litman, 2011), In his paper published in 2010, categorized land use as follows:

TABLE 2. 1: Litman Land use Categories

Source: (Litman, 2011)

Built Environment	**Open Space**
Residential	Agriculture
Commercial	Forest
Industrial	Undeveloped lands
Brownfields(for infill development)	
Transport Facilities	

Land-use patterns can be evaluated based on several attributes (Litman, 2011), Density level: is the number of people or the number of housing units within an area. A mix of land-use types: such as the location of commercial, residential, and other important amenities together or close to each other, is also related to clustering. Accessibility: the ability of people to be able to reach their desired activities and destination. Green-space: the portion of land used for parks, gardens, etc…

2.2.1.3. *Land use characterization*

This papers review indicates that to get the linkages between land use and transport it is vital that one begin with a look at ways to degree land-use character demonstrates characteristics at both the neighborhood level – arrive use and road arrange arrangement, and the territorial level – accessibility to business, shopping, and amusement. This segment sees ways in which spatial (land use) character has been measured and modeled.

Past studies have used mostly qualitative methods to study land use character. These methods are often descriptive and are not used to model travel behavior or the land use character itself. Thus the ability of these characteristics to measure what they claim to measure cannot be assessed. The measures have also tended to focus on the neighborhood level and are assessed manually through case studies and rely on survey techniques (Lynch, 1990).

(Lynch, 1990) Differentiates cities by size (population), density, grain (the pattern of workplaces and housing, segregation of racial groups, large and small dwellings), and shape (compact, linear, star-shaped, or constellations). He notes that the modern city's axial pattern of streets leading to and from centers is an important indicator of its internal pattern. He differentiates street patterns by linear, spindle-shaped, or rectangular grid-based.

2.2.1.4. *Land use mix and Measurement*

Land use mix

In 1961, Jane Jacobs said, "Intricate blending of diverse uses in cities is not a shape of chaos. On the opposite, they speak to a complex and exceedingly created shape of order." Since Jacobs (1961) to begin with raised the significance of land use blend in urban arranging, the differences in land use has gotten to be a central target of the investigation and honing on built situations concerning urban arranging, transportation arranging, wellbeing and preventive pharmaceutical, and property valuation (Song and Knaap, 2004; Ewing and Cervero, 2010). The benefits of arrive use mix have been demonstrated in a few areas, most strikingly in place-making, transportation, open wellbeing, and urban financial matters. From the place-making point of see, blended employment would increment the energy of open places such as streets, squares, and parks by advertising more openings for diverse activities. From a transportation viewpoint, the points of interest of mixed uses would bring different places of beginning and goals closer to each other; subsequently, empowering non-motorized modes and shorter travel separations. From open well-being of view, bringing a variety of alluring goals closer to private regions will advance strolling travel modes and physical exercises, in this way progressing human physiological conditions (Song and Knaap, 2004).

Therefore, mixed land use has become one of the central concepts in the urban planning field today. For example (Carlton, 2007) emphasized that "all TODs (Transit-Oriented Developments) must be mixed-use and contain a minimum amount of public, core, commercial and residential use. Vertical mixed-use buildings are encouraged, but considered a bonus to the basic horizontal mix-use requirement." Aside from TODs, mixed land use has been mentioned in possibly every planning idea in recent years, such as (Downs, 2007), "new urbanism" (Congress for the New Urbanism, 2000) , and "complete neighborhood" (Pivo, 2005). In fact, land use mix plays a central role in major urban planning and design concepts (Smart Growth, New Urbanism, TOD). However, "mixed-use", for the most part, remains an elusive, intangible concept.

Land Use Mix Index

It is critical to develop a widely accepted and significant quantitative level for the land use blend idea in order to assess its causes and effects on various urban environments and living components. A reenactment and comparison of the characteristics of different land-use differences records (Song et.al, 2013) found that Shannon entropy is the most efficient way of representing land with three or more uses.

The Shannon-Weaver diversity index is a popular tool for comparing variety across ecosystems. A diversity index's primary goal is to generate a quantifiable measure of biological variability that can be used to compare biological entities in space or time. This index considers two factors that contribute to the concept of variety in a community: species richness and evenness. Species richness in ecology refers to the number of species, whereas species evenness refers to the homogeneity of the species. That is, the more equal the proportions of each group are, the more homogeneous or even they are. These topics may be referred to differently in different sectors of application. (Konopiński, 2020).

Therefore, the Shannon entropy-based index has become the most influential and commonly accepted method for measuring land use mix in quantitative urban studies. For instance, in the transportation field, Shannon entropy is adopted in the “6Ds” research framework within the “diversity” concept measure, which has been applied to dozens of studies (Ewing and Cervero, 2010). It was later formalized by (Cervero and kockelman, 1997) in the “3D” model to become a standard for describing the status of land use mix in transportation studies.

Area Index

(Hess et.al, 2001), have explained the need to develop an index based on land use functional and spatial complementarity. Land use functional complementarity ensures the consideration of origins and destinations that are likely to be linked by travel. Land use spatial complementarity ensures that the land uses linked with travel are within adequate proximity.

It was assumed that the mode choice would be different for different work purposes inside the buffer zone of a 500-meter radius, created around the trip origin (household in this case), and outside the buffer zone, thereby incorporating land use spatial complementarity as well as functional complementarity.

According to (Bordolo et.al, 2013), an attempt has been made to develop an index called Area Index based on the land use types linked with travel. The area index for a work trip is the ratio of the work areas in the buffer zone to the work areas in the whole study area. The work areas included in this study were the commercial area, service area, and industrial area. It was considered that the residential land uses are linked by travel to the work areas, thereby incorporating the land use functional complementarity. The ratio, when close to 1 indicates that most of the workplaces lie in the buffer zone, thus more non-motorized trips would be realized. The ratio when close to 0 indicates that much of the workplaces are outside the buffer zone and more motorized trips may be realized. Thus, these ratios gave the understanding between mode choice behavior and the amount of particular land-use area available in the vicinity of the household. When Area Index was used for the analysis of shopping trips, the index value was computed based on the shopping space available in the buffer zone and the total shopping space in the study area. Area Index values for the destination of the trips have also been computed based on the hypothesis that the work and shopping space available in the vicinity of the destination influences the individual to make the non-home based trips.

2.2.1.5. *Land use and public transport*

Public Transport Demand is affected by land use and city-built environments. The relationship between land use and public transport is complex, each being directly dependent on the other and this complexity is enhanced by interaction with other factors including age distribution, employment characteristics, income levels, and car ownership. Hence it is difficult to establish the precise relationship between PT demand and land use patterns (Balcombe et.al, 2003).The built environments, investigated in three basic dimensions in the literature, namely “density”, “diversity”, and “design”, called “3Ds”, shape the travel behavior.

Compact neighborhoods can deteriorate the need for public transport modes in a few ways: Bringing origins and destinations closer, there become more opportunities for leaving one's car at home and walking or cycling to a destination or using PT vehicles. Compact neighborhoods moreover tend to have less parking, better quality transport services, wider mixes of land uses, and larger shares of low–income households, all of which reduce car use and increase alternative modes. All these characteristics of the trip ends affect travel behavior and choices (Balcombe et.al, 2003; Cervero and kockelman, 1997).

Merging housing, shopping, employment, and other facilities in mixed-use developments provide residents with the opportunity to live, work, and carry out other daily activities locally or with the minimum travel needs, without having to drive (Balcombe et.al, 2003). Travel demand is a derived demand in the sense that trips are made and distributed based on the desire to reach places, whether office buildings, ballparks, or shopping centers. The characteristics of these places i.e, their land uses, densities, and design features can affect not only the number of trips generated but also modes and routes of travel. While characteristics of origin-destination interchanges…are known to affect travel demand, so are features of the trip ends (i.e., origins and destinations) themselves (Cervero and kockelman, 1997). (Matas, 2004)**,** supports this by drawing attention that the higher population densities of (Spanish) cities make them better suited for PT use than for car use.

The Degree of centralization of employment and facilities (restaurants, shops, services, outlets, entertainment places.), as a design element, also influences travel behavior. A greater degree of centralization encourages PT use and reduces private car use. Distributed shopping centers around the city also reduce travel demand (Balcombe et.al, 2003; Cervero and kockelman, 1997).

Old European cities and newly established American cities are typical examples of how city design affects transport behavior. In the European cities, the Public transport use is higher than that in American cities, which have wider streets, more parking spaces, better–organized city planning, distributed shopping centers, etc. compared to the old historical European cities, where those infrastructures are mostly under protection and cannot be modified for better transport development. In such cities, Public Transport systems are adapted to the current state of the city-built environments and structures (Jone, 1975).

(Cervero and kockelman, 1997), found the effects of the built environment on travel demand being modest to moderate at best for their case of study. Densities exerted the strongest influence on personal business trips. Diversity also had a modest impact on travel demand but was a bit stronger than that density. Design from the built environment seemed to be particularly relevant to both working trip making and non–work trip making. The general conclusion was that higher densities, diverse land uses, and pedestrian-friendly designs… must co-exist to a certain degree if meaningful transportation benefits are to accrue.

In sum, the 3Ds are important demand determinants but PT demand can be shaped to a certain extent by utilizing specific land-use policies that could affect PT use. Some policies may include the development of new residential areas, new commercial and industrial zones, mixed-use (e.g. merged commercial and residential areas) development, car-free zones, and transit-oriented developments (Balcombe et.al, 2003)**.**

The relationship between public transport demand and land use characteristics has been extensively examined in the existing literature. The most frequently mentioned variables are, The location of houses, jobs, and other opportunities in combination with infrastructure networks Densities of houses, employment, and other categories of land use The level of mix the mix in land use categories has also been well recognized that the land use characteristics in a built environment can be categorized into land-use density, diversity, distance (known as 3D), and accessibility (Litman L. , 2005).

Public transport demand is affected by various factors (Balcombe et.al, 2003) and a meta-analysis reported by (Holmgren, 2007) suggested that public transport fare and users’‟ socio-economic factors should be taken into account in public transport demand models. (Cervero and kockelman, 1997), also concluded that the 3D (Density, diversity, and distance) of land use and accessibility have significant impacts on public transport use. In principle, density generally refers to housing, population, or employment density.

Diversity is used to illustrate the heterogeneity of land use and is normally measured as the entropy of the land mix. Urban design refers to the connectivity and walkability in a neighborhood environment, such as the number of intersections or the type of road network (e.g. grid or cul-de-sacs), whereas accessibility usually refers to the walking distance to the nearest public transport station or major town centers.

2.2.2. ***Transport***

Transport plays a vital role in the development of the modern era as an integral part of the socio-economic and political structure of the country. Thus urban transport, Transport infrastructure, and traffic management should involve optimal integration of the means and ways of mobility to create maximum ease and comfort while maintaining the socio-economic and physical integration of the city.

Transport is an integral part of human life. Proper transport links enable efficient frequency of services, the flow of passengers and commodities on (Rail, Roads, Air, Water) mode of travel. Transport theory (or the law) stresses strongly that whatever the mode will be, it should primarily consider the human aspect (i.e. safety, livability, economy, satisfaction…etc.) (Jamet and Freeman, 1998).

2.2.2.1. *Urban Transport*

"It is commonly accepted that cities are the engines of growth in most developing as well as developed countries. More importantly, urban transport can be viewed as the oil that prevents this engine from seizing up." (ORAAMP, 1999)

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

"The urban sector in most developing countries accounts for at least 50 % of the gross national product and in some countries over 70 %. Cities in developing countries often devote 15% to 25% of their annual expenditures to their transport system and sometimes much more" (Desta, 1995).

2.2.2.2. *Public Transport*

The History of Public Transport

The first public transportation known to history was introduced by the Romans, who established a system of vehicles for hire during the reigns of Emperors Augustus and Tiberius. (Black, 1995)These two- or four-wheel wagons were stationed at inns every five or six miles along the fine highways for which the Romans were famous.

Coaches that ran on regular schedules between major towns appeared in Europe during the 16th century. Stagecoaches were introduced in the 17th century. However, most roads were poor, fares were high, and the service was slow and uncomfortable. The first form of public transportation to operate solely within cities was the “hackney carriage”, the forerunner of the taxi, which appeared in Paris and London shortly after 1600. The name came from the French word “Hague nee”, meaning a horse of fair size and quality used for riding, but not for war or hunting.

As the 19th century opened, the average person walked to work. Cities were dense and compact; the geographical area of a city was largely limited to the radius of walking distance from the center. Some wealthy families lived on the outskirts and traveled by horseback or carriage, but horses were too expensive for common people to keep.

The modern era of urban mass transit began in 1819 with a coach line in Paris (Meyer et.al, 1984). It used an existing type of stagecoach called “a diligence”. The first transit service in the United States was started by Abraham Brower on Broadway in New York City in 1827. For this he designed a modified stagecoach seating 12 passengers, it was named “The Accommodation”. The second generation of this stagecoach had a different design: all the seats ran lengthwise, and there was a door at the rear with an iron stairway to the ground. This vehicle was named the “Sociable”.

2.2.2.3. *Public Transport Modes*

"However large-scale the operation of a public transport organization may be, the economic realities dictate that the services can never be instantly available at all times of day and night, can never be so comprehensive as to cover every road and street within the area and never so easy to use as to remove all physical, mental and psychological strain from travel." Travel by public.

The conflict between the needs of travelers and the costs of satisfying these demands leads to a divergence of views about the role that public transport should play. Transport is necessarily subject to constraints in time, space, money, and effort since people are restricted to traveling at certain times and to certain places only.

At one end of this spectrum, public transport is expected to 'pay its way with the services being provided in the most cost-effective way possible and paid for entirely by passenger revenues, While at the other end public transport is regarded as a social service to be funded largely from public monies so that users pay much less than the true costs, and those with a special need (the old, the infirm, children, those in remote areas, those with no car available) are treated even more benevolently.

Various studies have classified Modern public transport into four general categories based on the nature of other operations (Kassahun, 2007). These are Trolleybuses: - operate on public streets in either mixed traffic of bus-only lanes or exclusive bus ways. They employ engines that use fuel and or electric energy. Electric buses usually run with the help of cables that are mounted on electric poles which run along the whole line. Light rail transit Trains: - operate in mixed traffic along public streets to semi metro rail systems on exclusive trucks. Rapid rail transit (Metro, subways, or underground): - operate exclusively right-of-ways at high speed and high capacity passengers aboard from high-level platform to facilitate rapid loading. Sub-urban rail transit (Commuter rail system): - operates on trucks shared with inter-city passenger crews and freight. Urban Mass Transport systems can also be classified based on the line system they employ: On-street systems: buses; trolleybuses trams. Mixed on-street and off-street systems: bus lanes; bus ways; light rail. Off-street systems: metros; commuter rail

2.2.2.4. *Travel demand model*

The application of the concepts of demand and supply in transport economics requires that they be defined with more care than is generally the case in economic theory. This is because travel is described as derived demand. After all, it is demanded as a consequence of the desire to partake in activities in different locations. The fundamentals of transport modeling can model back to the Detroit and Chicago transportation studies in the USA in the 1950s (Bates, 2003).

The last 40 years have as seen the development and application of a large number of statistical and mathematical procedures directed towards improving the understanding of the behavior of agents who make decisions that impact the transport system (Hensher & Button, 2008)

(Bates, 2003) , notes that transport models have evolved from many disciplines; most notably economics, psychology, geography, sociology, and statistics. He notes that their initial focus was on estimating peak demand for transport services and predicting what provision should be made for this peak. The FSM was originally designed for the analysis of urban highway investment although substantial improvements have now made it usable in the public transport field (Bates, 2003)

A travel demand model is used to forecast the transportation arrangement. The layout of existing land uses also determines the potential for future development. For example, it would normally be considered inappropriate to build a factory in a residential area.

The outcome of the suitability and compatibility considerations is the uneven distribution of human activities. Certain areas are predominately for residential uses, some for commercial uses, and some for industrial uses. Such distribution makes it necessary for people to travel among different areas using the transportation system. In addition to the connections, the demands for carrying capacity and other facilities, such as parking, vary spatially and temporarily. The trips to and from a factory may have morning and afternoon peaks while such patterns may not exist for trips to a shopping mall (Wang and Hofe, 2007).

The modeling process consists of four individual parts, commonly referred to as the four-step travel demand forecast modeling process. Trip Generation: Forecast the number of trips originated from and attracted to each TAZ. Trip Distribution: Allocate the trips within and between the TAZs. Mode Choice: Divide trips among different modes of travel. Trip Assignment: Assign the trips to different routes connecting the TAZs

Trip Generation- How many trips will there be?

The first step in travel forecasting is trip generation. To undertake this step, the study area is delineated into geographic units called traffic analysis zones (TAZs) from which transportation planning data is derived. Information from land use, population, and economic forecasts is used to estimate how many trips will be made to and from each zone (Bates, 2003; Beimborn, 2006). People's travel behaviors vary for different trip purposes. To improve the accuracy of trip estimation, the trip generation analysis is usually done separately for different trip purposes. Some people may travel for purposes other than to reach a destination. For example, one may want to get in his/her car to be alone for a while. However, the majority of trips have an origin and a destination. The destination is closely related to the trip purposes, such as going to work, shopping, or entertaining. (Wang and Hofe, 2007).

Trip Distribution -Where do the trips go?

The process of trip distribution links the trip ends (productions and attractions) from the trip generation step to form an origin-destination matrix (Beimborn, 2006; Bates, 2003). According to (Well, 1975), "the principle which is applied in trip distribution is that trips will be made to a given zone in direct proportion to its relative attractiveness and some form of decreasing proportion to the separation of the attracting zone from the originating zone."

Models of mode split/choice-How will people travel?

The third step of the travel demand model is to estimate the proportion of travelers using different modes of transportation. There are many alternative modes available for an individual to travel from one place to another, such as driving alone or with someone else, walking, taking the train, bus, taxi, riding a bicycle, etc (Wang and Hofe, 2007).

Once the origin and destination of trips have been established in matrix form, the next step is to convert the person trips into vehicle trips by applying the modal split model. At this stage of the FSM trips between a given origin and destination are split into the different modes of transport such as trips using transit, trips by carpool or as automobile passengers, and trips by automobile drivers (Beimborn, 2006).

According to (Willumsen, 2001), the choice of transport is probably one of the most important classic models in transport planning because of the key role played by public transport in policymaking. It also has implications on the general efficiency with which we can travel, the amount of urban space devoted to transport function, and whether a range of choices is available to travelers. Mode choice is influenced by the characteristics of the trip maker, the characteristics of the journey, and the characteristics of the transport facility.

Traffic Assignment - What routes will be used?

After travels have been divided into highway and transit trips, traffic assignment allocates them to the precise path they will take to travel from their origin to their destination (Beimborn, 2006). The modal networks are filled with modal O-D trip matrices created by applying average car and bus occupancy rates to trip reasons. It should be mentioned that while working on the assignment, the public transportation network is isolated from the highway network (Benn, 1995); (Well, 1975).

According to (Bates, 2003), there are several distinct procedures involved in assignment, including the selection of a route (or path) for each I –j) combination. Aggregating (i-j) flows on the selected pathways' linkages; coping with supply-side consequences (capacity constraint) caused by the volume of connection flows in comparison to capacity.

2.2.3. ***<u>Concept of integration of land use and Public transport system.</u>***

Land use and transportation are two sides of the same coin. Transportation affects land use and land use affects transportation. Decisions that affect one also affect the other. As a result, it is important to coordinate transportation and land use planning decisions so they are complementary rather than contradictory. This ensures that transport planning decisions support land use planning objectives and land use planning decisions support transport planning objectives. This requires an understanding of how specific land-use patterns affect travel (Litman, 2011).

Over the last several decades, land-use/public transportation processes have evolved to become the metropolitan planning vehicle to address operational needs in planning and policy decisions (Anjomani, 2021). According to (Rodríguez, 2004) While planners have recognized for some time that transportation systems and land use have a reciprocal relationship—that is, land use patterns affect the viability of different kinds of transportation system options while the development of different kinds of transportation improvements yield different kinds of impacts in terms of land use and development patterns much work remains to understand the particulars of the relationship given variations in time and place.

While (Deakin) states that, transportation and land use plans are rarely coordinated and often are inconsistent. Such inconsistencies were less of a concern in the past when the tradition of providing transportation services on demand lessened the need for detailed plan coordination. According to (Cost, 1996), Public transport and activity patterns are closely related issues as the spatial distribution of different human activities leads to the need for travel and transport of goods. A considerable share of urban land is occupied for transportation use which shows that transportation not only relates to land uses but also it is itself a land use.

According to (ICF, 2005), discussion on important aspects of integrated consideration of transportation and land use is organized under three key topics: integrated transportation and land use planning, analysis methods for land use, and mitigation strategies.

Whereas (Straatemeier, 2019) states, that the land-use transport feedback cycle shows the two-way interaction between transport and land use. The distribution of different land-uses co-determines where activities (E.g., moving, working, recreating) take place. One of the key policy issues is "Integration of Land-use and Transport Plan", to ensure coordinated implementation of the city development plan and transport infrastructure and service plan; promote the interdependent overall city and urban transport development. The policy has also detailed policy statements and corresponding policy measures to integrate land use and transport development plans

Transport infrastructures encourage spatial interaction between various activities, which is assessed by accessibility. Accessibility represents the appeal and ease with which these activities may be reached. According to studies, the possibility for interaction between two areas grows as the cost of travel between them reduces (Parsons.et.al, 1998).

Whereas (Meyer et.al, 1984) shows that, the relationship between land use and public transportation in an area can be described as "land use and public transport interaction". The figure illustrates how the development of property for specific use in a location either generates additional trips originating from that location or attracts new journeys to that location.

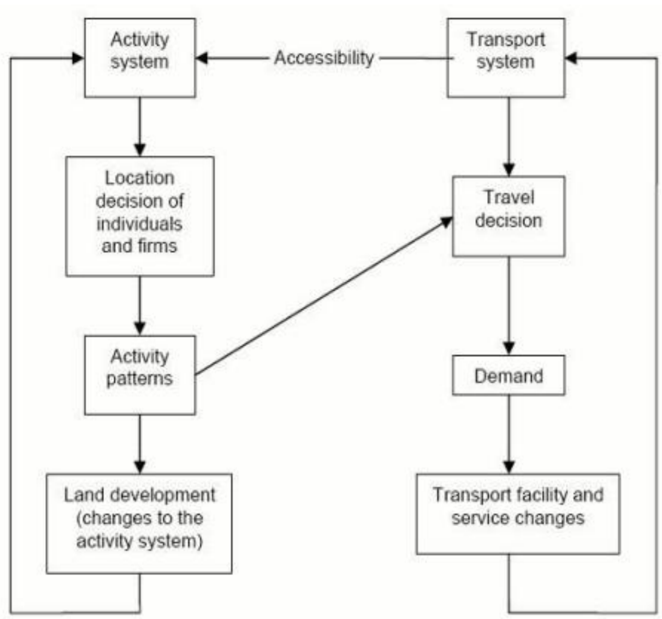


FIGURE 2. 1: Land use and Transportation interaction

Source: (Meyer et.al, 1984)

The spatial distribution of activities creates the need for a transport system that other people and goods the opportunity to travel or be transported from one activity to the other. In turn, 'the distribution of infrastructure in the transport system combined with existing land-use patterns creates opportunities for spatial interaction and can be measured as accessibility.

(Wee.et.al B. a., 1998) as described by (Wee, 2000), illustrates that the relationship between land use and public transportation is much more intricate and thorough. The volume of passenger trips in a given area and its mode split are determined by the location of various socioeconomic activities. Any change in any of the three categories of determinants will have a major impact on the entire system.

The volume of passenger trips in a given area and its mode split are determined by the location of various socioeconomic activities. People's needs and desires are influenced by socioeconomic and cultural factors, and transportation resistance is primarily determined by travel time and cost. All three categories have a significant impact in all directions.

In addition, (Wee, 2000) also suggest as employed in the empirical analysis of this study, new indicators to quantify the impact of land use on transportation are suggested. The choice value of a region, the consumer surplus, the cost of unsafety, people's valuation of one thing over another, financial elements of land use-transport alternatives, and the land use's resilience are some of these indicators of a mode of transportation

The lack of integration between land use and public transport system is a common theme across most countries. The only way to solve this problem is to create local strategies that incorporate land-use and transport planning, according to the World Economic Forum (WEF) in Switzerland. (Wegener a. F., 2009) Proposed the integration process of land-use and transport planning by "Vertical and Horizontal Coordination". Unlike horizontal integration, vertical integration is already required by planning regulations in most countries and supported by a formal process (Pujinda, 2006).

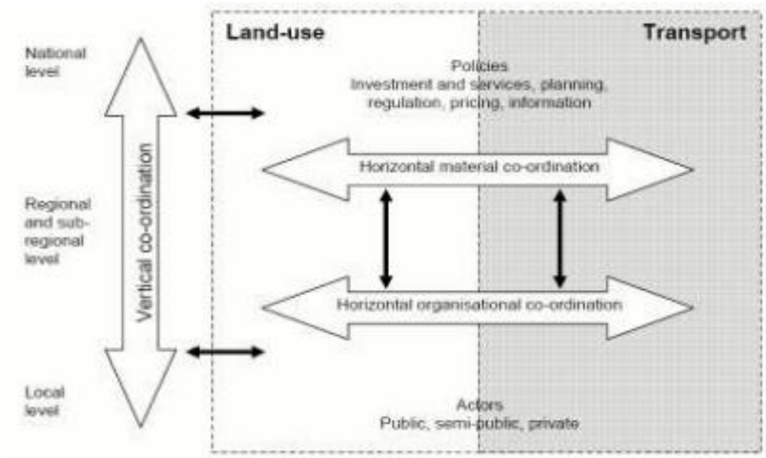


FIGURE 2. 2: Co-ordination and integration of land-use and transport planning

Source: (Wegener a. F., 2009)

(Wegener, 2014) This shows that the relationship between urban development and transport is not simple and one way but complex and two ways. On the one hand, spatial division of labor, i.e., the separation of locations of human activities in space, requires spatial interaction, i.e., travel and goods transport. According to the figure below the land-use transport, the feedback cycle shows that the distribution of land uses such as residential, industrial, or commercial over the urban area determines the locations of human activities such as living, working, shopping, education, or leisure. The distribution of human activities in space requires spatial interactions or trips in the transport system to overcome the distance between the locations of activities.

The distribution of infrastructure in the transport system creates opportunities for spatial interactions and can be measured as accessibility. The distribution of accessibility in space co-determines location decisions and so results in changes in the land-use system.

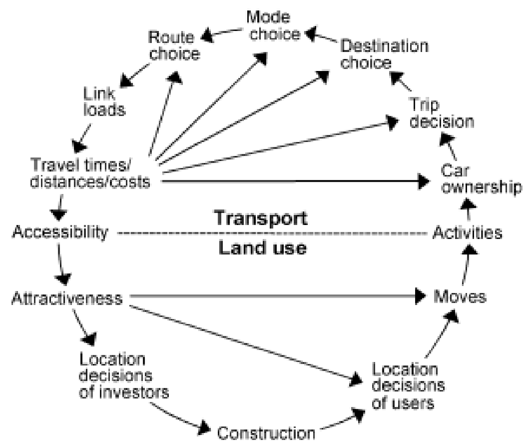


FIGURE 2. 3: The land-use transport feedback cycle

Source: (Wegener, 2014)

2.2.4. ***<u>Linking land use and transportation: the debate</u>***

The link between land use and public transport has been hotly debated and questioned by researchers. This section briefly reviews some of the debates. (Gomez-Ibanez, 1981), noted that the hope that transport policy can change land use seems to be based on historical and historical observations "might be a false guide to present and future" (Srinivasan, 2000). Whereas, the evidence of these studies is decidedly mixed. (Giuliano and Small, 1993) Conclude that commuters are taking little advantage of the cost-minimizing opportunities afforded by the high level of decentralization of residences and workplaces observed.

Similarly, (Scott et.al, 1997), concludes that “policies advocating jobs-housing balance as the principal strategy for facilitating more efficient commuting are unlikely to meet the expectations of policymakers.” (Nori et.al, 2020).

(Giuliano, 1989), also notes that the decentralization of population and employment has weakened the importance of transportation cost and accessibility in location choice. Other changes in the urban environment, according to (Giuliano, 1989) include changes in the structure of economic activity (becoming more national/global rather than local), the scale of development, and the influence of local governments in land use decision making has also influenced location choices of households and firms (Srinivasan, 2000).

(Merriman et. al, 1995), estimate “low” differences between actual and required commuting for different metropolitan areas and thus conclude that the connection is strong and therefore urban policies that hinge on the strength of the connection could result in significant reductions in commuting time (Nori et.al, 2020).

2.3. Empirical Review

(Anderson et.al, 1996) Reviewed much research on this problem and finish that city land-use patterns have a sizable effect on mobility in standard and on vehicle use greater specifically. Especially compact buildings and mixed land use are of importance.

(Newman et.al, 1999) Concluded that the better the densities of cities were, the decrease the energy use in keeping with inhabitants. The look has been criticized frequently. One reason, for example, is they did now no longer accurate for variations in incomes and gas prices/transport costs. (Newman et.al, 1999) And (Kenworthy et.al, 1999) these days up to date the study, correcting for the maximum essential intervening factors. They nevertheless determined a robust relationship between densities and electricity use for transport.

(Hilbers et.al, 2005) Confirmed that one-of-a-kind sorts of new residential regions have significant variations in mobility. They corrected for socio-economic variables. Public transport use through humans residing in new residential regions, constructed inside a present metropolis or town is, for example, about one-1/3 beneath the extent of vehicle use through humans residing in new residential regions constructed at the brink of a city. However, mobility variations among numerous sorts of residential regions constructed at the brink of the city are very limited.

(Wee V. , 2003), showed that the region of corporations additionally topics and reviewed numerous Dutch research on the effect of company places on mobility. They finish that public transport use through human beings running at corporations positioned close to public transport stations is a whole lot decrease than through human beings working at different places. An example: completed research on the modal preference of human beings running in The Hague. If the task region changed into much less than two hundred meters from a station, the percentage of the automobile in delivery changed into much less than 20% and that of public transport, 57%.

Transit-Oriented Development in Curitiba ensures that residential, business and recreational areas are built. Transit-Oriented Development in Curitiba ensures that residential, business and recreational areas are built-in high-density areas close to the public transport nodes. Also, industrial areas are developed with residential zones surrounding them, and not mixed with them, to improve the quality of life of workers, by reducing travel times as well as ensuring unpolluted places to live in. This practice has been followed not only within the city but also in the Curitiba Metropolitan region as well in partnership with the municipalities (Swamy et.al, 2013).

According to the de-attention coverage followed, local facilities are advanced to create equitable populace area distribution. High site visitors producing regions inclusive of shopping complexes, commercial facilities, and high-upward push residential regions are built inside reachable distances of the general public transport stations (Swamy et.al, 2013).

(Ewing and Cervero, 2010), found that land use mix reduces vehicle travel and significantly increases walking. It is found that households located in highly accessible neighborhoods travel a median distance of 3.2 km (2.0 mi) one-way for errands versus 8.1 km (5.0 mi) for households in less accessible locations.

Suburban dispersion of employment can reduce average commute distance but tends to increase total per-capita vehicle travel. (Crane & Chatman, 2003) , found that a 5% increase in fringe county employment lead to a 1.5% reduction in the average commute distance, but this is offset by increased non-work vehicle mileage

2.4. Significantly related study and Best practices in other nations

This paper review some related studies to the integration of land use and public transport applied in other nations with their identified problem, methodologies they applied, and their final out as follows.

Karbala city

The location of urban activities in the interrelationship will create a new transport system by generating trips and influencing regional changes, case study Karbala city, one of the cities of the Middle Euphrates in Iraq, an area of 135 km 2, and the population of 487827 people.

The problem of the city is the lack of integration of the land use network with the transportation system in the city of Karbala, (Integration: planning the land uses by a method that increases the use of public transport and reduces reliance on private transport, this is sustainable (Ahmed et.al, 2017).

The study analyzes the case of the city Karbala through a strategy of Adoption of the criterion of the zone of influence of land uses adopted by the Ministry of Housing in 2018 (Urban Housing Standards Book, 2010), for different uses, as an indicator of integration. The need to adopt a strategy for integrated planning between the uses of urban land and the public transport system for Karbala when preparing the master plan. Adopting the zone of influence of land use when planning the city, to achieve the integration of the road network leads to sustainability.

Lesson learned: Karbala city show direction to adopt identifying a zone of influence of land use rather than increasing the number of PT to solve the problem.

Hong Kong

Hong Kong is a city-state in the People's Republic of China covering 1104 Sq.km with a population of more than 7 million (Transport Department, 2011). With an extremely high density of 6544 persons/ Sq.km (Census, 2011,2012) and scarcity of land, planning for land use as well as transport has been a challenge for the Government Planning Authorities. The city has grown on only 30% of the total land, the rest of which is mountainous terrain (Tiry, 2007).

Planning for the road network and the integration of multi-modal transit centers had been carried out in tandem with Transit-Oriented Development the use of the Consolidation and Decentralization regulations in Hong Kong to result in the integration of the land use and transportation (Swamy et.al, 2013).

This integrates all modes of public transport through a single Octopus Card. The trams are generally taken only by tourists to experience the quaint charm of Hong Kong urbanism, 2008 (Swamy et.al, 2013).

Lesson learned: Hong Kong uses a different method to integrate land use and transport, this is applying a multi-modal system on a single route to increase the efficiency of PT toward the urban center.

Curitiba

Curitiba is the capital of the state of Parana in Brazil. The city has experienced rapid urbanization since the 1970s with careful urban planning and integration of its land-use and transportation system. It covers 435 Sq.km with a population of 1.8 million people in 2007 and a density of 4200 persons/Sq.km (Curitiba, 2012).

The planning and implementation of accessible public transport, land use, and road network concurrently, using instruments like Transit Oriented Development and Transfer of Development Rights have ensured effective integration of land use and transportation in Curitiba (Swamy et.al, 2013).

Curitiba has used urban planning as an instrument to guide public as well as private investments for the socio-economic development of the city. Land within two blocks of the transit network has been zoned for high-density mixed-use development (Goodman et.al, 2005-2006).

Lesson learned: from the city of Curitiba the method of TOD with land use mix measure can be taken into account as a solution to understand the integration of land use and public transport system.

2.5. Lesson drawn from the Review

Generally, the above-reviewed literature has its perspective and methodologies to show that, land use patterns are influenced by transportation, while transportation modes and modes of transportation are influenced by land use. Decisions that influence one person also affect the other in this complicated connection. As a result, it's become critical to integrate land use and public transport decisions so that they work together rather than against one other. This is to guarantee that transportation policy and planning decisions, and vice versa, complement land use policy and planning objectives.

2.6. Research Gaps

There is a gap in studies for considering and analyzing only policy and planning implementation strategies rather than recommending different strategies for integrating land use with the public transport system, integrating land makes use with public transport, identifying public transport routes, a form of media used, street integration and identity of residential regions served with the aid of using the network, to perceive regions now no longer serviced with the aid of using the general public transport network in addition measuring land use mix using Shannon diversity index and Area Index is helpful to understand the integration of land use and public transport system.

These methodologies have not been applied to understand the integration of land use and public transport system in the Adama context The GIS, and SPSS software are used for those that make use of and analyses with the aid of buffer areas that have been performed for the spatial location of the offerings and the calculation in their area of effect of service.

CHAPTER THREE

3. METHODS AND MATERIAL

3.1. Introduction

The philosophy used in this research is the pragmatism research philosophy scheme, through pragmatism research philosophy this research addressed the research question by understanding human thought and explaining reality and beliefs which are time and context bounded. It is valuing free research and the researcher detected neutral and independent of what is researched, it seeks to understand the existing scenario. The research is a mixed research type that describes and explains the integration of land use and public transport system in Adama city which reduced vehicle miles of travel; improvements in air quality; increased levels of transit use; economic and community revitalization. Typically, the deductive research approach is used with highly structured data with the support of measurement.

3.2. Description of Study area

The study was conducted in Adama City which is one of the fast-growing cities in Ethiopia. It stretches between 8°26’15” N to 8°37’00” N latitude and 39°12’15” E to 39°19’45” E longitude. Adama is one of the cities found in the Oromia National regional state of Ethiopia. The city is located about 100 km southeast of the national capital Addis Ababa along the main highway leading to Djibouti ranging from 1444 to 1974 m. a. s. l covering 134.1 km^2.

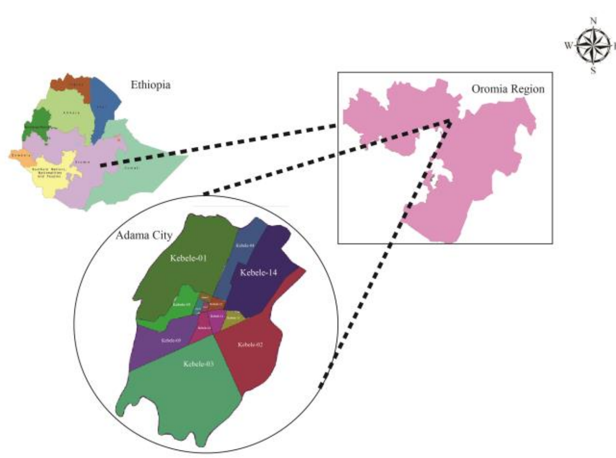


FIGURE 3. 1: Location map of Study Area

3.2. Sampling Technique

This study used different kinds of sampling for different methods of collecting data. The study used 14 kebeles of Adama city as major TAZ for the data collection, while there were 313 sub-TAZ classified based on a number of neighborhood blocks within each major TAZ. Non-probability sampling technique was adopted for the questionnaire survey to take samples from responders in Adama city. It was applied by using random walk or quota based to take samples from the 14 major TAZ With a total of 313 sub-TAZ, encountered in the city. This sampling technique is usually used since it removes constraints on the researcher when the responders are unable to respond to the survey and select only responders without private car ownership. For public transport route sampling purposive or judgmental non-probability sampling technique is used. In this sampling technique, the sample is based upon some appropriate characteristics like Public transport routes for buses and taxis.

The data was collected using well-structured questionnaires that are given using self-filling by the researcher or face-to-face interviewing with respondents, PT drivers, and office workers from the Land management office and the Transport office of Adama city. The questionnaire was prepared in the English language and then translated into the local language (Amharic). The interview proceeds in the local language and is translated into the learning language (English).

3.2.1. ***Sample size***

The selected samples were represented in terms of the population density of 14 major TAZs. It was conducted in 14 kebeles of the city. According to the census of 2007 Adama town population was 220,212. According to population projection for 2016 Adama town population was estimated to be 356,344. (Disassa et.al, 2016). The respondents were considered those that have no private car ownership from each kebele (TAZ).

The total sample was taken using the formula from (The research advisors, 2006):

- Sample Size = [Z2*P (1-P)] / C2 Eq (1)
- S= sample size
- Z= given Z value
- P= percentage of population
- C= confidential level

Required Sample Size†

Population Size	Confidence = 95% Margin of Error 5.0%	3.5%	2.5%	1.0%	Confidence = 99% Margin of Error 5.0%	3.5%	2.5%	1.0%
10	10	10	10	10	10	10	10	10
20	19	20	20	20	19	20	20	20
30	28	29	29	30	29	29	30	30
50	44	47	48	50	47	48	49	50
75	63	69	72	74	67	71	73	75
100	80	89	94	99	87	93	96	99
150	108	126	137	148	122	135	142	149
200	132	160	177	196	154	174	186	198
250	152	190	215	244	182	211	229	246
300	169	217	251	291	207	246	270	295
400	196	265	318	384	250	309	348	391
500	217	306	377	475	285	365	421	485
600	234	340	432	565	315	416	490	579
700	248	370	481	653	341	462	554	672
800	260	396	526	739	363	503	615	763
1,000	278	440	606	906	399	575	727	943
1,200	291	474	674	1067	427	636	827	1119
1,500	306	515	759	1297	460	712	959	1376
2,000	322	563	869	1655	498	808	1141	1785
2,500	333	597	952	1984	524	879	1288	2173
3,500	346	641	1068	2565	558	977	1510	2890
5,000	357	678	1176	3288	586	1066	1734	3842
7,500	365	710	1275	4211	610	1147	1960	5165
10,000	370	727	1332	4899	622	1193	2098	6239
25,000	378	760	1448	6939	646	1285	2399	9972
50,000	381	772	1491	8056	655	1318	2520	12455
75,000	382	776	1506	8514	658	1330	2563	13583
100,000	383	778	1513	8762	659	1336	2585	14227
250,000	384	782	1527	9248	662	1347	2626	15555
500,000	384	783	1532	9423	663	1350	2640	16055
1,000,000	384	783	1534	9512	663	1352	2647	16317
2,500,000	384	784	1536	9567	663	1353	2651	16478
10,000,000	384	784	1536	9594	663	1354	2653	16560
100,000,000	384	784	1537	9603	663	1354	2654	16584
300,000,000	384	784	1537	9603	663	1354	2654	16586

FIGURE 3. 2: Sample size table.

Source: (The research advisors, 2006)

According to the table above, the sample size is calculated as follows

$$S = \frac{Z^2 \times P \times (1-P)}{C^2} = \frac{(1.960)^2 \times 0.5 \times (1-0.5)}{0.05^2}$$

$$= 3.8416 \times \frac{0.25}{0.0025} = 384.16 = \mathbf{384}$$

The sample size of the research is **384.** Of the total sample size, **6** are directed for key informant interviews and the rest **378** are used for survey questionnaire purposes. Which is summarized in

TABLE 3. 1: Sample Size

TAZ Number	Area(Ha) A	Population N	Population density/Ha PD= N/A,	Activity type (Land use type)	Sample size from each TAZ (in number)	Sample size from each kebele (in %)
1	1571.29	30,109	19.16196	Residence dominant	18	5.65%
2	338.30	21,508	63.57671	Residence dominant	30	7.9%
3	334.77	31,421	93.85847	Residence dominant	20	5.4%
4	256.02	32,045	125.166	Residence dominant with service	20	5.3%
5	351.11	30,252	86.16103	Commercial dominant	21	5.6%
6	30.93	11,147	360.3944	Commercial dominant mixed-use	37	9.79%
7	49.42	18,389	372.0963	Commercial dominant Mixed-use	41	10.%
8	54.91	17,363	316.2083	Commercial dominant Mixed-use	35	9.25%
9	482.00	34,854	72.3112	Residence dominant	21	4.88%
10	192.87	28,215	146.2902	Residence dominant	21	6%
11	161.89	29,646	183.1243	Residence dominant	23	5.73%
12	85.14	16,954	199.1308	Residence dominant	38	10.03%
13	127.31	17,226	135.3075	Residence dominant	35	9.45%
14	1016.38	33,209	32.673	Residence dominant with service	18	5.02%
Total			64,701		378	100%

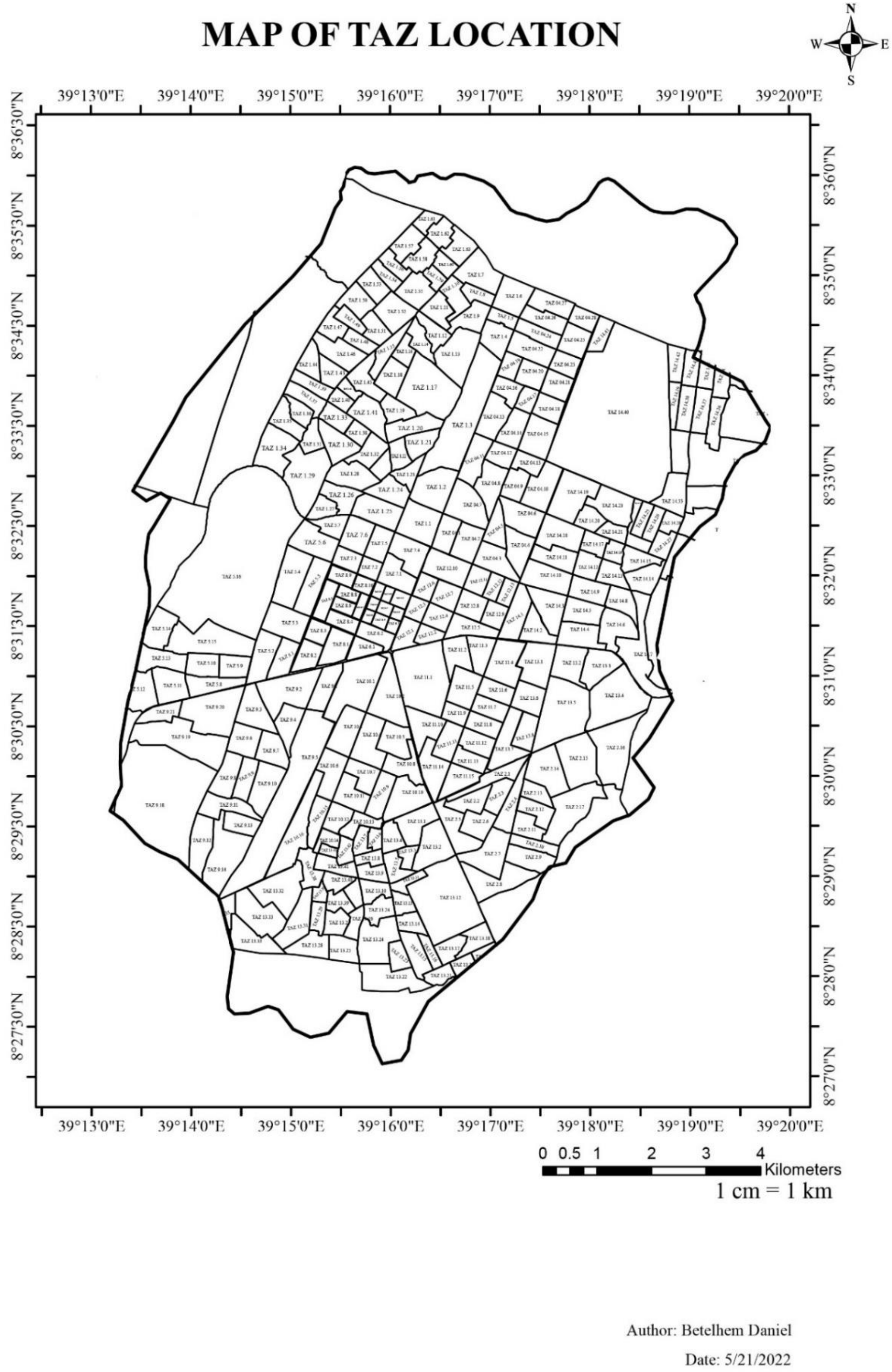


FIGURE 3. 1: Map of TAZ Location

Source: Author

TABLE 3. 2: TAZ Classification with number of samples

TAZ	Sub- TAZ Neighborhood Block in number	Total Sample
1	63	18
2	18	30
3	43	20
4	29	20
5	16	21
6	11	37
7	5	41
8	10	35
9	21	21
10	16	21
11	15	23
12	13	38
13	8	35
14	46	18
TOTAL	313	378

3.3. Source of Data

Data were collected from both primary and secondary sources. The primary data was based on a survey conducted to get information from sample responders and field observation (refer to Appendix C). The secondary data was based on key informant interviews and census data, GIS files from Land management, and transportation offices of Adama town.

3.4. Data Collection and Analysis Method

3.4.1. ***To identify the existing public transport system in integrating with land use in Adama city.***

3.4.1.1. ***Methods***

For this analysis field observation, mapping, questioning drivers, and Adama city transport office employees were the sources of data. To identify modes of the public transport system in the city, primarily public transport routes in the town are identified and mapped with color-coding specifically bus routes and taxi routes.

Then the integration of streets in the town with public transport routes is analyzed. In addition to this origin and destination, spatial coverage, stop-overs, travel time and travel cost, and stations of the public transport system are identified and indicate the waiting areas of people. Finally, TAZ indicated by the waiting areas is selected for the travel demand analysis. The descriptive Analysis method is used to describe the route characteristics.

3.4.1.2. *Travel Demand Model*

To identify the dominant mode of public transport in town, the travel demand method is used based on information such as trip generation (trip origin and destination), trip purpose, mode of public transport users, and travel cost collected from survey questionnaires as a source of data.

Trip production

Data used in the trip generation is obtained from government offices and field surveys. Those data are often used for estimating trip generation. It may take considerable effort to collect data for the study area. Once relevant data are collected, linear regression analysis is a common tool used to derive the trip production rate for each category.

The person trips by respondent income category are calculated as:

$$PT = Nhh * PTPH \qquad \text{Eq (2)}$$

Where,

PT=Person trips;

Nhh= Number of respondent;

PTPH =Person trips per respondent;

The following formula is used to calculate trip generation based on different respondent income categories:

$$TP = \sum_{i=1,n}(ri * Hi) \qquad \text{Eq (3)}$$

Where,

TP = Trips generated;

n =Number of responder categories;

i = Responder category;

ri = Trip production rate for responders category i ;

Hi = Number of responders in category i;

Trip Attraction

Similar to trip generation, data required for calculating the trip attraction rates are obtained from government and field surveys. The number of respondent is usually part of the census data regularly collected and TAZ land-use type such as residential and Non-residential (commercial and services) is determined from secondary data. Once the data are collected, linear regression analysis is a common tool used to derive the trip attraction rate for each land use category.

Vehicle trips attracted to each kebele are then calculated as:

$$\mathrm{TAR} = \mathrm{Nhh} * \mathrm{TARR} \qquad \text{Eq (4)}$$

Where,

TA_R= Vehicle Trip Attractiveness of the TAZ;

Nhh— Number of responders in the TAZ;

TAR_R— Trip Attraction rate by responders;

Trips attracted by Non- residential are calculated from the size of Non- residential land use and the Non- residential trip attraction rates.

$$\mathrm{TANR} = \mathrm{NR} * \mathrm{TARNR} \qquad \text{Eq (5)}$$

Where,

$TA_{N\,=}$ Vehicle Trip Attractiveness of the TAZ;

$A_{NR=}$ Non-Residential Land use size in the TAZ;

$TAR_{NR\,=}$ Trip Attraction Rate of the Non-Residential land use;

Using this method of analysis, trip production and trip attraction TAZ s are identified. This result is used as input for the second objective of the study, to measure the land-use mix of selected TAZs.

3.4.1.3. *Utility Function and Multinomial Logit (MNL) model Analysis Method*

Data from questioners and field observation provide about the mode of public transport that are used in Adama city. Using this result the study analyzes this mode of public transport choice based on three basic variables. The three independent variables are the cost of travel, carrying Capacity, and comfort level (convenience).

The utility function and Multinomial Logit (MNL) model are used as a method of analysis for the mode of choice for public transport specifically public bus and taxi. The modes associated with shorter travel times, lower costs, or more convenience are likely to have high utility.

The general form of the utility function with n variables is:

$$U = ao + a1x1 + a2x2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. + anxn \qquad \text{Eq(5)}$$

Where,

U= the utility of the transportation mode;

ao =constant;

$a1$ =Weight for the first variable;

$a2$ =Weight for the second variable;

an =Weight for the nth variable;

X1= the first independent variable;

X2=the second independent variable;

Xn = the nth independent variable;

In the mode choice model, there are many ways to establish the relationship between the proportion of travelers using each travel mode and its utility. One such model is the Multinomial Logit (MNL) model.

According to the MNL model, the probability that mode choice k is made under the assumption of utility maximization is the fraction of the total utility. This probability is expressed as:

$$\text{Prob(k)} = \frac{\text{Exp(Uk)}}{\sum_{k=1}^{n} \text{Exp(Uk)}} \qquad \text{Eq(6)}$$

Where,

Prob(k) = the Probability of mode k being selected;

Uk = the Utility value for mode k; n = Total number of mode choices

3.4.1.4. ***Regression analysis method***

The linear regression analysis method is used to get the coefficient value of the dependent and independent variables required by the Logit model to measure the public transport quality through the m choice of public transport mode by the users.

3.4.1.5. *Materials*

For the survey period, a neighborhood block with a boundary map of each 14 TAZ was printed in A4 with a width of 29.7cm and height of 21cm (portrait) paper. It was used to identify the TAZ boundary selected for the questionnaire data collection. In addition to this during the key informant interview period, a smartphone (Samsung A12) was used for recording purposes. Statistical analyzer software (SPSS) was used for data analysis and presented the result in terms of graphical and tabular forms. PT route map was printed in A4 paper format for field observation purposes to identify PT stopovers with a given route (OD) using pencil. ARC GIS 10.8 software was used to prepare the PT route map and its station with stopovers. Generally, all these software processes are implemented using a personal computer as a tool.

3.4.1.6. *Travel Demand Model Material*

In the travel demand modeling analysis method, Data collected was organized in MS-Excel and exported in Statistical analyzer software (SPSS) for data analysis and present the result in terms of different graphical and tabular forms. Generally, all these software processes are implemented using a personal computer as a tool.

3.4.2. *To measure the land use mix level of Adama city*

3.4.2.1. *Methods*

During the process of measuring the land use mix index for each kebeles (TAZs), this study applied the Shannon-Weaver diversity index, Area index for measuring land use mix degree, land use diversity, and land use balance in the quantitative method. Land use data of Adama city was collected from the land administration office of Adama city.

There are four basic land use categories used for the measurement of land use namely: residential land use (Home), commercial land use-working (including marketplace, retail trade, wholesale trade, shops, mixed and pure commercial), service (insurance, information media, and telecommunications; manufacturing, food and beverage services, rental and hiring services, schools, hospitals), and recreation land use type.

The land use mix entropy derived from the following equation indicates the land-use mix degree in a given TAZ.

$$ENI = -\sum [(p_i) * \ln(p_i)], \qquad \text{Eq(8)}$$

Where:

ENI = Shannon diversity entropy index;

p_i = Proportion of Land-use type i in a TAZ;

$$p_i = n / N, \qquad \text{Eq(9)}$$

Where:

n – Proportion of a given land use type; and

N =Total Proportion of Land-use type i in a TAZ,

After the Shannon diversity index is calculated evenness of the index (Alatalo index)is calculated using the following formula:

$$ALT= ENI / \ln (N), \qquad \text{Eq(10)}$$

Where:

N is the number of species.

Evenness gives a value between 0 and 1. Evenness of zero represents extremely homogenous land use, whereas Evenness of one indicates the land use is equally heterogeneous across all land-use types. The dataset includes four land-use types: commercial, residential, service and recreational.

Area index was calculated as:

$$AIT = \frac{AWT_I}{\text{Total area of work in Adama city}} \qquad Eq(11)$$

Where:

AIT: Area index for trip;

AWT_i: Area of work area in TAZ_i

3.4.2.2. ***Regression and correlation analysis method***

This analysis method is used to get the correlation coefficient result from the relationship between the dependent and independent variables which are required to understand the integration of land use with the public transport system.

3.4.2.3. *Materials*

In the land-use mix measurement method, the entropy index was organized in MS-Excel and used the index value in ARC GIS 10.8 software for data analysis and to present the result. Generally, all these software processes are implemented using a personal computer as a tool.

3.5. Ethical Consideration

Ethical consideration can be specified as one of the most important part of the research. So, in doing the studies, it could be a significant portion of the research handle. So; in doing the studies it continued and legitimate prerequisites concerning research participants. Members both people and bunches being watched was supported by giving definition and description about the research concern before their contribution of data towards to the research.

3.6. Research Design

The figure below show the procedures followed in carrying out the research. The research problem was identified through a literature review and investigation of the real-world problem. To solve the problem, appropriate research objectives and questions were defined. Next, key concepts were conceptualized and operationalized based on the literature survey. Then, the necessary data were collected during the fieldwork and prepared to make it suitable for the analysis. Finally, analyses at different levels were carried out, and based on the analysis result conclusion and recommendations for the future were drawn.

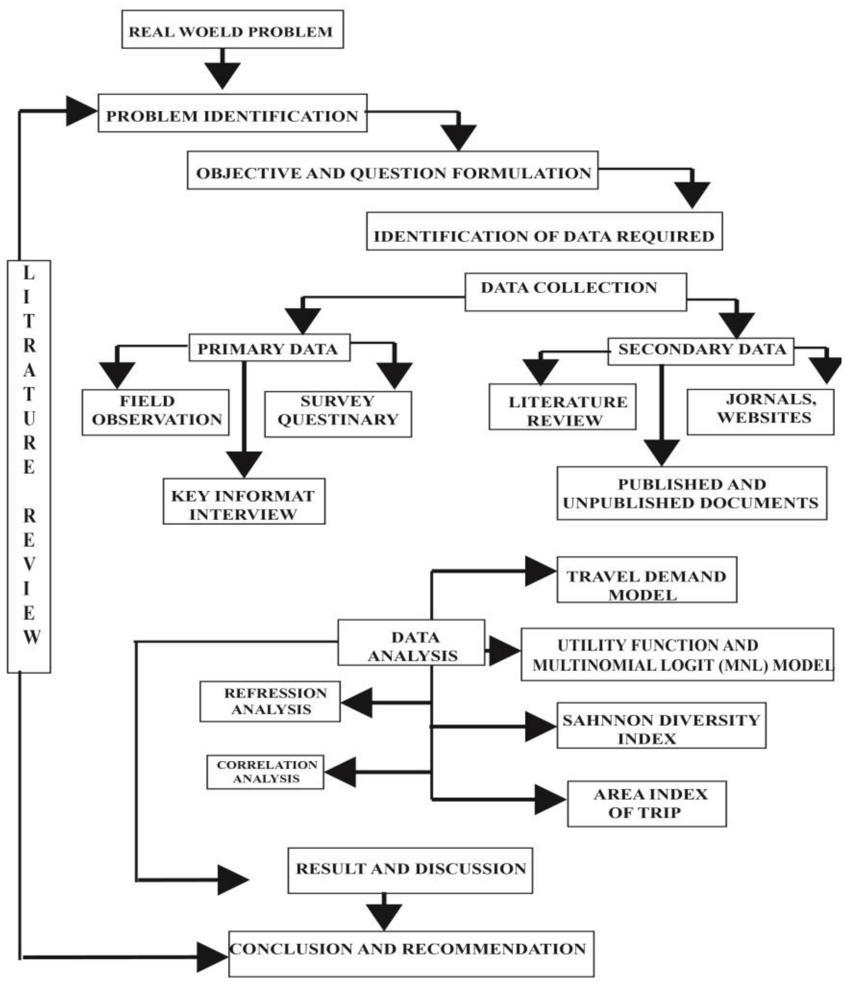


FIGURE 3. 2: Research design

Source: Author

CHAPTER FOUR

4. RESULT AND DISCUSSION

4.1. ***To identify the existing public transport system in integrating with land use in Adama city.***

4.1.1. ***Public Transport System***

During this process, the major mode of public transport routes with their stopovers in addition to their origin and destination has been identified and mapped. In addition, the route direction and flows showed that it is necessary to measure and calculate the population density of Adama city to identify the reason behind specific route characteristics.

According to Adama City Transport Authority, the current public transportation service in the City is mainly covered by public buses and taxis (mini-bus). According to the information gathered from the interview with Adama City Transport Officer Mrs.Tigist, the Public bus in Adama city is controlled by the City Municipality Office, while taxies (mini busses) are governed by City Transport Office and provided by a group of people who are organized in a group of 3 to manage the transportation flow in the city.

These organized group of people had their own members of taxi owners and have their loading and unloading places. The major mode of the public transport system in Adama city is analyzed as follows.

4.1.1.1. *Public bus*

In Adama city, the public bus is one of the major modes of the public transport system. Public bus transport is authorized and controlled by Adama City Municipality Office. In 2008 E.C, there were 4 public buses in number giving service to Adama city residents. Currently, in 2014 E.C there are 13 public buses giving service to residents while 1 public bus is in the maintenance process.

These public buses are giving service through 6 routes in the city. There are two types of public buses in Adama city, the first type is the big public bus with an average carrying capacity of 130 people per trip(from origin to destination) while, the second type is the medium public type with an average carrying capacity of 60 people per trip(from origin to destination).

Big size public bus

Medium size public bus

FIGURE 4. 1: Image of Pubic bus types in Adama City

Public Bus Route

Origin and destination

In Adama City total length of the street network for all types of modes of the transport system is 921.83km. From this total coverage, the public bus route in Adama city covers 23.58km which is 2.577%. In Adama city there are 6 main public bus routes as shown in Table 4.1 below, it indicate that route assigned from bole to Franko covers a longer route length while the route assigned from kella (Amede) to Franko cover shorter route length relatively.

TABLE 4. 1: Public bus routes of Adama City

Source: Adama City Municipality Office

Route-code	Origin	Destination	Length(Km)
(A)	Bollo(duket)	Geda(Posta)	4.446km
(B)	Waqo bota	Geda(Posta)	4.106km
(C)	Bole	Franko	4.848km
(D)	Kella(Amede)	Franko	2.328km
(E)	Adama korkoro	Franko	4.473km
(F)	Urae'l(105)	Geda(Posta)	3.379km
Total			23.58km

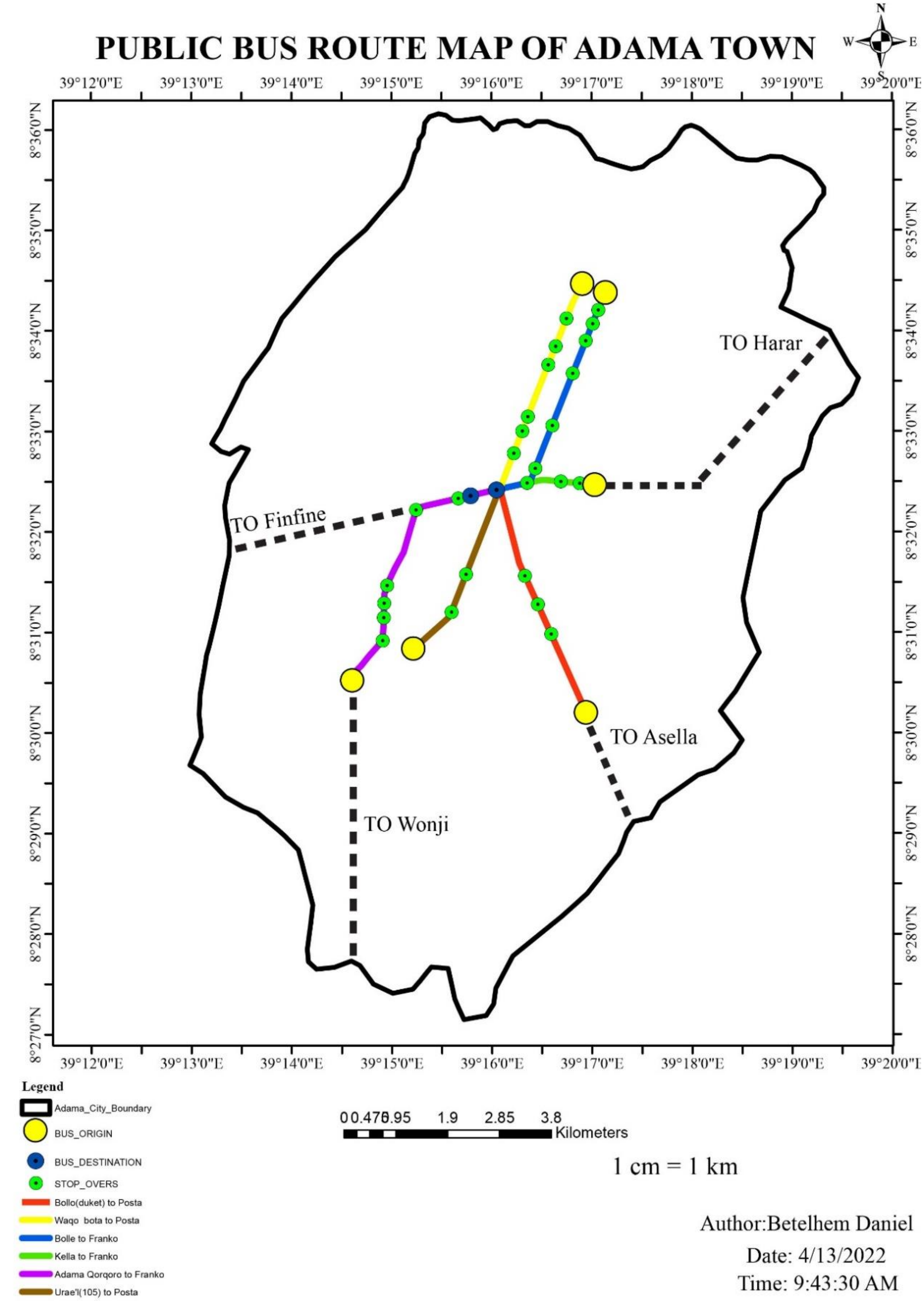


FIGURE 4. 2: Public Bus Routes in Adama City

Source: Author, Field observation

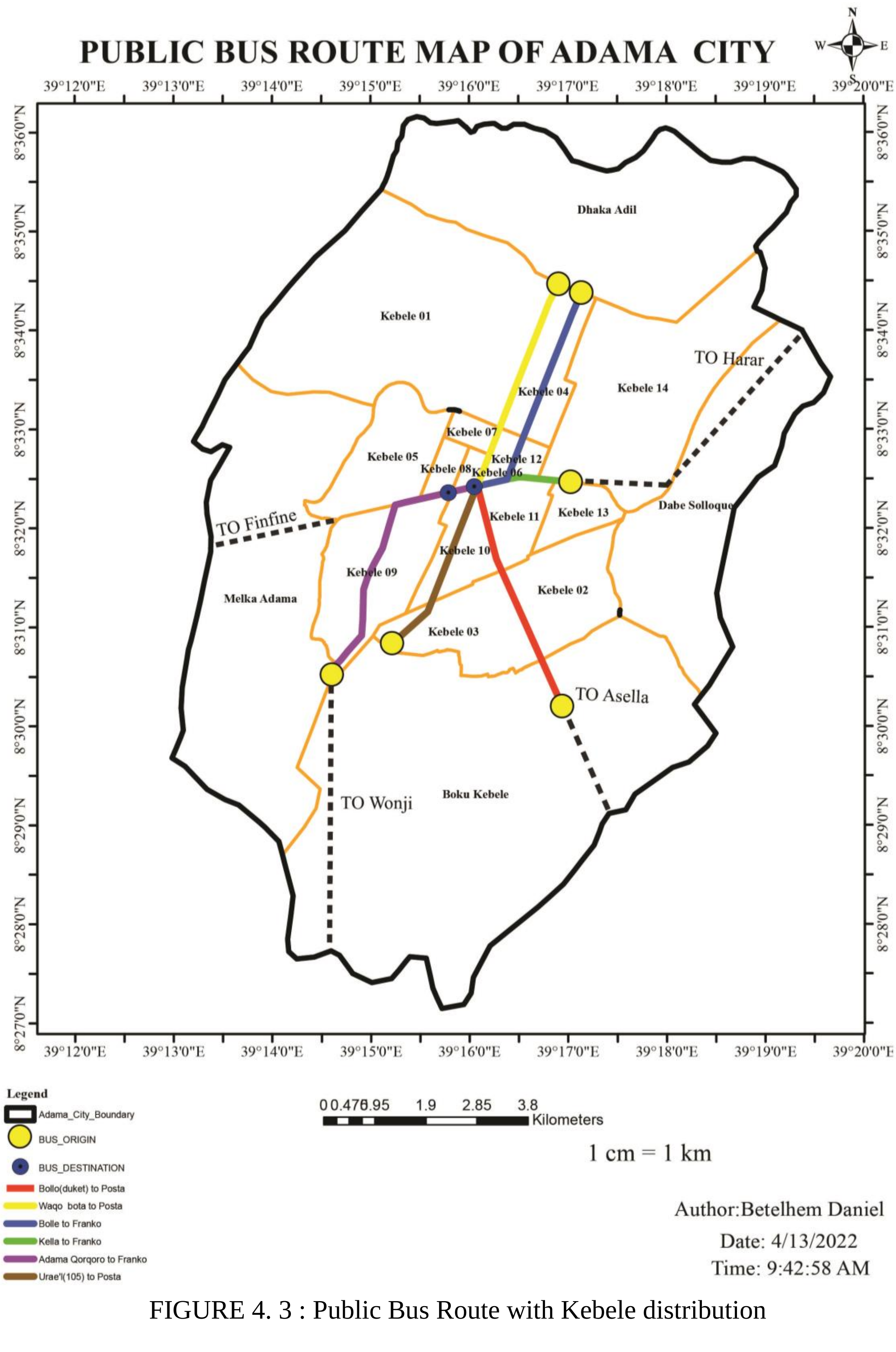


FIGURE 4. 3 : Public Bus Route with Kebele distribution

Source: Author, Field observation

From the data collected from Adama City Municipality Office, the origin and destination of daily trips made by the public bus transport system tend to indicate trip attractor and producer areas in Adama city. From the result in Table 4.1 above**,** Franko and Geda (Posta) are the two common areas of destinations for the public bus transport system in Adama city.

Meaning that Franko (TAZ 8) and Geda (Posta) (TAZ 6) have high activity (dominant land use) rates or mobility scales which can attract travelers for many reasons. For further progress of the study in order to answer for the second objective, the population density of these areas has been calculated and a large proportion of the sample size has been taken from these areas for the field survey in order to determine the trip generation model.

According to Figure 4.3 , TAZ 3, 9, 13, and 14 are the origin site for public bus routes, while TAZ 6 and TAZ 8 are destinations of public bus transport routes.

According to the Public transport route evaluation standard stated by (Benn, 1995), Space between the bus routes for CBD with a high population density value is 0.805km apart, while for areas with less population density value is 1.61km apart. The current space between public bus routes and the standard space given has been related in Table 4.2 below.

TABLE 4. 2: Space between public bus routes in Adama City

Source: Author, GIS Map

Routes	Minimum Space between routes(km)	Population density(PD) category of bounded area	Standard space(km)	Evaluation
B to D	0.5 km	Medium PD	0.805 km	Within standard
C to D	1.5 km	Medium PD	0.805 km	Below standard
A to F	0.9 km	Medium PD	0.805 km	Below standard
D to A	1.2 km	Medium PD	0.805 km	Below standard
F to E	2.1 km	Low PD	1.61 km	Below standard
B to E	2.3km	High PD	0.805 km	Below standard

Travel time, Carrying Capacity and Cost

According to the result shown below in Table 4.3 from the survey data shown that public bus users are requested to pay constant travel cost of 2br for all travel made through all public bus routes. In addition this result shows that average TT in Adama city using public bus is 25 min for single trip.

TABLE 4.3: Average Capacity and Travel time of Public Bus

Source: Author, Field observation

Rout-Code	No of the Bus assigned	Average Capacity of Bus(person/trip)	Travel Cost (TC) (Birr)	Average Travel Time(TT) (O-D)
A	4	(3*130=390person) (1*60=60person)	2 Br	45min-1hr
B	2	(2*60=120person)	2 Br	20min
C	3	(3*60=180person)	2 Br	20min
D	2	(2*60=120person)	2 Br	20min
E	1	(1*60=60person)	2 Br	20min
F	1	(1*60=60person)	2 Br	20min
TOTAL	13	990*2 1980 person(O-D)		Average=25min

According to data collected from field observation and data from the 64 respondents who tend to use the public bus as a mode of transport for their trip shown Table 4.4 below, the average waiting time for 18 respondents was less than 10 min, for 23 respondents WT was 11-20 min, for 11 respondents WT was 21-30 min, for 12 respondents WT was more t7an 30 min.

TABLE 4. 3: Average waiting time for public bus * Descriptive statistics: Frequency Analysis

Source: Author, survey Questioner

Average Waiting time(WT)		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 10min	18	28.2	28.2	28.1
	11-20min	23	35.9	35.9	64.1
	21-30min	11	17.2	17.2	81.3
	More than 30min	12	18.8	18.8	100.0
	Total	64	100.0	100.0	

Stop Overs

The following Table 4.5, showed the stopovers in a given route separately, this enabled the study to identify the areas or kebeles which play a contribution for the trip production and attraction, which is calculated on the travel demand model analysis using its result.

TABLE 4. 4: Stop Overs on Public Bus Routes

Source: Author, Field observation

Route-Code	Stop-Overs(stations)
A	Beg Tera(Kebele 11) Asela Menaharia(Kebele 02) Gumruk(Kebele 02)
B	Mebrat(Kebele 06) Sar-Tera outlet(Kebele 01) Medanyalem church (Kebele 01)
C	Bekele Mamo Hotel(kebele 11) Kidane mihret Church(Kebele 12) Haile Mariam Hospital(kebele 04) 04 mazoria(kebele 04) Geda No2/Adama General Hospital (kebele 01) Nafyad school(kebele 14) Bole Mosque(kebele 14) Wangari(kebele 14)
D	Bekele Mamo Hotel(kebele 11) Hani (kebele 11) Amede Gebeya(kebele 13)
E	Warka(kebele05) Oromia COC(kebele 09) Selam mosque(kebele 09) Kuriftu Resort(kebele 09)
F	Adama Bus station(kebele 10) Peacock(kebele 03)

4.1.1.2. *Taxi (Mini-bus)*

Taxi (Minibus) is one of the public transport service that most of the city residents are highly dependent on. Relative to the Public bus transport system. In this study Minibus have high fares and not affordable for low-income groups. A minibus has a capacity of holding 12people per vehicle.

In Adama city, the taxi (minibus) is one of the major modes of the public transport system. Taxi (mini-bus) transport is authorized and controlled by the Adama city Transport Authority Office. In 2008 E.C, there was 500 taxis (mini-bus) in number giving service to Adama city residents. Currently, in 2014 E.C, there are 660 Taxis (mini-bus) giving service to residents.

These taxis (mini-buses) are giving service through 5 major routes in the city. Taxis (mini busses) are governed by City Transport Office and provided by a group of people who are organized in a group of 3 namely NIB, JALATAMAA, and MEELBAA to manage the transportation flow in the city.

FIGURE 4. 4: Taxi (Mini-bus) in Adama City

Source: Author, Field observation

Taxi (Mini-bus) Route Analysis

Origin and Destination

In Adama City total length of the street network for all types of modes of the transport system is 921.83 km. From this total coverage, the taxi (mini-bus) route in Adama city covers 18.426km which is 1.998%. These show that the spatial coverage of public bus routes is low.

The limited number of taxis (mini-bus) provided in Adama city is one of the reasons behind the low coverage status of the routes. In a fast expanding city like Adama only public transport route is not sufficient and adequate.

TABLE 4. 5: Major Taxi (mini-bus) route in Adama City

Source: Adama city Transport Authority Office

Route-Code	**Origin**	**Destination**	**Length(Km)**
(A)	Bole	Franko	5.059km
(B)	Kella	Franko	2.298km
(C)	ASTU	Franko	4.582km
(D)	Adama korkoro(09)	Franko	4.439km
(E)	Mazoria(Haile Resort)	Franko	2.048km
			18.426km

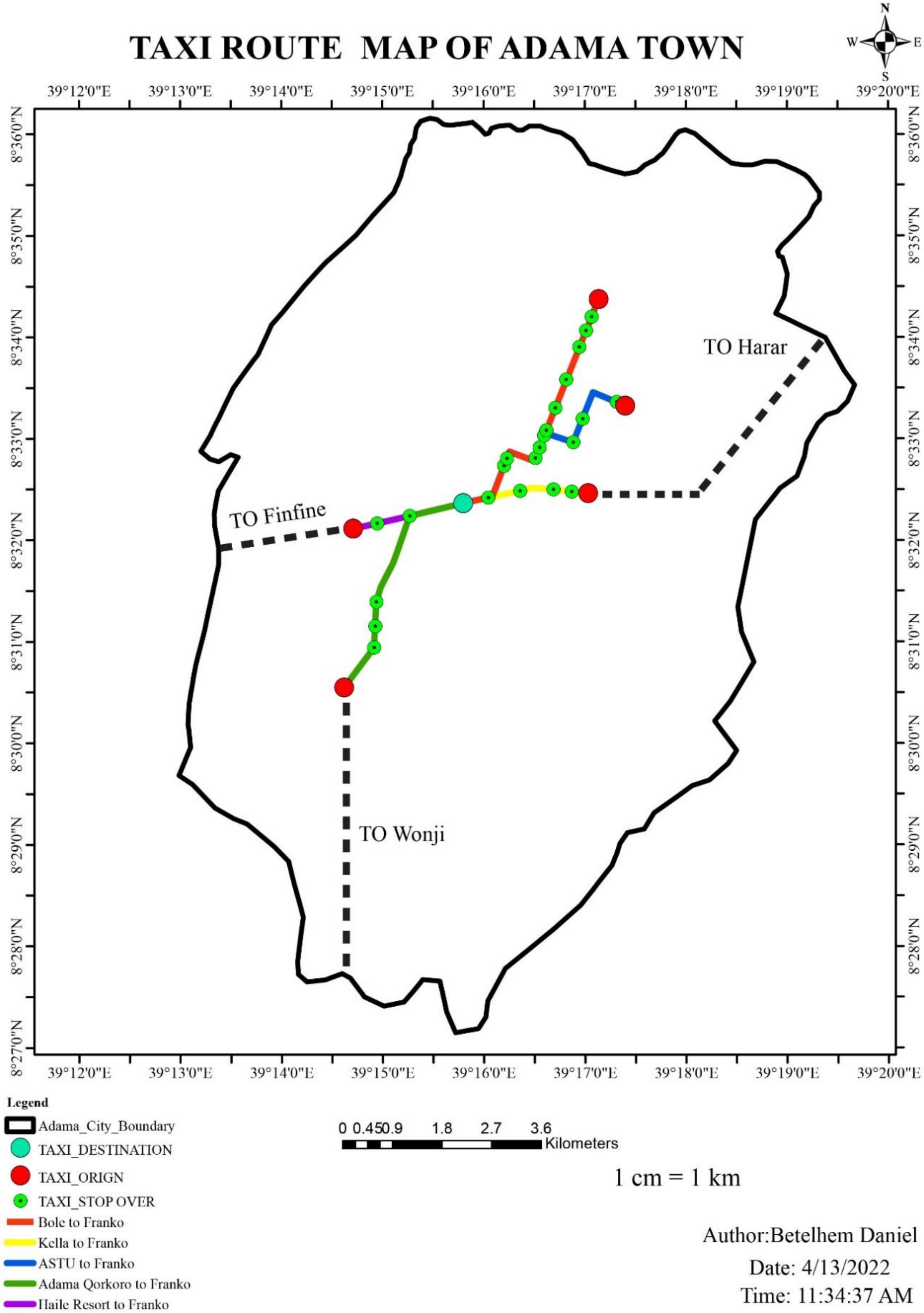


FIGURE 4. 5: Major Taxi Route Map of Adama City

Source: Author, Field observation

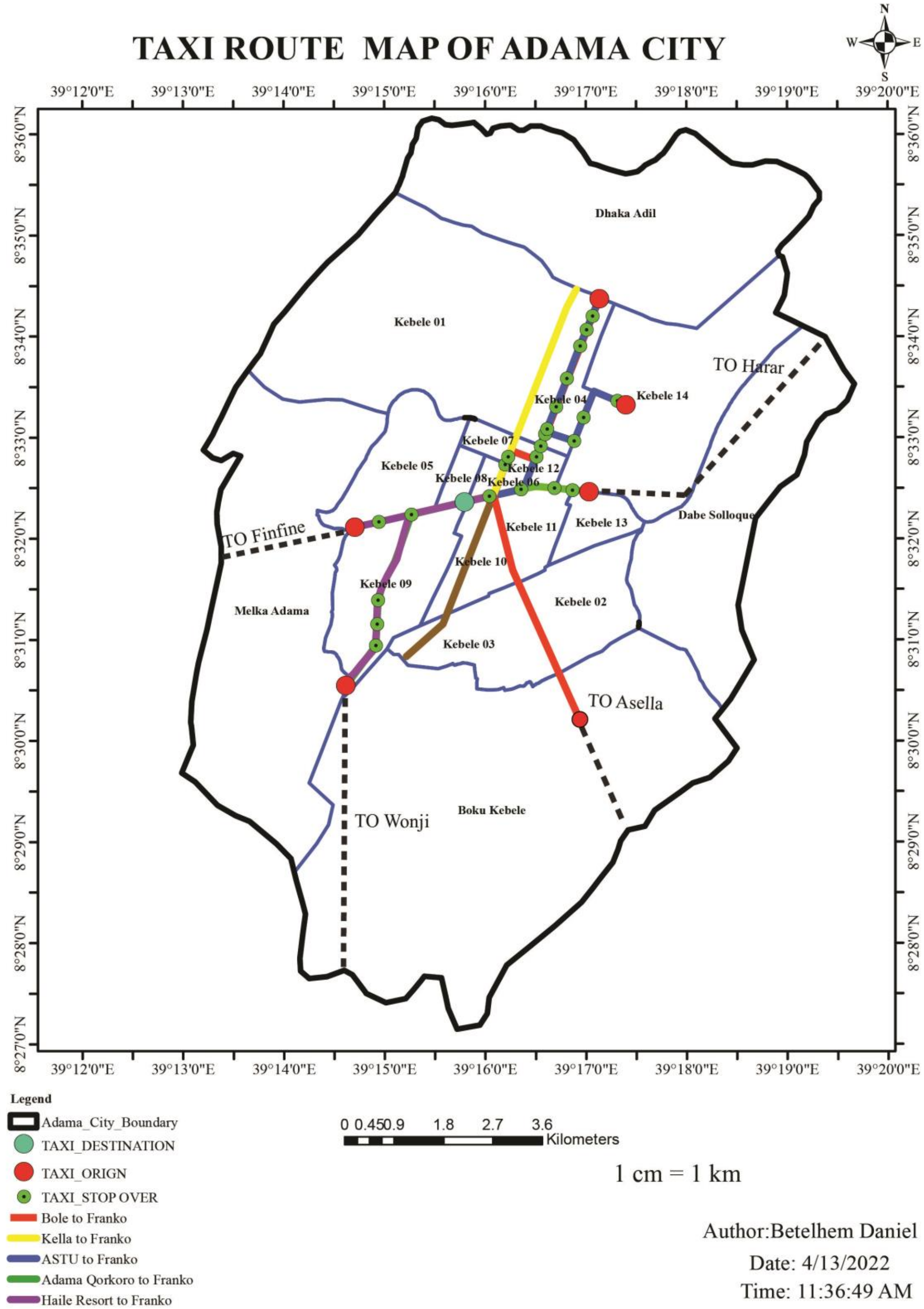


FIGURE 4. 6: Public Bus Route with Kebele distribution

Source: Author, Field observation

From the data collected from Adama Transport Authority Office, the origin and destination of daily trips made by the taxi (mini-bus) transport system tend to indicate trip attractor and producer areas in Adama city. From the result in Table 4.6 above, Franko is the common area of destinations for the taxi (mini-bus) transport system in Adama city.

Meaning that Franko has high activity (dominant land use) rates or mobility scales which can attract travelers for many reasons. For further progress of the study in order to answer for the second objective, the population density of these areas has been calculated and a large proportion of the sample size has been taken from these areas for the field survey in order to determine trip generation model. According to Table 4.6 above, TAZ 02, 03, 09, 13, 14 are the origin site for taxi (mini-bus) routes, while TAZ 6 and TAZ 8 are the destination of taxi (mini-bus) routes.

According to the public transport route evaluation standard stated by (Benn, 1995), Space between the taxi (mini-bus) route for CBD with a high population density value is 0.805km apart, while for areas with less population density value is 1.61km apart. The current space between Taxi (mini-bus) routes and the standard space given are related in Table 4.7 below.

TABLE 4. 6: Space between Taxi (mini-bus) routes in Adama City

Source: Author, GIS Map

Routes	Minimum Space between routes(km)	Population density(PD) category of bounded area	Standard space(km)	Evaluation
A to C	0.5 km	Medium PD	0.805 km	Within standard
C to B	1.0 km	Medium PD	0.805 km	Below standard
B to D	6.8 km	Medium PD	0.805 km	Below standard
D to E	1.1km	Medium PD	0.805 km	Below standard
A to E	2.2 km	Low PD	1.61 km	Below standard

Travel time, Carrying Capacity and Cost

According to the result shown below in Table 4.8 from the survey data indicate that taxi (mini-bus)users are requested to pay in average 5 br for single trip, but travel cost varies from day to night season and travel route. In addition this result shows that average TT in Adama city using taxi (mini-bus) is 20 min for single trip.

TABLE 4. 7: Average Capacity and Travel time of Taxi (Mini-Bus)

Source: Author, Field observation

Route-Code	No of Taxi assigned			Average Capacity of Bus(person/trip) 1 Taxi=12 seats	Travel Cost (TC) (Birr)		Average Travel Time (TT) (Min)
	W/A/Q/ NIB	W/A/Q/JALATAMA A	W/A/Q/ WALIGALAA		Day time	Night time	
A	65	92	113	270*12=3240	5 br	10br	20 min
B	53	68	76	197*12=2364	5br	10br	15 min
C	49	66	63	178*12=2136	5br	10br	25 min
D	2	3	6	11*12=132	5br	10br	20 min
E	4	-	-	4*12=48	5br	10br	15 min
TOTAL	173	229	258	7920 person(O-D)			Average=20min
	660						

According to data collected from field observation and data from the 314 respondents who tends to use the taxi (mini-bus) as a mode of transport for their trip shown Table 4.9 below, the average waiting time for 45 respondents was less than 10 min, for 113 respondents WT was 11-20 min, for 91 respondents WT was 21-30 min, for 65 respondents WT was more than 30 min.

TABLE 4. 8: Average waiting time for public bus * Descriptive statistics: Frequency Analysis

Source: Author, survey Questioner

Average Waiting Time(WT)		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 10min	45	14.3	14.3	14.3
	11-20min	113	36.0	36.0	50.3
	21-30min	91	29.0	29.0	79.3
	More than 30min	65	20.7	20.7	100.0
	Total	314	100.0	100.0	

According to stop spacing standard stated on Public transport route evaluation standard (Benn, 1995) for residential and commercial areas is 4 stops/mile. The stopovers or stations for the Taxi (mini-bus) in Adama city is not legally located but, the Taxi (mini-bus) tends to stop and unload the travelers depending on their interest and most of the time depending on their trip purpose location which is out of standards.

Stop Overs

The following Table 4.10, showed the stopovers in a given route separately, this enabled the study to identify TAZs' which play a contribution for the trip production and attraction, which is calculated on the travel demand model analysis using its result**.**

TABLE 4. 9: Stop Overs on Taxi (mini-bus) Routes

Source: Author, Field observation

Route-Code	Stop-Overs(stations)
A	Mebrat Hile Mariam Hospital 04 Geda No2/Adama General Hospital Nafyad school Bole Mosque Wangari
B	Posta(Abba Gedaa) Bekele Mamo Hotel Hani Amede Gebeya
C	Posta(Abba Gedaa) Mebrat Hile Mariam Hospital 04 O4 Condominium Cherkacherk Darik Coffe
D	Kuriftu Resort Oromia COC Selam mosque O9 Condominium
E	Kuriftu Resor

FIGURE 4. 7: Street integration Map of Adama City

Source: ASTU, Unpublished 2022

The figure 4.7 above showed the street integration of Adama city developed by space syntax software. From the figure it is found that the public transport routes lies on a good integration level with the local street toward in Adama city. The map of the street integration of Adama city showed that, when the distance from the public transport route increase, the integration based on connectivity with the subordinate roads will decrease. This is one of the problems has been identified that when the distance or location of activity to the public transport stop overs or station increase, the less integration status meaning that public transport users would experience long travel distance to get public transport service.

This shows that two basic scenarios, are the activity required by the users was not available in nearby short walking distance (less than 500m) or as per the standard stated by (UN Inhabitat, 2015) .This indicate that the land use is not heterogeneous. In addition, due to the less availability of facilities, services area within walking distance residents tends to use public transport system as a travel choice but the routes and residential areas or trip origin basically home is located at far distance (more than 500m distance), this showed that the routes are not integrated with the trip origin locations.

This increase the walking distance and time for single trip. In addition to this when the distance from the center of the city increased, the integration level would decreased as result the public transport route cannot be accesses to that TAZ, if there is no integrated PT route system, the TAZ cannot experience mixed development because without integrated street system different facilities, services, infrastructures and other activities cannot be placed or transit oriented development would not be installed.

Population Density

Population density measurement indicates the mobility rate, which directly shows working trip with employment density. The employment density points out the trip generation areas meaning that area with the character of attracting trip and producing trip, meaning the land use character or type of activity held in the area or kebeles.

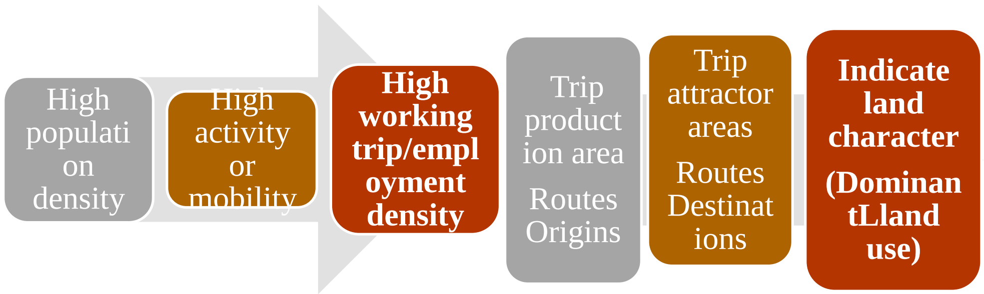


FIGURE 4. 8: Population Density Value Reflections

$$\text{Population Density} = \text{Number of people} / \text{Hectare of land} \quad \ldots\ldots\ldots\ldots\text{Eq(1)}$$

According to (UN Inhabitat, 2015), the average standard of population density for urban areas is 100-150 people per hectare. In the case of Adama city, 6 TAZ s are grouped into low population density groups, 4 TAZ are categorized under the medium population density scale and 3 TAZ are high population density areas (Table 14).

TABLE 4. 10: Population Distribution in Adama City

Source: Author

Population Density(PD) Distribution in Adama town					
Low Population Density		Medium Population Density		High Population Density	
TAZ	PD	TAZ	PD	Kebele	PD
TAZ -1	19.16196	TAZ -4	125.166	TAZ - 6	360.3944
TAZ -2	63.57671	TAZ -10	146.2902		
				TAZ -7	372.0963
TAZ -3	93.85847	TAZ -11	183.1243		
TAZ -5	86.16103	TAZ -12	199.1308		
TAZ -9	72.3112	TAZ -13	135.3075	TAZ -8	316.2083
TAZ -14	32.673				

From the above result, we conclude that TAZ 6, 7 and 8 are trip attractor TAZ in Adama town, by having different activities, their land-use status and land mix level is identified and measured on the second objective of the study. The Map in the Figure 4.9 below shows the population density distribution throughout the 14 kebeles in Adama City based on the population number of the kebele at a given bounded kebele area.

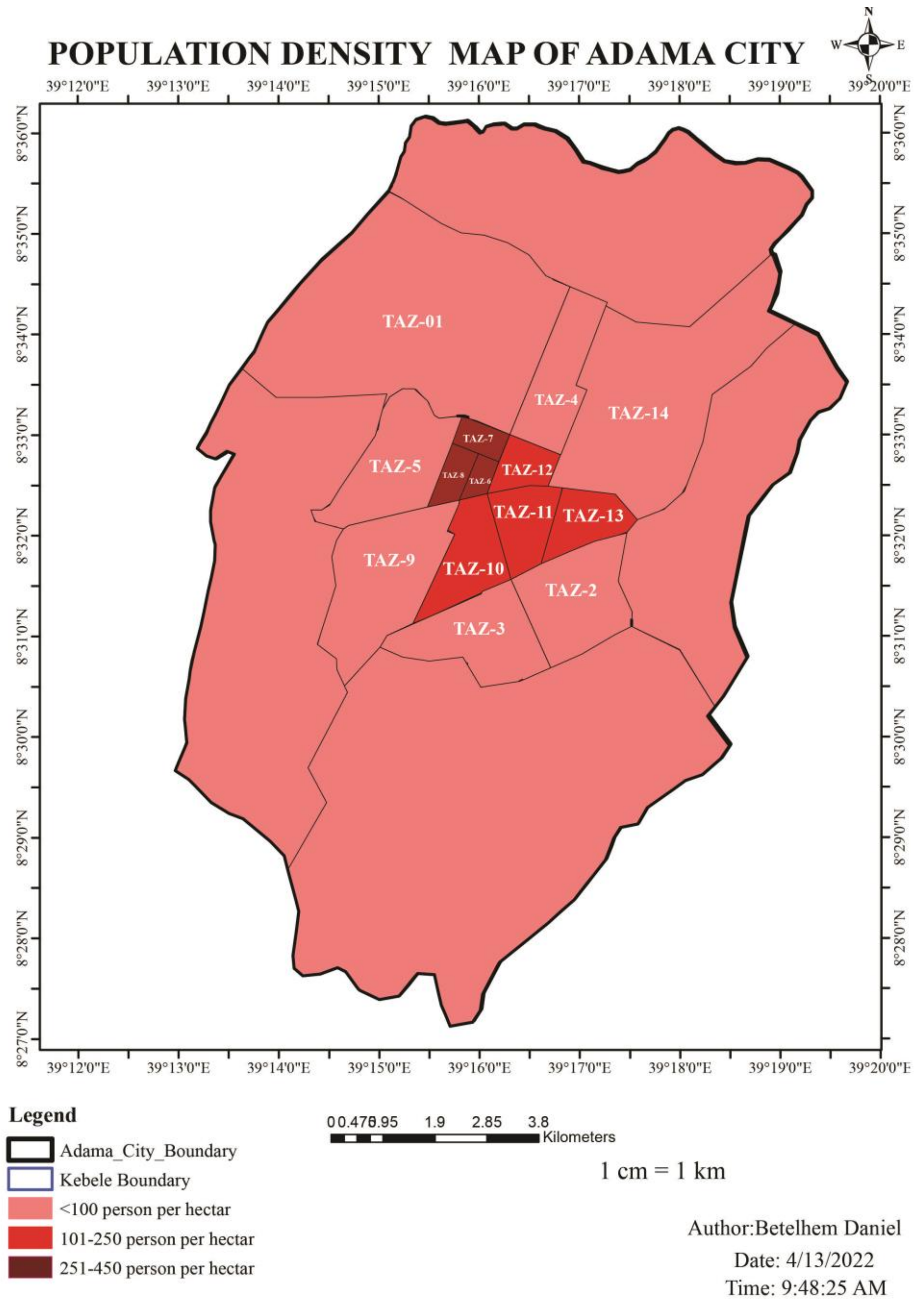


FIGURE 4. 9: Population Density Map of Adama Town

Source: Author

4.1.2. ***Travel demand model***

4.1.2.1. *Travel demand model for Public bus*

Trip Generation: Trip production

A trip is defined as a connection between an origin (O) and a destination (D). Consequently, trip generation is a process to determine the number of trips from and to a particular site or area. Data used in the trip generation is obtained from government offices and field surveys. Those data are often used for estimating trip generation. According to the sampling technique of the study, samples was taken at urban neighborhood-level based on the population density along 14 kebeles (TAZ) as traffic analysis zone (TAZ) in Adama City. TAZ with high population density contributes a large number of sample high activity rate in relation to TAZ land use character.

From the total survey questionnaire respondents of 378, 64 of them are public bus users. The respondents were categorized by their trip purpose and average monthly income level. This study analyzed the connection of transportation analysis to demographic analysis and economic analysis. Table 4.12 showed the income level of Public bus user respondents using statistical descriptive using frequency analysis using data from survey questioner.

TABLE 4. 11: Pubic bus Respondent Classification based on income level

Source: Author, survey questioner

TAZ	Respondent Monthly Average income				
	500-1500	1500-2500	2500-3500	3500-4500	>45000
1	1	0	1	0	0
2	0	1	0	0	2
3	4	1	1	1	-
4	0	0	0	1	0
5	1	0	0	0	1
6	5	2	1	0	0
7	8	0	0	1	0
8	3	3	0	0	0
9	3	0	0	0	0
10	1	2	0	0	0
11	5	2	0	0	0
12	6	0	1	0	1
13	2	0	0	0	0
14	2	0	0	1	0
Total	41	11	4	4	4

From this result shown above in Table 4.12, the low-income groups with a monthly average income of 500 to 1500 are the highest public bus users. In the case of Adama City the public bus efficiency is very low in regard to with population growth and expansion development. In addition, this result showed that the low-income groups of Adama city residents are the group affected by the inefficiency problem of public bus facilities.

The trip purpose was one of the categories for the respondent during the survey data collection process. According to this study, trip purposes are classified into three main groups. The first group is HBW(Home Based Work) trip purpose meaning trip from home to work which indicate trip from same origin and destination, the second group is HBNW (Home Based Non-Work) trip purpose meaning trips from home to non-work purpose such as trip to school shopping, social service which indicate trips having same origin but different destinations. The third group is NHB (Non Home Based) trip purpose meaning trips having different origin and different destination. Table 4.13 showed the trip purpose of Public bus user respondents using statistical descriptive using cross-tabulation analysis using data from the survey questioner.

TABLE 4. 12: Pubic bus Respondent Classification based on trip purposes

Source: Author, survey questioner

	The major purpose of trip making			
TAZ	HBW	HBNW	NHB	Total
01	1	1	0	2
02	3	0	0	3
03	4	0	3	7
04	1	0	0	1
05	1	0	1	2
06	1	2	5	8
07	6	0	3	9
08	4	0	2	6
09	0	0	3	3
10	2	1	0	3
11	3	0	4	7
12	2	0	6	8
13	1	0	1	2
14	2	0	1	3
Total	31	4	29	64

TABLE 4. 13: Frequency distribution of major purpose of trip making

Source: Author

Major purpose of trip making									
						Bootstrap for Percent			
								95% Confidence Interval	
		Frequency	Percent	Valid Percent	Cumulative Percent	Bias	Std. Error	Lower	Upper
Valid	HBW	31	49	49	49	-.1	5.2	11.0	32.8
	HBNW	4	6	6	55	.0	5.5	17.2	39.1
	NHB	29	45	45	100.0	-.1	4.8	9.4	28.1
	Total	64	100.0	100.0		.0	.0	100.0	100.0

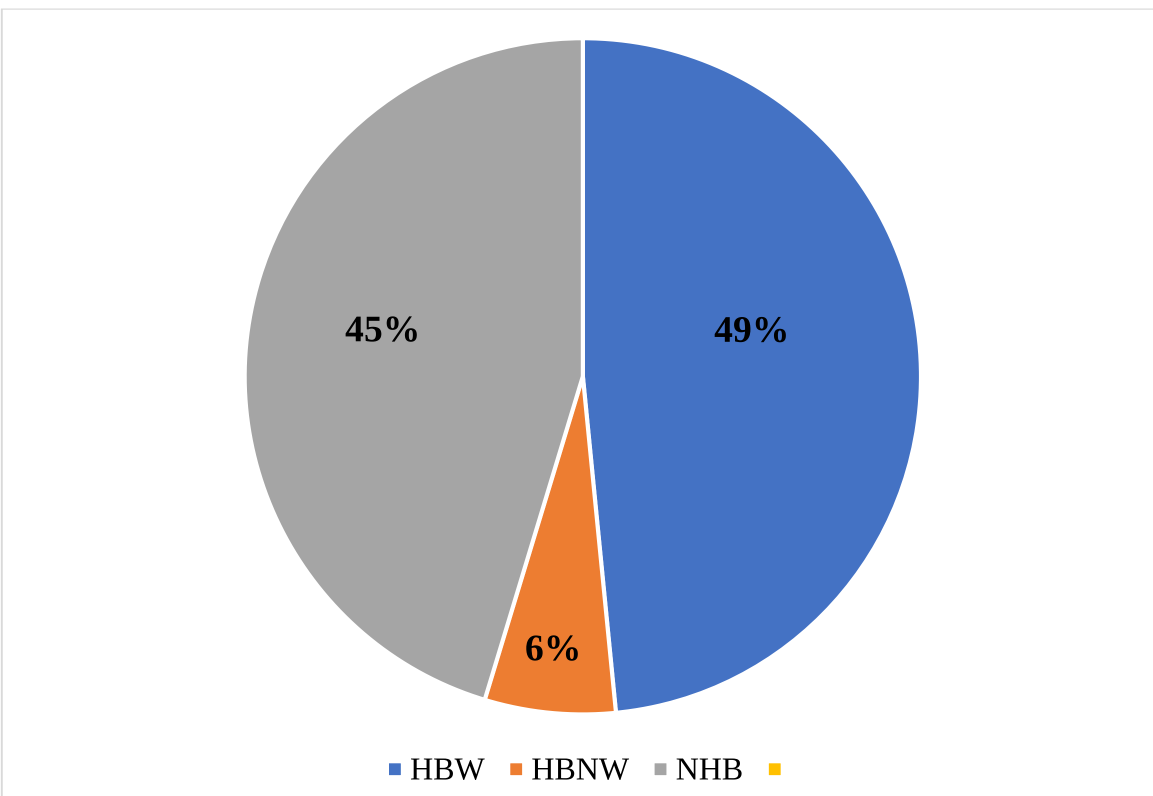


FIGURE 4. 10: Trip making purpose of public bus users

TABLE 4. 14: Descriptive statistics analysis for trip purpose and income level of public bus users

Descriptive Statistics							
				Bootstrap			
						95% Confidence Interval	
		Statistic	Std. Error	Bias	Std. Error	Lower	Upper
Average Monthly Income	N	64		0	0	64	64
	Range	11800.00					
	Minimum	200.00					
	Maximum	12000.00					
	Mean	1976.093	294.172	-16.1177	299.7738	1436.024	2616.0569
	Std. Deviation	2353.380 96		- 83.11992	491.3724	1253.953	3192.7274
	Variance	5538402		- 143111.3	2223349.	1572400.	10193512.
	Skewness	2.834	.299	-.193	.607	1.008	3.689
	Kurtosis	9.453	.590	-.610	4.494	-.003	19.054
Major purpose of trip making	N	64		0	0	64	64
	Range	3					
	Minimum	1					
	Maximum	4					
	Mean	2.47	.130	.00	.13	2.22	2.70
	Std. Deviation	1.038		-.012	.062	.902	1.142
	Variance	1.078		-.021	.127	.813	1.303
	Skewness	-.002	.299	.005	.169	-.314	.339
	Kurtosis	-1.143	.590	.055	.179	-1.407	-.702
Valid N (list wise)	N	64		0	0	64	64

The Skewness and Kurtosis value determine the asymmetry degree of the series and peakness or flatness of the distribution of series respectively. The average monthly income value of public bus users have a Skewness value of 2.834, which is >0 meaning that the asymmetry degree of the series is a long right tail and more high value namely positive Skewness.

In addition to this average monthly income value of public bus users have a Kurtosis value of 9.453, which is >3 meaning that the peaked curve is with more high values namely leptokurtic or positive kurtosis.

Major purpose of trip making of public bus users have a Skewness value of -0.002,which is <0 meaning that the asymmetry degree of the series is a long left tail and more low value namely negative Skewness. In addition to this major purpose of trip making of public bus users have Kurtosis value of -1.143, which is< 3 meaning that the flatted curves is with more lower value namely platykurtic or negative kurtosis.

In order to calculate trip production the study used data collected from survey questioner based on trip purpose and income level. Regression analysis is used as shown in Table 4.16 to derive the trip production rate for each category using income level and trip purpose data as dependent and independent data respectively.

The person trips by respondent income category are calculated as:

$$\mathrm{PT} = \mathrm{Nhh} * \mathrm{PTPH} \qquad \text{Eq (12)}$$

Where,

PT=Person trips;

Nhh= Number of respondent;

PTPH =Person trips per respondent;

The following formula is used to calculate trip production based on different respondent income categories:

$$TP = \sum_{i=1,n}(ri * Hi) \qquad \text{Eq (13)}$$

Where,

TP = Trips generated; n =Number of responder categories; i = Responder category; ri = Trip production rate for responders category i ; Hi = Number of responders in category i

TABLE 4. 15: Trip production rate of Public bus users by regression analysis

Income/Br / Trip purpose	Person trip per person by trip purpose				
	500-1000	1500-2500	2500-3500	3500-4500	>4500
HBW	0.605	1.347	2	3.25	1.5
HBNW	0.061	0.26	0.75	0	0
NHB	0.702	1.17	3.5	1.75	1.166

The number of person trips by income level and trip purpose for public bus user responders using the calculation of:

$$TP = \sum_{i=1,n}(ri * Hi) \qquad \text{Eq (14)}$$

Where,

TP = Trips generated;

n =Number of responder categories;

i =Responder category;

ri = Trip production rate for responder category i ;

Hi = Number of responders in category i;

TAZ	TAZ-1			TAZ -2			TAZ -3			TAZ -4			TAZ -5			TAZ -6			TAZ -7		
Trip Purpose / Income Level(br)	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB
500-1500	1	0.061	0.70	0	0	0	2.4	0.244	2.808	0	0	0	0.60	0.061	0.70	3.05	0.305	3.51	4.84	0.488	5.616
1500-2500	0	0	0	1.34	0.26	1.17	1.3	0.26	1.17	0	0	0	0	0	0	2.69	0.52	2.34	0	0	0
2500-3500	2	0.75	3.5	0	0	0	2	0.75	3.5	0	0	0	0	0	0	2	0.75	3.5	0	0	0
3500-4500	0	0	0	0	0	0	3.2	0	1.75	3.25	0	1.75	0	0	0	0	0	0	3.25	0	1.75
>4500	0	0	0	3	0	2.33	0	0	0	0	0	0	1.5	0	1.16	0	0	0	0	0	0
TOTAL	3	1	4	1	0	4	9	1	9	3	0	2	2	0	2	6	2	7	8	0.488	7

TAZ	TAZ-8			TAZ -9			TAZ -10			TAZ -11			TAZ -12			TAZ -13			TAZ -14		
Trip Purpose / Income Level(br)	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB
500-1500	1.81	0.1	2.10	1.81	0.183	2.10	0.60	0.061	0.70	3.02	0.305	3.5	3.63	0.366	4.2	1.21	0.12	1.404	1.21	0.12	1.404
1500-2500	4.04	0.7	3.51	0	0	0	2.69	0.52	2.34	2.69	0.52	2.3	0	0	0	0	0	0	0	0	0
2500-3500	0	0	0	0	0	0	0	0	0	0	0	0	2	0.75	3.5	0	0	0	0	0	0
3500-4500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.25	0	1.75
>4500	0	0	0	0	0	0	0	0	0	0	0	0	1.5	0	1.16	0	0	0	0	0	0
TOTAL	6	1	6	2	0.183	2	3	0.581	3	6	1	6	5	1	8	1	0.12	1	5	0.12	3

TABLE 4. 16: Number of person trip by income level and trip purpose for public bus user respond

Converting person trip to vehicle trip using vehicle occupancy based on trip purpose'

$$\text{Public bus occupancy} = \frac{\text{Number of the person making trips based on the purpose}}{\text{Total number of public buses in Adama city}}$$

In Adama town, there are only 13 public buses.

- Public bus occupancy rate(HBW)=60/13=4.61
- Public bus occupancy rate(HBNW)=10/13=0.7
- Public bus occupancy rate(NHB)=64/13=4.92

TABLE 4. 17: Person trip by Trip Purpose of public bus user

TAZ / Purpose	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total	Public bus Occupancy Rate
HBW	3	2	9	3	2	6	8	5	2	3	6	5	1	5	60	4.61
HBNW	1	1	1	0	0.061	2	0.48	1	0.1	1	1	1	0.12	0.122	10	0.76
NHB	4	4	9	2	2	7	7	6	2	3	6	8	1	3	64	4.92
TOTAL	8	7	10	5	4	15	15	12	5	7	13	14	2	8	134	

$$\text{Vehicle trip (pubic bus)} = \frac{\text{Number of trips by purpose}}{\text{Public bus occupancy rate by purpose}} \qquad \text{Eq (15)}$$

TABLE 4. 18: Number of Vehicle-Trips Produced by Trip Purpose and Kebele by public bus users

TAZ / Trip-purpose	Vehicle (public bus) trip by Trip Purpose													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
HBW	0.65	0.43	2	0.65	0.43	1.30	1.73	1	0.43	0.61	1.3	1.08	0.21	1.08
HBNW	1.31	1.31	1	0	0.08	2.63	0.64	1.31	0.24	1.31	1.31	1.31	0.16	0.16
NHB	0.81	0.81	2	0.4	0.4	1.42	1.42	1.21	0.4	0.60	1.21	1.62	0.20	0.60
Total	3	3	4	1	1	5	4	4	1	3	4	4	1	2

From the trip production calculated above, the result showed that in order to calculate trip generated by a person or person trip, the public bus occupancy rate should be identified according to the city status. The occupancy rate for public bus determined the vehicular occupancy covered by each person trip, according to the result HBW trip by person had high public bus vehicular occupancy rate than HBNW and NHB trip relatively. this showed than since HBW trip was identified as major trip purpose making of Adama city, in addition NBW trip had high Occupancy rate.

During the conversion of person trip in to vehicular trip, public bus occupancy rate has been used as variable. Since the study covered transportation system trip by person should be converted to trip by vehicle, in this case public bus is the vehicle. According to the result showed in Table 4.19 TAZ 3, 6, 7, 8, 11, and 12 had high vehicle trip-production relatively to other TAZs. THIS shows that these TAZs had more of residential character than other, since its dwellers tended to be attracted by other TAZ through different facilities and activities provided.

Trip Generation: Trip Attraction

Trip attraction predicts the number of trips to be attracted to (end in) each TAZ. The attractiveness of a TAZ is related to the size and type of land uses that are the destination of trips. The majority of such land uses are non-residential land, such as services, retail, recreations, etc. The trip attraction is normally expressed as the number of vehicle trips per household or per unit area of non-residential land use. In addition to the zonal characteristics, the number of trips attracted to a zone is related to the attractiveness of other zones in the city. All trip attracting TAZ in the city compete for the number of trips produced in the city. TAZs that are more attractive will attract more trips than the zones that are less attractive.

In order to operationalize this for this study, the seven land uses was classified in to into four categories Residential was left as its own category; pure and mixed retails, shops, and trades were collapsed into a second category as commercial to represent commercial and employment destinations within each zone; administration, infrastructures, schools, hospitals, private and governmental institutions were collapsed into the third category as service to represent social services and facilities within each zone .Green space, open spaces and environmentally sensitive areas were collapsed into fourth category as recreation to represent opportunities for leisure.

In order to calculate trip attraction the study used data collected from survey questioner based on trip purpose and land-use file of Adama city from the Adama land administration office. Regression analysis is used as shown in Table 4.20 to derive the trip attraction rate using the public bus for each category.

TABLE 4. 19: Trip attraction rate for public bus

Trip purpose	HBW	HBNW	NHB
Selected responders(unit)	1.73	3.5	1.72
Residential(hec)	0.004	0.001	0.003
Commercial (hec)	0.15	0.015	0.167
Service(hec)	0.014	0.001	0.013
Recreation (hec)	0.002	0.001	0.001

Vehicle trips attracted to each zone are then calculated as:

$$TAR = Nhh * TARR \qquad \text{Eq(16)}$$

Where,

TA_R= Vehicle Trip Attractiveness of the zone by households;

Nhh— Number of respondents in the zone;

TAR_R— Trip Attraction rate by respondent;

Trips attracted by Non- residential are calculated from the size of Non- residential land use and the Non- residential trip attraction rates.

$$TANR = NR * TARNR \qquad \text{Eq(17)}$$

Where,

TA_{N} = Vehicle Trip Attractiveness of the zone;

A_{NR}= Non-Residential Land use size in the zone;

TAR_{NR} = Trip Attraction Rate of the Non-Residential land use;

TABLE 4. 20: Trip Attractiveness by land use and trip purpose using public bus

TAZ / Trip-purpose	Trip Attraction(Bus) by Trip Purpose													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
HBW	9	9	14	4	7	16	17	14	12	8	14	16	4	12
HBNW	2567	524	25	40	27	40	27	67	99	37	43	50	24	41
NHB	7	8	13	3	6	16	17	13	10	7	14	16	4	10
Total	2583	541	52	47	40	76	61	94	121	52	71	82	32	63

From trip generation calculation, trip attraction is one of the input for the development of travel demand model. In order to calculate trip attraction level of a given TAZ, trip attraction rate , number of sample taken from each TAZ, land use coverage of each type in hectare of each given TAZ has been used as variable. In order to determine the trip attraction rate for public bus users trip making purpose, number of sample taken from each TAZ, land use coverage in hectare (residential, commercial, service, and recreation) has been used as dependent and independent variables as shown in Table 4.20 .

According to the result showed in Table 4.21 TAZ 1, 2, 6, 9, and 12 had high trip-attraction level relatively to other TAZs. This implied that these TAZs had more activity attraction characteristics which pull users from their dwelling toward to them due to the facility and activities provided.

4.1.2.2. *Travel demand model for Taxi (mini-bus)*

Trip Generation: Trip production

A trip is defined as a connection between an origin (O) and a destination (D). Consequently, trip generation is a process to determine the number of trips from and to a particular site or area. Data used in the trip generation is obtained from government offices and field surveys. Those data are often used for estimating trip generation. According to the sampling technique of the study, sample was taken based on the population density along 14 TAZs' in Adama City. TAZ with high population density contributes large number of samples due to the situation of high mobility and activity rate in relation to TAZ land use character.

From the total survey questionnaire respondents of 378, 314 of them are Taxi (mini-bus) users. The respondents are categorized by their trip purpose and average monthly income level. This study analyzed connection of transportation analysis to demographic analysis and economic analysis. Table 4.22 showed the income level of Taxi (mini-bus) user respondents using statistical descriptive using frequency analysis using data from the survey questioner.

TABLE 4. 21: Taxi (mini-bus) Respondent Classification based on income level

Source: Author, survey questioner

TAZ	Household income				
	500-1500	1500-2500	2500-3500	3500-4500	>45000
1	5	3	2	0	9
2	9	2	5	1	10
3	6	2	2	2	3
4	0	1	3	5	11
5	10	3	3	0	4
6	19	6	5	1	3
7	17	5	0	1	4
8	13	11	2	3	3
9	2	5	4	4	1
10	6	10	2	1	2
11	5	3	4	1	2
12	9	9	3	0	10
13	8	3	2	2	6
14	5	3	5	3	0
TOTAL	**114**	**66**	**42**	**24**	**68**

From this result showed above in Table 4.22, the low-income group with a monthly average income of from 500-1500 birr are the highest Taxi (mini-bus) users. In the case of Adama city, the taxi (mini-bus) efficiency is very low in regard to population growth and expansion development. In addition, TC of taxi (mini-bus) is very high and not affordable for low-income group, this result showed that the low-income group of Adama city residents are the group affected by the inefficiency problem of taxi (mini-bus) facilities.

The trip purpose was one of the categories for the respondent during the survey data collection process. According to this study, trip purposes are classified into three main groups. The first group is HBW (Home Based Work) trip purpose meaning trip from home to work which indicate a trip from the same origin and destination, the second group is HBNW (Home Based Non-Work) trip purpose meaning trips from home to non-work purpose such as a trip to school shopping, social service which indicates trips having same origin but different destinations.

The third group is NHB (Non-Home Based) trip purpose meaning trips having different origins and different destinations such as recreation. Table 4.23 showed the trip purpose of taxi (mini-bus) user respondents using statistical descriptive using cross-tabulation analysis using data from the survey questioner.

TABLE 4. 22: Taxi (mini-bus) Responders Classification based on trip purposes

Source: Author, survey questioner

	Major purpose of trip making			
TAZ	HBW	HBNW	NHB	Total
01	15	3	1	19
02	19	3	5	27
03	9	0	6	15
04	17	1	2	20
05	12	0	8	20
06	7	7	20	34
07	13	2	12	27
08	23	0	9	32
09	5	6	5	16
10	16	0	5	21
11	9	2	4	15
12	21	4	6	31
13	15	2	4	21
14	11	0	5	16
Total	192	30	92	314

TABLE 4. 23: Frequency distribution of major purpose of trip making

Major purpose of trip making					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	HBW	192	61	61.1	61
	HBNW	30	10	9.6	71
	NHB	92	29	29.3	100.0
	Total	314	100.0	100.0	

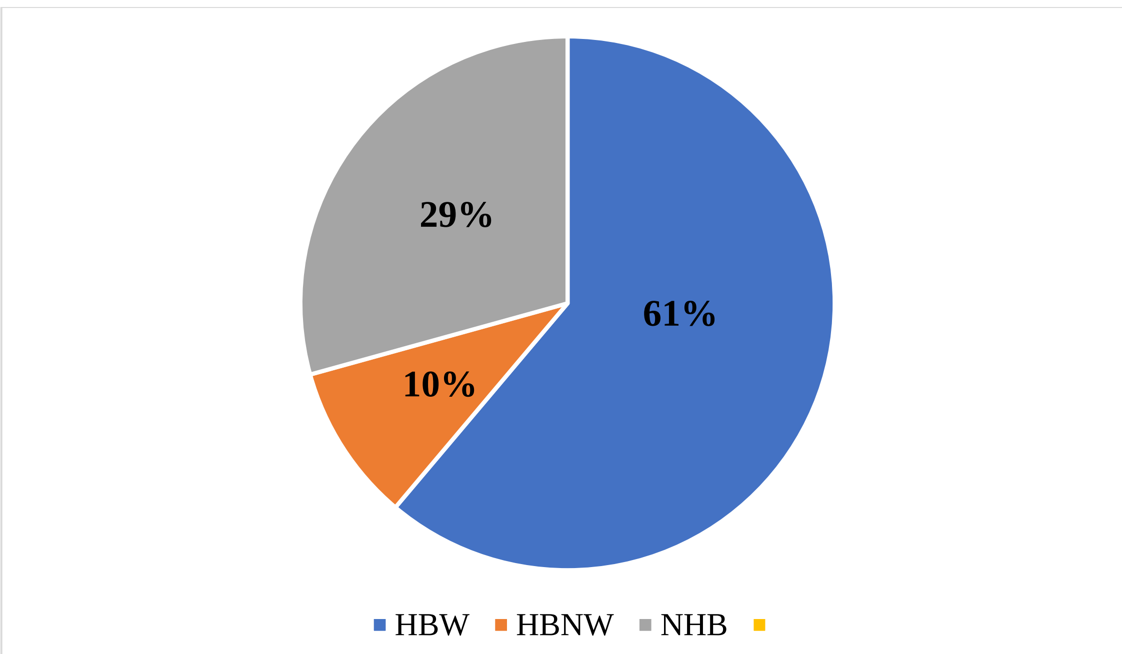


FIGURE 4. 11: Trip making purpose of Taxi (minibus) users

TABLE 4. 24: Descriptive statistics analysis for trip purpose and income level of public bus users

Descriptive Statistics							
				Bootstrap			
						95% Confidence Interval	
		Statistic	Std. Error	Bias	Std. Error	Lower	Upper
Average monthly Income	N	314		0	0	314	314
	Minimum	100.00					
	Maximum	18000.00					
	Mean	2952.006		5.0785	169.0846	2633.062	3297.9565
	Std. Deviation	2821.975		-9.76401	210.4224	2413.774	3276.9240
	Variance	7963546.		-10875.6	1196697	5826312	10738233
	Skewness	1.876	.138	-.036	.269	1.332	2.323
	Kurtosis	4.512	.274	-.219	1.646	1.374	7.608
Major purpose of trip making	N	314		0	0	314	314
	Minimum	1					
	Maximum	3					
	Mean	1.68		.00	.05	1.58	1.79
	Std. Deviation	.898		-.003	.021	.854	.932
	Variance	.806		-.004	.037	.729	.868
	Skewness	.672	.138	.011	.126	.436	.915
	Kurtosis	-1.424	.274	.032	.186	-1.701	-.991
Valid N (list wise)	N	314		0	0	314	314

Source: Author

The Skewness and Kurtosis value determine the asymmetry degree of the series and peakness or flatness of the distribution of series respectively. The average monthly income value of taxi (mini-bus) users have a Skewness value of 1.876, which is >0 meaning that the asymmetry degree of the series is a long right tail and more high value namely positive Skewness. In addition to this average monthly income value of public bus users have a Kurtosis value of 4.512, which is >3 meaning that the peaked curve is with more high values namely leptokurtic or positive kurtosis.

Major purpose of trip making of public bus users have a Skewness value of 0.672, which is >0 meaning that the asymmetry degree of the series is a long right tail and more low value namely positive Skewness. In addition to this major purpose of trip making of public bus users have Kurtosis value of -1.424, which is< 3 meaning that the flatted curves is with more lower value namely platykurtic or negative kurtosis.

In order to calculate trip production the study used data collected from survey questioner based on trip purpose and income level. Regression analysis is used as shown in Table 4.26 to derive the trip production rate for each category using income level and trip purpose data as dependent and independent data respectively.

.

The person trips by respondent income category are calculated as:

$$\mathrm{PT} = \mathrm{Nhh} * \mathrm{PTPH} \qquad \text{Eq (18)}$$

Where,

PT=Person trips;

Nhh= Number of respondent;

PTPH =Person trips per respondent;

The following formula is used to calculate trip generation based on different respondent income categories:

$$TP = \sum_{i=1,n}(ri * Hi) \qquad \text{Eq (19)}$$

Where,

TP = Trips generated; n =Number of responder categories; i = Responder category;

ri = Trip production rate for responders category i; Hi = Number of responders in category i;

TABLE 4. 25: Trip production rate of Taxi (mini-bus) users by regression analysis

	Person trip per person by trip purpose				
Trip purpose	500-1000	1500-2500	2500-3500	3500-4500	>4500
HBW	1.225	2.246	3.551	4.43	2.142
HBNW	0.218	0.33	0.694	0.652	0.314
NHB	0.8	1.126	1.844	1.916	0.737

The number of person trip by income level and trip purpose for Taxi (mini-bus) user responders using the calculation of:

$$TP = \sum_{i=1,n}(ri * Hi) \qquad \text{Eq (20)}$$

Where,

TP = Trips generated;

n =Number of responder categories;

i =Responder category;

ri = Trip production rate for responder category i ;

Hi = Number of responders in category i;

TAZ	TAZ-1			TAZ -2			TAZ -3			TAZ -4			TAZ -5			TAZ -6			TAZ -7		
Trip Purpose / Income Level(Br)	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB
1500-2500	7	1	3	5	0.66	2	5	0.66	2	2.24	0.33	1.12	7	1	3	13	2	7	11	2	6
2500-3500	7	1	4	18	3	9	7	1	4	11	2	6	11	2	6	18	3	9	0	0	0
3500-4500	0	0	0	4	0.652	2	9	1	4	22	3	9	0	0	0	4	0.652	2	4	0.652	2
>4500	19	3	7	21	6	7	6	1	2	24	3	8	9	1	3	6	1	2	9	1	3
TOTAL	39	6	18	59	12	27	35	5	17	59	8	24	39	6	20	65	11	35	45	8	25

TAZ	TAZ-8			TAZ -9			TAZ -10			TAZ -11			TAZ -12			TAZ -13			TAZ -14		
Trip Purpose / Income Level(br)	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB
1500-2500	25	4	12	11.2	2	6	22.4	3	11	7	1	3	20	3	10	7	1	3	7	1	3
2500-3500	7	1	4	14	3	7	7	1	4	14	3	7	11	2	6	7	1	4	18	3	9
3500-4500	13	2	6	18	3	8	4	0.652	2	4	0.652	2	0	0	0	9	1	4	13	2	6
>4500	6	1	2	2	0.314	0.737	4	0.628	1	4	0.628	1	21	6	7	13	2	4	0	0	0
TOTAL	67	11	34	48	9	24	45	6	23	35	6	17	63	13	30	46	7	21	44	7	22

TABLE 4. 26: Number of person trip by income level and trip purpose for Taxi user respond

Converting person trip to vehicle trip using vehicle occupancy based on trip purpose'

$$\text{Taxi occupancy} = \frac{\text{Number of person making trips based on the purpose}}{\text{Total number of Taxi in Adama}} \qquad \text{Eq (21)}$$

In Adama town, there are only 660 taxis (midi bus-12 seat).

- Taxi occupancy rate(HBW)=689/660=1.04
- Taxi occupancy rate(HBNW)=115/660=0.17
- Taxi occupancy rate(NHB)=337/660=0.51

TABLE 4. 27: Person trip by Trip Purpose of Taxi (mini-bus) users

TAZ / Trip Purpose	Person trip by Trip Purpose															Taxi Occupancy Rate
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total	
HBW	39	59	35	59	39	65	45	67	48	45	35	63	46	44	689	1.04
HBNW	6	12	5	8	6	11	8	11	9	6	6	13	7	7	115	0.17
NHB	18	27	17	24	20	35	25	34	24	23	17	30	21	22	337	0.51
TOTAL	63	98	57	91	65	111	78	112	81	74	58	106	74	73	1141	

TABLE 4. 28: Number of Vehicle-Trips Produced by Trip Purpose in TAZ by Taxi users

TAZ / Trip-purpose	Vehicle (Taxi) trip by Trip Purpose													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
HBW	37	56	34	56	37	62	43	64	46	43	34	60	44	42
HBNW	35	70	29	47	35	64	47	64	53	35	76	76	41	41
NHB	35	53	33	47	39	68	49	66	47	45	33	59	41	43
Total	107	179	96	150	111	194	139	194	176	123	143	169	126	126

The outcome of the trip production calculation above demonstrated that the Taxi (mini-bus) occupancy rate should be identified according to the city status in order to compute trip generated by a person or person trip. The vehicular occupancy covered by each person trip was decided by the Taxi (mini-bus) occupancy rate; as a result showed in Table 4.28, HBW trips had a higher public bus vehicular occupancy rate than HBNW and NHB trips. This demonstrated that, whereas HBW trips were recognized as Adama city's primary trip reason, NBW trips had a high occupancy rate.

During the conversion of person trip in to vehicular trip, Taxi (mini-bus) occupancy rate has been used as variable. Since the study covered transportation system trip by person should be converted to trip by vehicle, in this case Taxi (mini-bus) is the vehicle. According to the result showed in Table 4.29 TAZ 2, 4, 6, 8, 9, and 12 had high vehicle trip-production relatively to other TAZs. This showed that these TAZs had more of residential character than other, since its dwellers tended to be attracted by other TAZ through different facilities and activities provided.

Trip Generation: Trip Attraction

Trip attraction predicts the number of trips to be attracted to (end in) each zone. The attractiveness of a zone is related to the size and type of land uses that are the destination of trips. The majority of such land uses are non-residential land, such as services, retails, recreations, etc. The trip attraction is normally expressed as the number of vehicle trips per household or per unit area of non-residential land use. In addition to the TAZ characteristics, the number of trips attracted to a zone is related to the attractiveness of other zones in the city. All trip attracting zones in a region compete for the number of trips produced in the city.TAZ that are more attractive will attract more trips than the zones that are less attractive.

In order to operationalize this for this study, the seven land uses into four categories. Residential was left as its own category; pure and mixed retails, shops and trades were collapsed into a second category as commercial to represent commercial and employment destinations within each zone; administration, infrastructures, schools, hospitals, private and governmental institutions were collapsed into third category as service to represent social services and facilities within each zone and green space, open spaces and environmental sensitive areas were collapsed in to fourth category as recreation to represent opportunities for leisure.

In order to calculate trip attraction the study used data collected from survey questioner based on trip purpose and land use file of Adama city from Adama land administration office. Regression analysis is used as shown in Table 4.30 to derive the trip attraction rate using taxi (mini-bus) for each category.

TABLE 4. 29: Trip attraction rate for Taxi (mini-bus)

Trip purpose	HBW	HBNW	NHB
Selected responders(unit)	1.51	5.62	2.59
Residential(hec)	10.76	36.2	10.8
Commercial (hec)	0.73	3.02	1.21
Service(hec)	3.04	9.22	4.46
Recreation (hec)	6.33	22.12	4.93

Vehicle trips attracted to each zone are then calculated as:

$$\mathrm{TAR} = \mathrm{Nhh} * \mathrm{TARR} \qquad \text{Eq(22)}$$

Where,

TA_R= Vehicle Trip Attractiveness of the zone by responders;

Nhh— Number of responder in the zone;

TAR_R— Trip Attraction rate by responders;

Trips attracted by Non- residential are calculated from the size of Non- residential land use and the Non- residential trip attraction rates.

$$\mathrm{TANR} = \mathrm{NR} * \mathrm{TARNR} \qquad \text{Eq(23)}$$

Where,

TA_N = Vehicle Trip Attractiveness of the zone;

A_{NR}= Non-Residential Land use size in the zone;

TAR_{NR} = Trip Attraction Rate of the Non-Residential land use;

TABLE 4. 30: Trip Attractiveness by land use and trip purpose using Taxi (mini-bus)

	Trip Attraction(Taxi) by Trip Purpose													
Trip-purpose	1	2	3	4	5	6	7	8	9	10	11	12	13	14
HBW	12710	2201	2707	2360	2367	249	323	465	3011	1662	1380	652	1042	7082
HBNW	43317	7429	9119	7935	7875	861	1097	1570	10117	5594	4645	2200	3502	23999
NHB	11785	2216	2717	2420	2531	294	360	543	3088	1702	1414	720	1092	6785
Total	67812	11846	14543	12715	12773	1404	1780	2578	16216	8958	7439	3572	5636	37866

From trip generation calculation, trip attraction is one of the input for the development of travel demand model. In order to calculate trip attraction level of a given TAZ, trip attraction rate , number of sample taken from each TAZ, land use coverage of each type in hectare of each given TAZ has been used as variable. In order to determine the trip attraction rate for taxi (mini-bus) users trip making purpose, number of sample taken from each TAZ, land use coverage in hectare (residential, commercial, service, and recreation) has been used as dependent and independent variables as shown in Table 4.30.

According to the result showed in Table 4.31 TAZ 1, 2, 3, 4, 5, 9, and 14 had high trip-attraction level relatively to other TAZs. This implied that these TAZs had more activity attraction characteristics which pull users from their dwelling toward to them due to the facility and activities provided.

Generally, the result showed in Table 4.32 that TAZ 02, 06, 07, 08, 09, and 12 are relatively common trip production zones in Adama city in regard to both Public bus and Taxi (mini-bus) transport systems. While, the result showed in Table 36 that TAZ 01, 02, 03, 04, 05, and 14 are trip attraction zone in Adama city in regard to both Public bus and Taxi (mini-bus) transport systems.

Trip production by public transport in Adama City

TABLE 4. 31: Total trip production using public transport system in Adama city in a given TAZ

TAZ / Trip-purpose	Total Vehicle trip by Trip Purpose By both pubic bus and Taxi(mini-bus)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
HBW	38	56	36	57	37	63	44	65	46	44	35	61	44	43
HBNW	36	71	30	47	35	67	48	65	53	36	77	77	41	41
NHB	36	54	35	47	39	69	50	67	47	46	61	61	41	44
Total	110	182	100	151	112	199	143	198	177	126	147	173	127	128

Trip attraction by public transport in Adama City

TABLE 4. 32: Total trip attractiveness using public transport system in Adama city in a given TAZ

TAZ / Trip-purpose	Trip Attraction by Trip Purpose By both public bus and Taxi(mini-bus)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
HBW	12719	2210	2721	2364	2374	265	340	479	3023	1670	1394	668	1046	7094
HBNW	45884	7953	9144	7975	7902	901	1124	1637	1110	5631	4688	2250	3526	24040
NHB	11792	2224	14556	2423	2537	310	377	556	1712	1709	1428	736	1096	6795
Total	70395	12387	26421	12762	12813	1476	1841	2672	5845	9010	7510	3654	5668	37929

4.1.2.3. *<u>Mode of choice for Public transport</u>*

According to the survey process responders were required to express their perception about their mode of choice regarding level of service such as Convenience, Cost, Mode frequency and their reason behind their choice. The result were analyzed using statistical descriptive frequency analysis and Cross- tabulation method.

Reason behind their choice

In a Table 4.34 below, presented the reason behind public transport users' mode choice. According the result shown below taxi (mini-bus) get the high level of choice than public bus through criteria of speed, availability, cost, level of comfort.

TABLE 4. 33: Reason to choose Public transport as the major mode of travel from responders

Major mode of travel * Reason to choose the public transport as major mode of travel Cross-tabulation count								
		Reason to choose the major mode of travel						
		No Option	Best in terms of Cost	Best in terms of Comfort	Most Available	Speed prefere nce	Other	Total
Major mode of travel	Public bus	25	9	5	3	1	21	64
	Taxi	116	48	23	53	48	26	314
Total		141	57	28	56	49	47	378
Percent		37.3	15.08	7.41	14.81	12.96	12.43	100

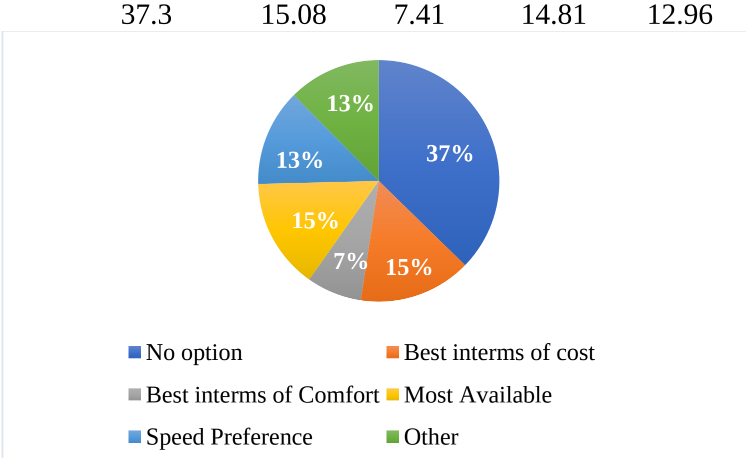


FIGURE 4. 12: Graphical presentation for Reason to choose Public transport as the major mode of travel from responders

Perception about Public Transport Mode Frequency

In a Table 4.35 below, presented the perception of public transport users about public transport mode frequency. According the result shown below taxi (mini-bus) get the high level of frequency than public bus.

TABLE 4. 34: Perception about the public transport Mode Frequency

Major mode of travel * Perception about the public transport Mode Frequency Cross-tabulation						
		Perception about the Mode Frequency				Total
		Very low	Low	High	Very high	
Major mode of travel	Public bus	6	22	20	15	64
	Taxi	39	118	116	41	314
Total		45	140	136	56	378
Percent		11.9	37.04	35.98	8.2	100

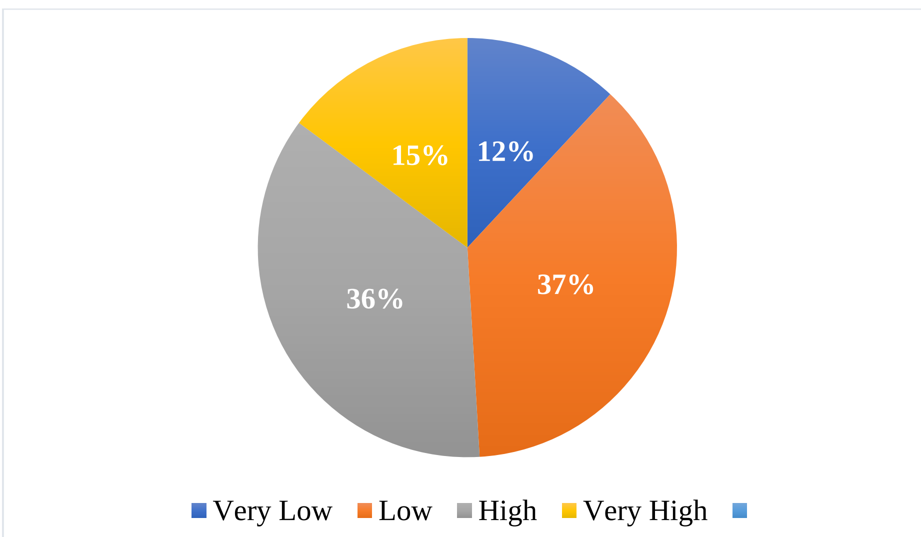


FIGURE 4. 13: Graphical presentation Perception about the public transport Mode Frequency

Perception about Public Transport Convenient

In a Table 4.36 below, presented the perception of public transport users about public transport mode regarding to level of comfort of convenient. According the result shown below taxi (mini-bus) get the high level of convenient than public bus.

TABLE 4. 35: Perception about the Mode Convenient

Major mode of travel * Perception about the Mode Convenient Cross-tabulation						
		Perception about the Mode Convenient				
		Inconvenient	Less Convenient	Convenient	Very convenient	Total
Major mode of travel	Public bus	27	16	18	2	64
	Taxi	51	122	121	19	314
Total		78	138	139	21	378
Percent		20.63	36.51	36.77	5.82	100

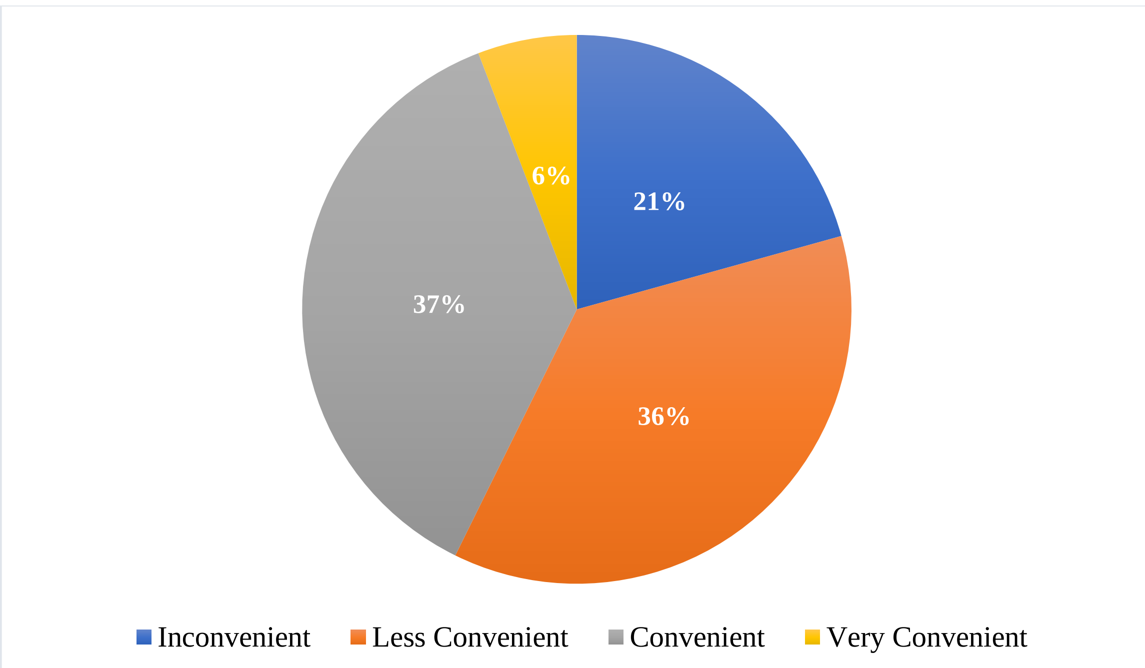


FIGURE 4. 14: Graphical representation of Perception about the Mode Convenient

Perception about Public Transport Travel Cost

In a Table 4.37 below, presented the perception of public transport users about public transport mode regarding to travel cost. According the result shown below public bus get the low travel cost as result public bus is more preferable than taxi (mini-bus).

TABLE 4. 36: Perception about the travel cost

Major mode of travel * Perception about the travel cost of public transport Cross- tabulation

Count

		Perception of the travel cost				
		Very costly	Costly	Less costly	Not costly	Total
Major mode of travel	Public bus	7	10	10	37	64
	Taxi	36	125	90	63	314
Total		43	135	100	100	378
Percent		11.38	35.71	26.46	26.46	100

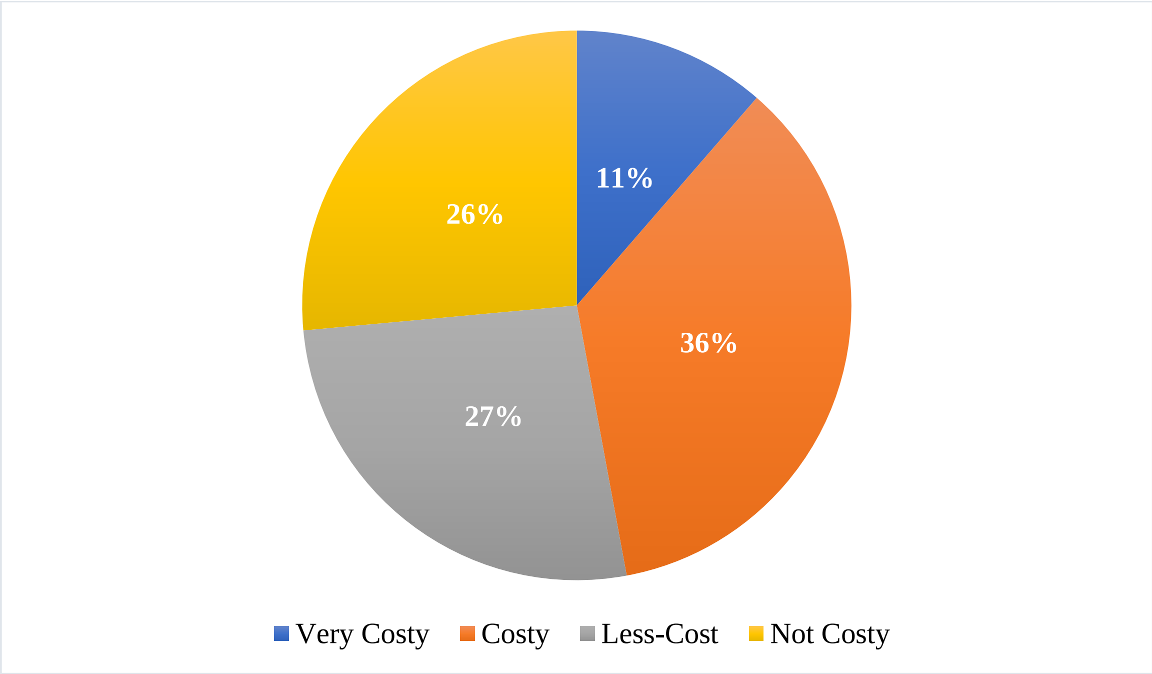


FIGURE 4. 15: Graphical representation of Perception about the travel

Utility Function and Multinomial Logit (MNL) model

The utility function and Multinomial Logit (MNL) model are used as a method of analysis for the mode of choice for public transport specifically public buses and taxis. The two-mode choices are public bus and taxi (mini-bus). The three independent variables are the cost of travel, travel time, and comfort level. While Mode choice of users is considered as dependent variable. The modes associated with shorter travel times, lower costs, or more convenience are likely to have high utility. The coefficients for travel cost and travel time are negative and for comfortable level is positive. The sign of the coefficients reflect the change direction of the independent variables. The negative value implies that as the value of the independent variable increases, the utility will decrease. In the case of travel cost and travel time, travelers tend to use the travel mode that costs less and uses less travel time. For the third variable, people would give the travel preference to the mode that is more flexible.

In a Table 4.38 below it is presented the independent variable values table for both public bus and taxi (mini-bus) users.

TABLE 4. 37: Independent variables value for utility function

Travel mode	Travel Cost(x_1) (Birr)	Travel Time(x_2) (Min)	Comfort Level(x_3)
Public Bus(B)	2	25	5
Taxi (T)	5	20	10

In a Table 4.39, below presented the coefficients table for public bus users showing how the dependent variable major mode choice was related with independent variables: travel time, travel cost, mode comfort level.

TABLE 4. 38: Test of model for public bus users

Z Coefficients [a]						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.642	.575		2.856	.000
	Average Travel Time	-.158	.120	.165	1.315	.000
	Average Travel Cost	-.184	.121	.190	1.521	.000
	Mode Comfort Level	.067	.141	-.060	1.477	.000

It is referred by the t-value or the p-value under significant; the value of (t= 1.315, 1.521. and 1.477, t≠0) or (0.000 shows $p < 0.05$, of 95% of confidence level) show that the variables are significant. The negative of t-values represents an inversely relationship between the specific dependent and independent variable.

In the Table 4.40 below, presented the coefficients table for the taxi (mini-bus) users showing how the dependent variable major mode choice is related with independent variables: travel time, travel cost, mode comfort level.

TABLE 4. 39: Test of model for taxi (mini-bus) users

		Coefficients [a]				
		Unstandardized Coefficients		Standardized Coefficients		
	Model	B	Std. Error	Beta	t	Sig.
1	(Constant)	1.799	.231		7.789	.000
	Average Travel Time	-.061	.053	-.066	1.139	.000
	Average Travel Cost	-.001	.055	-.001	1.023	.000
	Mode Comfort Level	.017	.027	.035	1.619	.000

It is referred by the t-value or the p-value under significant; the value of (t=1.139.1.023. and 1.619, t≠0) or (0.000 shows $p < 0.05$, of 95% of confidence level) showed that the variables was significant. The negative of t-values represents an inversely relationship between the specific dependent and independent variable.

The general form of the utility function with for this study variables is:

$$U = ao + a1x1 + a2x2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. + anxn$$

Eq(24)

Where,

U= the utility of the transportation mode; $U = a_0 + a_1x_1 + a_2x_2 + a_3x_3 \ldots\ldots$

B_0=constant x_1= coefficient for Travel Cost

x_2= coefficient for Travel Time x_3= coefficient for Comfort level

$a1$ =Weight for Travel Cost; $a2$ =Weight for Travel Time;

$a3$ =Weight for Comfort Level;

Inserting the variable values into Eq. (13), utility function for public bus (UB) and Taxi (Mini-Bus) (UT) was calculated:

$$\begin{aligned} UB &= a_0 + a_1x_1 + a_2x_2 + a_3x_3 \\ &= 1.642 - (0.184\times2) - (0.158\times25) + (0.067\times5) \\ &= -2.341 \end{aligned}$$

$$\begin{aligned} UT &= a_0 + a_1x_1 + a_2x_2 + a_3x_3 \\ &= 1.799 - (0.001\times5) - (0.061\times20) + (0.017\times10) \\ &= 0.744 \end{aligned}$$

In the mode choice model, there were many ways to establish the relationship between the proportion of travelers using each travel mode and its utility. One such model is the Multinomial Logit (MNL) model.

According to the MNL model, the probability that mode choice k was made under the assumption of utility maximization is the fraction of the total utility. This probability was expressed as:

$$\mathrm{Prob(k)} = \frac{\mathrm{Exp(Uk)}}{\sum_{k=1}^{n} \mathrm{Exp(Uk)}} \qquad \text{Eq(25)}$$

Where,

Prob(k) = the Probability of mode k being selected;

Uk = the Utility value for mode k;

n = Total number of mode choices

Inserting the variable values into Eq. (25), the probability of a choice for public bus (UB) and Taxi (Mini-Bus) (UT) was calculated:

$$\mathrm{Prob(B)} = \ \mathrm{Exp(UB)/(Exp(UB)} + \ \mathrm{Exp(UT)}$$

$$\mathrm{Prob(B)} = \ \mathrm{Exp}(-2.342)/(\mathrm{Exp}(-2.341) + \ \mathrm{Exp}(0.744)$$

$$\mathrm{Prob(B)} = \ 0.043636 = 4.3636\%$$

$$\mathrm{Prob(T)} = \ \mathrm{Exp(UT)/(Exp(UB)} + \ \mathrm{Exp(UT)}$$

$$\mathrm{Prob(T)} = \ \mathrm{Exp}(0.744)/(\mathrm{Exp}(-2.341) + \ \mathrm{Exp}(0.744)$$

$$\mathrm{Prob(B)} = \ 0.956363 = 95.6363\%$$

The model result showed that the probability of choice for public bus in Adama city is found to be 4.3636% and for the taxi (mini-bus) is found to be 95.6363%. Use of the multinomial logit model ensured that the sum of trips allocated to all modes of transportation always equal to the total trips.

4.2. Discussion

Public Transport System

Public transportation is a transportation service that is available to the general public and that carries passengers to destinations at a low cost. . The mode is an essential component, especially for low-income groups. Public transportation or mass transit includes a system that is available for use to all people that are willing to pay the established fare. These modes operate on fixed routes and schedules.

The high density of activities makes it necessary for high capacity modes of transport in cities because they are more economical, more energy-efficient, and require much less space than private cars. Moreover, public modes of transportation provide service for all persons while cars can only be used by those who own and can drive them.

The most common public transports in Adama city are public buses and taxis (mini-bus). The public transportation system is organized and monitored by the governmental sectors such as the Adama city transport office and Adama city municipality office. This shows that the public transport service is in a well -organized and manageable situation in regard to the transport planning system through accountability and transparency.

Public transport Route

In Adama city the spatial coverage of public transport service routes for both public buses and taxis (min-bus) is low. From total street network spatial coverage of 921.83 km, 41.926 km is covered by public transportation, which is 4.575%. The low spatial coverage of public transport routes is one of the main reasons for the limited number of public transport vehicles distributed in Adama city. There are 13 buses and 500 taxis (mini-bus) currently giving service in Adama city. This shows that the distribution of public transportation is limited by the low spatial coverage of public transport routes and the low number of public transport vehicles. Public transport route origin and destination indicate that there is common and fixed destination zone for both public buses and taxi routes.

Franko and Abba Gada or TAZ 8 AND TAZ 6 respectively are the common destination for both public buses and taxis routes. This shows that TAZ 6 and TAZ 8 have a high activity rate with dominant land use character which attracts travelers for many reasons, meaning that TAZ 6 and TAZ 8 are CBDs having high population density value and land use dominant with commercial and service character rather than being area for living purpose. TAZ with high population density indicates high number of dwelling and activity meaning that this TAZ attracts high HBW, HBNW, NHB trips for both public buses and taxis users.

According to the public transport route evaluation stated by (Benn, 1995), space between public transport routes should be 0.805 km apart and 1.6 km apart for high and low population density areas respectively. In case of Adama city average space between public transport routes is 1.868 km apart, which is below the standard mention above. This shows that when the space between routes is wider, public transport service is not enabled to address all residents or users in Adama city. The result indicate that more than 90% of the distribution of public transport system don't consider the integration between population m density, mobility or activity along land use character of Adama city, which are the key variable for improving the quality of public transport system. This will lead the residents of Adama city to high automobile dependency, which is very huge obstacle for the further pedestrian –friendly development of the city because of lack of accessibility and permeability towards to the distribution of public transport service.

Travel time, Carrying Capacity and Cost

TC for a single trip for every route trip using the public bus is very appropriate and affordable in relatively to the income of residents of Adama city. But when regarding to the TT, during the site observation it has been concluded that public bus consumes high TT especially on the route from Bollo to Geda (posta), specifically the TT on this route will be increased on Thursday and Friday due to process of customs located in Bollo (duket) site. When the TT of a given route is high, the waiting time for the next trip on the route stopovers will also increase which is out of the standard.

According to (UN Inhabitat, 2015), the standard waiting time for public transport at a given station should be 5min, but according to data collected from field observation and data from the 64 respondents who tends to use public bus as a mode of transport for their trip shown Table1.14 below, the average waiting time for 18 respondents was less than 10 min, for 23 respondents WT was 11-20 min, for 11 respondents WT was 21-30 min, for 12 respondents WT was more than 30 min. Generally, the study concluded that WT for the public bus in Adama city is 15-20 min, which is the below the standard.

Travel cost for a single trip for every route trip using the Taxi (mini-bus) is not very appropriate and affordable in concern to the income of residents of Adama city. Specially during the field observation, the study find out that there are difference on cost on travel depending on travel day season, meaning the travel cost will be double at night time(after 1;30PM) that of the day time season. But when we come to the travel time, during the site observation it has been concluded that Taxi (mini-bus) consumes good or moderate travel time in contrast to that of Public Bus.

When the travel time (TT) of a given route is high, the waiting time for the next trip on the route stopovers will also increase which is out of the standard. According to (UN Inhabitat, 2015), the standard waiting time for public transport at a given station should be **5min,** but according to data collected from field observation and data from the 314 respondents who tends to use the Taxi (mini-bus) as a mode of transport for their trip shown Table 20 below, the average waiting time for 45 respondents was less than 10 min, for 113 respondents WT was 11-20 min, for 91 respondents WT was 21-30 min, for 65 respondents WT was more than 30 min. Generally, the study concluded that WT for the public bus in Adama city is 20-25 min, which is the below the standard.

Stopover

According to stop spacing standard stated on the public transport route evaluation standard (Benn, 1995) for residential and commercial areas is 4 stops/mile. The stopovers or stations for the public transportation in Adama city is not legally located but both public bus and taxi (minibus) tends to stop and unload the travelers depending on their interest and most of the time depending on their trip purpose location which is out of standards.

Travel demand Model

According to the result from the survey data from total sample of public transport users, 64 of them were public bus users while 314 of them were taxi (mini-bus) users. From this result the study determined that in Adama city Taxi (mini-bus) is more preferable public transport system. In transport demand model preparation process there were basic variables that has been taken into consideration regarding to the data collection. As result public transport users' income level, trip making purpose, travel cost, travel time and level of comfort were taken as parameter for the production of the model.

Trip Generation-Trip Production and Trip Attraction

According to the result obtained from the survey data, trip purpose analysis shows that HBW trip with coverage of 49% can be taken as the main reason for making the trip by public bus user responders. This show that respondent tends to leave their dwelling area in order to work and earn income, meaning that the working environment is not provided with human-oriented development and with long travel distance.

But according to (UN Inhabitat, 2015), services and facilities should be within walking distance of 500m. This shows that Adama city development strategy doesn't consider human-based transit orient development. Next to the HBW trip, the NHB trip with coverage of 45% is considered as the second major trip making the reason for public bus users.

The result from trip purpose analysis show that HBW trip covers 61%, it covers the large portion as reason for making trip by Taxi (mini-bus) user responders. This show that respondent tends to leave their dwelling area in order to work and earn income, meaning that working environment are not provided with human oriented development and with long travel distance.

But according to (UN Inhabitat, 2015), service and facilities should be within walking distance of 500m .this show that Adama city development strategy don't consider human based transit orient development. Next to HBW trip NHB trip with coverage of 29% is considered as the second major trip making reason for public bus users.

Using the regression analysis method trip production rate was determined by taking trip making purpose and income level of public transport users as parameter variables. From the calculation that has been done, this study result determined that TAZ 02, 06, 07, 08, 09, and 12 are relatively the common trip production TAZ in Adama city. This shows that these TAZs is dominated with a high portion of residential activity, when the dwellers tend to live and move to other TAZ in Adama city for different activity such as work, school, shopping, hospital and other services.

Using the regression analysis method trip attraction rate was determined by taking trip-making purposes and four land-use categories of Adama city as parameter variables. From the calculation that has been done, this study result determined that TAZ 01, 02, 03, 04, 05, and 14 are the common trip attractions TAZ in Adama city. This shows that these TAZs is dominated with a high portion of different activity such as work, school, shopping, and other than residential activity, where the dwellers tend to live. This travel demand model gave direction determine the land use mix level of Adama City on the second Objective of the study.

Mode of choice for Public transport

According to the data collected from the public transport users, their perception toward public transport in regards to its cost, travel time and level of comfort. According to the result, this study concluded that taxis (mini-bus) have a high probability of choice in regards to its travel time and level of comfort or convenience than public bus, while public buses have a greater probability of choice in regard to its travel cost. This means that the low income of Adama city residents is the main group of public bus users but this group faces low quality of comfort and longer travel time. This shows that the public transport system of Adama city doesn't take low-income groups into consideration in regard to the level of service of both public bus and taxi (mini-bus) facilities.

Utility Function and Multinomial Logit (MNL) model

In addition to the result from the data collected from survey in regarding to the perception of public transport users. This study examined and calculated the level of service and public transport quality in relation to the probability of modal choice using utility function and multinomial logit (MNL) model.

The model considered transportation system, traveler characteristics, and journey in terms of travel cost and comfort level, major trip making purpose, and travel time respectively as dependent and independent variables. From this, it is concluded that travel time and travel cost are inversely related to the utility function of a given public transport mode, while the level of comfort has a direct relationship with the utility function (probability of being chosen) of a given public transport mode. According to the final result of the model in the Adama city public transport system, taxis (mini-bus) have a 95.6363% of probability of being chosen, while public buses have a 4.3636% of probability of being chosen. This indicates that taxis (mini-bus) is the most preferable public transport system in both public transport users' perception evaluation and utility function and multinomial Logit (MNL) model.

4.3. To measure land use mix level of Adama city

Land-use mix is a component which plays a pivotal role in planning and public policymaking. This study used secondary data of land use proportion of Adama city collected from the land administration office of Adama city in order to measure the land use mix degree and land use diversity in TAZ (kebele) level ,using different land use mix indices such as ENI, ALT or generally Shannon diversity index method .The study tried to preserve the continuity with the theory behind land use mix and only compare measures that differ in method, four categories were defined from the land use dataset. The underlying assumption of this study identified that the shorter travel distances allow active transportation choices can be generated by the mixing of complementary land uses. In order to operationalize this for this study, the study divided the seven land uses into four categories. Table 4.41 below showed the land use classification in Adama city in hectare and in percent.

TABLE 4. 40: Land use classification of Adama city

Source: Land Administration Office of Adama City

TAZ	Land Use Type Area(Hec)			
	Residential	Commercial	Service	Recreational
01	732.82	2.21	54.94	730.93
02	149.82	12.57	47.57	62.26
03	216.28	7.23	32.48	39.95
04	204.23	11.63	27.98	6.19
05	156.109	7.64	135.14	38.13
06	17.15	11.47	1.51	0
07	33.94	7.81	5.87	1.67
08	30.67	19.26	3.15	0
09	197.68	25.24	112.56	79.46
10	129.72	10.66	30.28	21.21
11	109.45	12.43	23.88	15.43
12	49.62	14.34	19.86	0.65
13	79.19	6.96	28.36	10.61
14	337.6	11.64	205.825	440.993

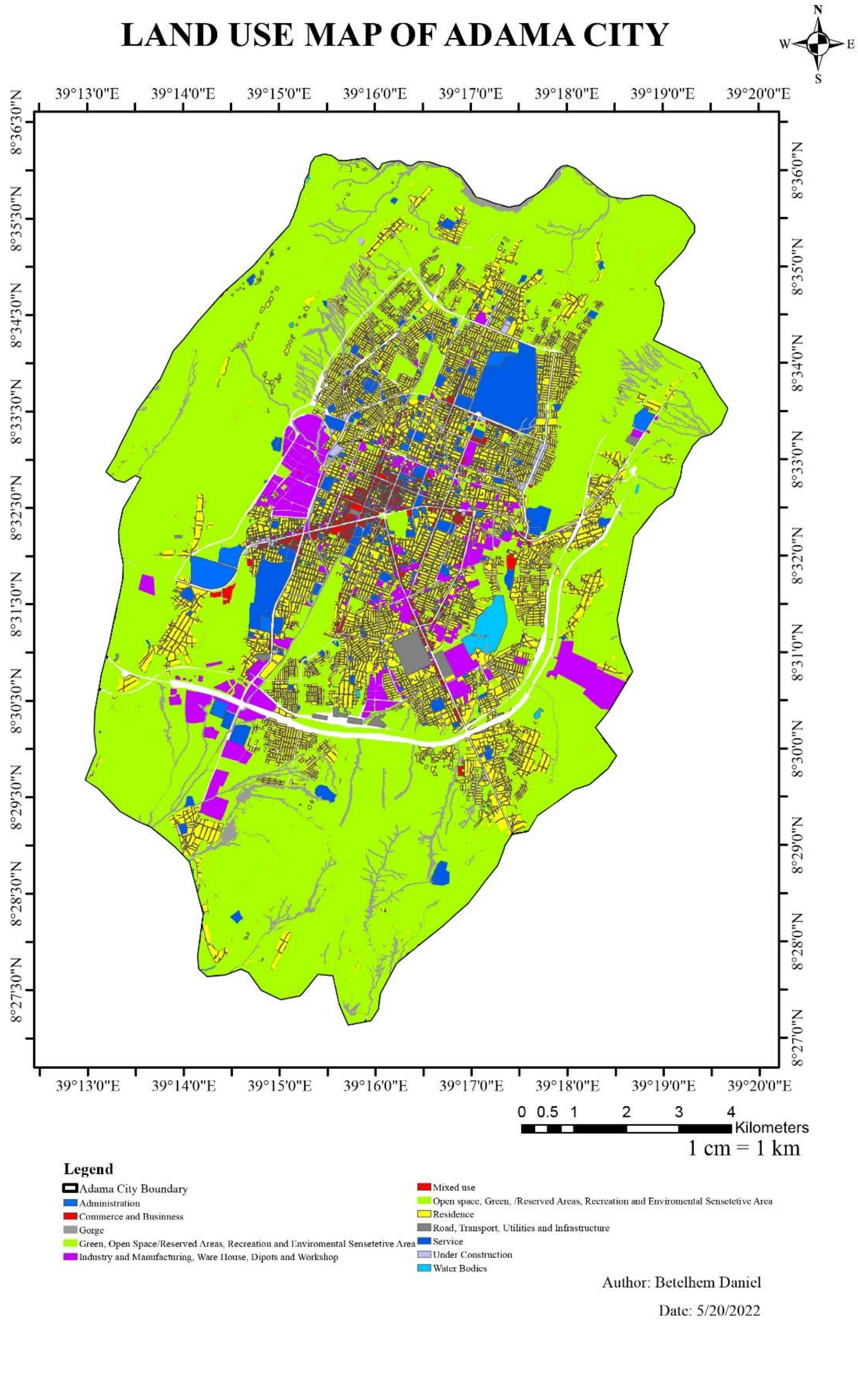
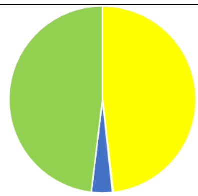
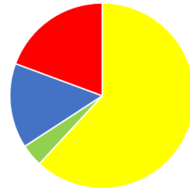
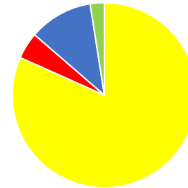
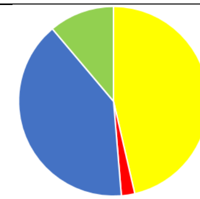
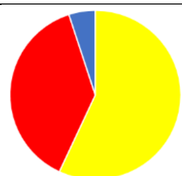
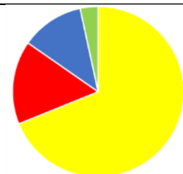
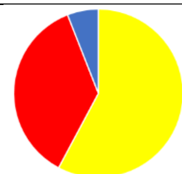
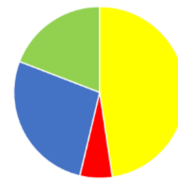
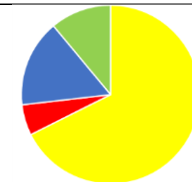
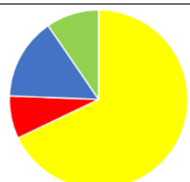
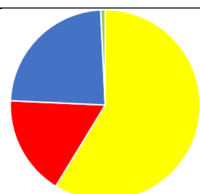
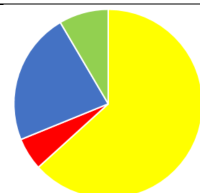
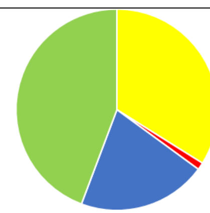


FIGURE 4. 16: Land use map of Adama city

Source: Land Administration Office of Adama City

TAZ	1	2	3	4	5
Pattern					
Proportion	Residential:48.18% Commercial:0.15% Service:3.61% Recreational:48.1%	Residential:55.04% Commercial:4.62% Service:17.47% Recreational:22.87%	Residential:73.08% Commercial:2.44% Service:10.98% Recreational: 13.5%	Residential:81.68 % Commercial:4.65 % Service:11.19 % Recreational: 2.48%	Residential:46.32 % Commercial:2.27 % Service:40.1 % Recreational: 11.13%
TAZ	6	7	8	9	10
Pattern					
Proportion	Residential:56.9 % Commercial:38.1% Service:5.01 % Recreational: 0%	Residential:68.86 % Commercial:15.84% Service:11.91 % Recreational: 3.39%	Residential:57.78 % Commercial:36.28 % Service:5.93 % Recreational: 0%	Residential:47.64 % Commercial:6.08 % Service:27.13 % Recreational: 19.15%	Residential:67.61% Commercial:5.56 % Service:15.78 % Recreational: 11.1%
TAZ	11	12	13	14	
Pattern					
Proportion	Residential:67.9 % Commercial:7.7 % Service:14.81 % Recreational:9.57%	Residential:58.74% Commercial:16.98 % Service:23.51 % Recreational: 0.77%	Residential:63.29 % Commercial:5.56 % Service:22.67 % Recreational: 8.48%	Residential:34.24 % Commercial:1.18 % Service:20.87 % Recreational: 44.72%	

Key: Residential: Commercial: Service: Recreational:

TABLE 4. 41: TAZ Land use classification

Main Category	Sub type-1	Sub type-2	Detail
Residential	Residential	Residential	Accommodations
Non-residential	Commercial	Market, Retails and Business Facilities	Business services, finance and insurance, information media, retail trade, wholesale trade.
	Service	Institutions and Facilities	Admin and support services, education and training, health care and social assistance, public administration, safety, telecommunications; manufacturing, food and beverage services,
	Recreational	Green area and Open spaces	Green space, open spaces and environmental sensitive areas

TABLE 4. 42: Land use classification

The table below showed the land use mix indices independent variable value for each TAZ in Adama city.

TABLE 4. 43: Land-use mix level of each TAZ

TAZ	Shannon Land-use diversity entropy index (ENI)	Evenness of the index (ALT)
01	0.623	0.45
02	0.540	0.39
03	0.554	0.4
04	0.831	0.6
05	0.900	0.65
06	0.859	0.62
07	0.887	0.64
08	0.845	0.61
09	0.817	0.6
10	0.859	0.62
11	0.887	0.64
12	0.85	0.62
13	0.887	0.64
14	0.609	0.44

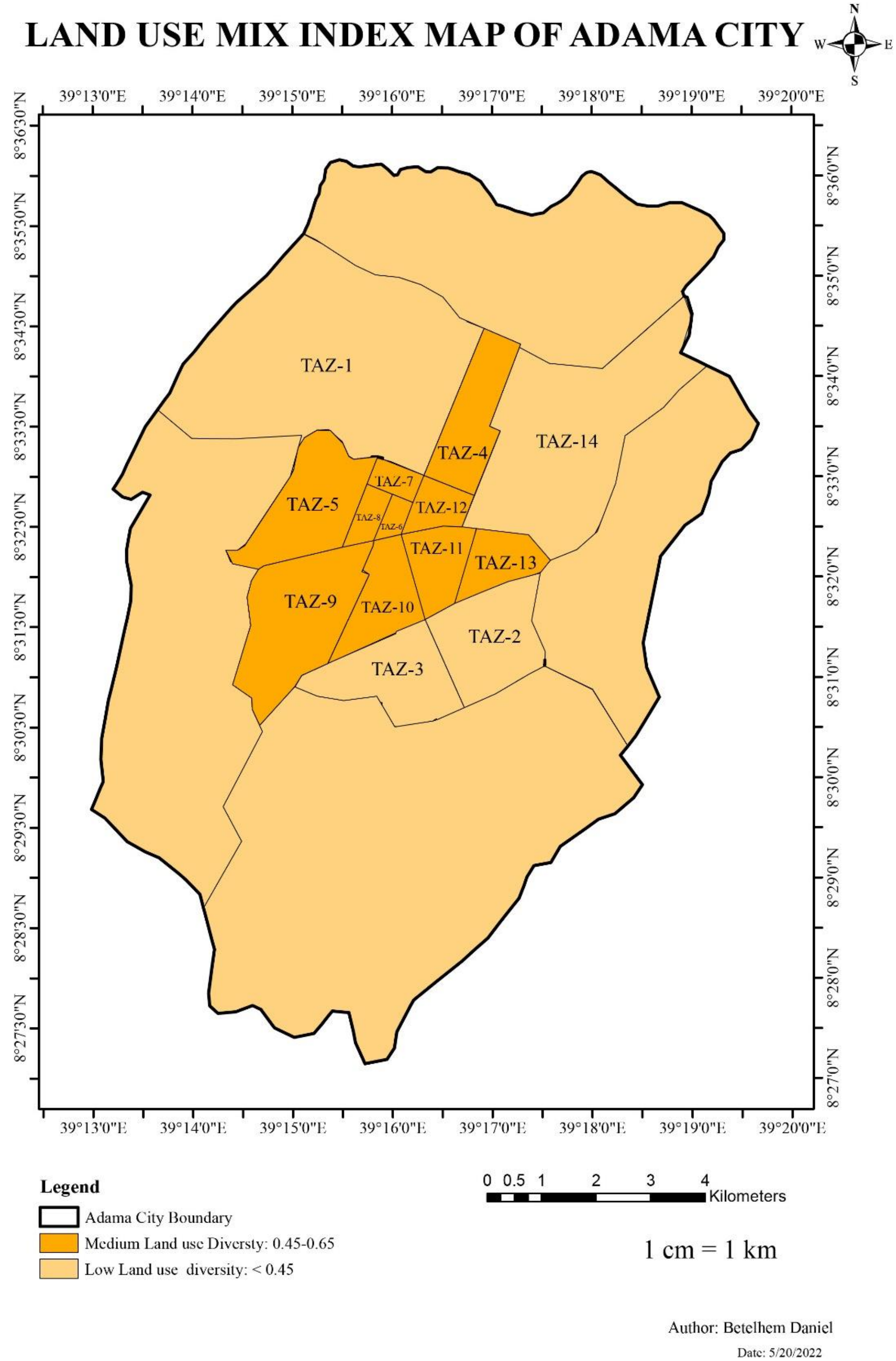


FIGURE 4. 17: Land use mix index map of Adama city

Source: Author

The result showed that according to the land use index value, land use diversity or land use mix of each TAZ has been identified. According to (Konopinski, 2020), land use mix index is classified as: a value less than 0.45 with low diversity, a value of 0.45-0.65 as medium diversity and value of >0,65 as high diversity area. As a result of this, the study concluded that TAZ 1, 2, 3, and 14land-usew land-use diversity, while TAZ 4, 5, 6, 7, 8, 9, 10, 11, 12, and 13 have medium land-use diversity.

Area index

According to (Hess.et.al, 1780), the Area index for trip is the ratio of the work areas in the zone to the work areas in the whole study area. The work areas included in this study were commercial area, service area, and Manufacturing area. It was considered that the residential land uses are linked by travel to the work and other areas, thereby incorporating the land use functional complementarity. Land use functional complementarity ensured the consideration of origins and destinations that was likely to be linked by travel. Land use spatial complementarity ensured that the land uses linked with travel were within adequate proximity.

$$AIT = \frac{AWT_I}{\text{Total area of work in Adama city}} \qquad Eq(29)$$

Where: AIT: Area index for trip; AWT_i: Area of work area in TAZ_i ;

The total work area, meaning basic work area group such as commercial, service, and manufacturing covers 930.445 hectare. In which residents of Adama city tended to make trip to access job areas or other facility areas. The table below showed the Area Trip Index of each TAZ in Adama city in order to give understanding between mode choice behavior and amount of particular land use available in the vicinity of the households.

TABLE 4. 44: Area index of trip for each TAZ

TAZ	1	2	3	4	5	6	7
AWT_I (Hec)	57.15	60.14	79.66	39.61	142.78	12.98	13.68
AIT	0.06	0.06	0.08	0.04	0.15	0.01	0.01
TAZ	8	9	10	11	12	13	14
AWT_I (Hec)	22.41	137.8	40.94	36.31	34.2	35.32	217.465
AIT	0.02	0.15	0.04	0.03	0.03	0.03	0.23

TABLE 4. 45: Descriptive statistics for area index for trip

Descriptive Statistics		
Area Index for trip	N	14
	Minimum	0.01
	Maximum	0.3
	Mean	0.0864285
	Std. Deviation	0.088804638
	Variance	0.007886264.
	Skewness	1.46494665
	Kurtosis	1.385971913
	Range	0.29
	Sum	1.21
	Count	14
	Largest(1)	0.3
	Confidence Level (95.0%)	0.051274271

The Skewness and Kurtosis value showed the asymmetry degree of the series and peakness or flatness of the distribution of series respectively. The Area Index for trip had a Skewness value of approximately 1.464, which is >0 meaning that the asymmetry degree of the series was a long right tail and more high value namely positive Skewness. In addition to this Area Index for the trip had a Kurtosis value of approximately 1.385, which was <3 meaning that the peaked curve was flatted-curve with more low values namely platykurtic or negative kurtosis.

Integration of land use with public transport system

In order to understand the integration of land use with public transport system in Adama city, this study examined the integration of the dependent variables and zonal independent variable through the correlation analysis method and also evaluate the significance of the values through the regression analysis. Density and land use mix was focused on as the two primary variables for the characterization of land use in transportation research. As commonly constructed, these variables was not capture well actual development patterns on the ground, thus obscuring a potentially strong relationship between land use and transportation behavior. In addition to land mix and population density, the Area index for trip or travel was used as a variable to determine the integration of land use and public transport system.

TABLE 4. 46: PD, ENT, AND AIT of each TAZ

TAZ	Population Density	Land use mix Index	Area Index for Trip
1	19.161	0.6	0.06
2	63.576	0.79	0.06
3	93.858	0.59	0.08
4	125.166	0.6	0.04
5	86.161	0.75	0.15
6	360.394	0.6	0.01
7	372.096	0.65	0.01
8	316.208	0.6	0.02
9	72.311	0.8	0.15
10	146.29	0.67	0.04
11	183.124	0.69	0.03
12	199.13	0.7	0.03
13	135.307	0.68	0.3
14	32.673	0.78	0.23

Table 4.48 below showed the correlation matrix Pearson correlation coefficient, between dependent and independent variables in order to understand the integration of land use and the public transport system. Pearson correlation coefficient has a value between -1 and 1 where:-1 indicates a perfect negative linear correlation between two variables, 0 indicates no linear correlation between two variables, 1 indicate a perfect positive linear correlation between two variables.

TABLE 4. 47: Correlation matrix coefficient

	Population Density	Land use mix Index	Area Index for trip
Population Density	1		
Land use mix Index	-0.45443	1	
Area Index for trip	-0.52268	0.47887	1

The result showed that, population density with land use mix index was correlated with a coefficient of r= -0.454 showing that population density and land use mix was inversely related to each other, population density with Area index for trip was correlated with a coefficient of r= - 0.522 showing that population density and Area index for trip was inversely related to each other, and land use mix index was correlated with the area index for trip with a coefficient of r= 0.4788 showing that land use mix and Area index for trip was directly related to each other.

The result concluded that the integration between land use and public transport system could be understood through the relationship definition between the population density, land use mix index and area index of trip, when population density of a given TAZ increase, both Area index of trip and land use diversity will decrease, when the land use diversity degree increase the value of area index of trip will also increase meaning that value of AIT near to 1 indicates that there is short travel distance or walking distance activity with in vicinity of the TAZ.

The following represented graphs show the linear association between each variables. The negative sign showed the inverse relationship between variables.

Correlation between Population density and Land use mix index

TABLE 4. 48: Correlation Coefficient-A

	Coefficients	Standard Error	t	Significant
Intercept	625.5632929	266.4114	2.34811	0.006839
Land use mix index	-689.7295896	390.2951	-1.7672	0.001592

It is referred by the t-value or the p-value under significant; the value of (t= -1.767, t≠0) or (0.001 shows p <0.05, of 95% of confidence level) show that the variables are significant. The negative of t-values represents an inversely relationship.

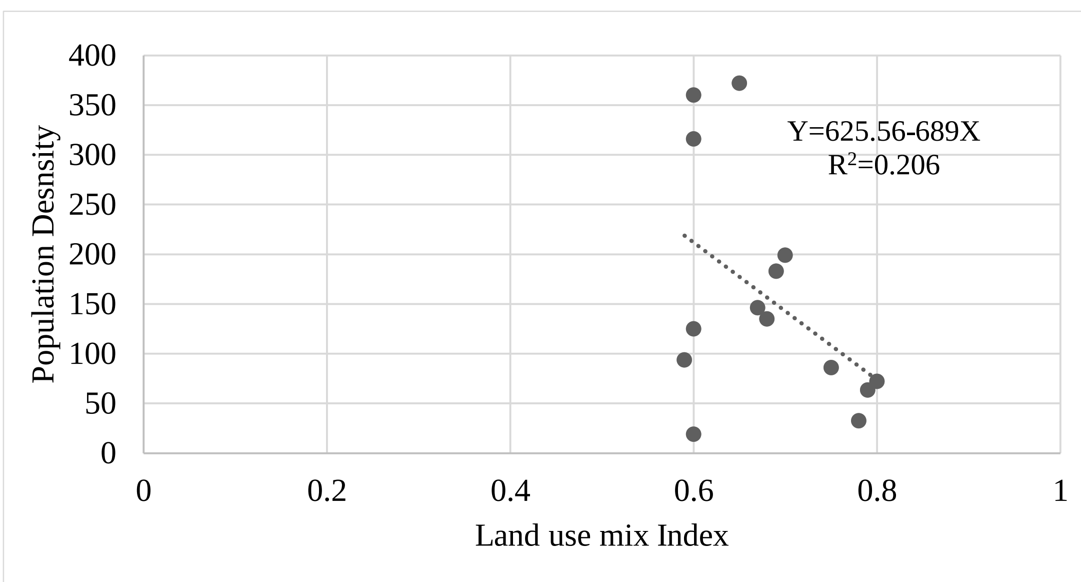


FIGURE 4. 18: Linear association between population density and land use mix index

Correlation between Area index of trip and Land use mix index

TABLE 4. 49: Correlation Coefficient-B

Model	Coefficients	Standard Error	t Stat	Significant
Constant	-0.289570896	0.200162	-1.44668	0.0037
Land use mix index	0.554104478	0.293239	1.889602	0.0022

It is referred by the t-value or the p-value under significant; the value of (t= -1.446, t≠0) or (0.002 shows p <0.05, of 95% of confidence level) show that the variables are significant. The positive of t-values represents a directly relationship.

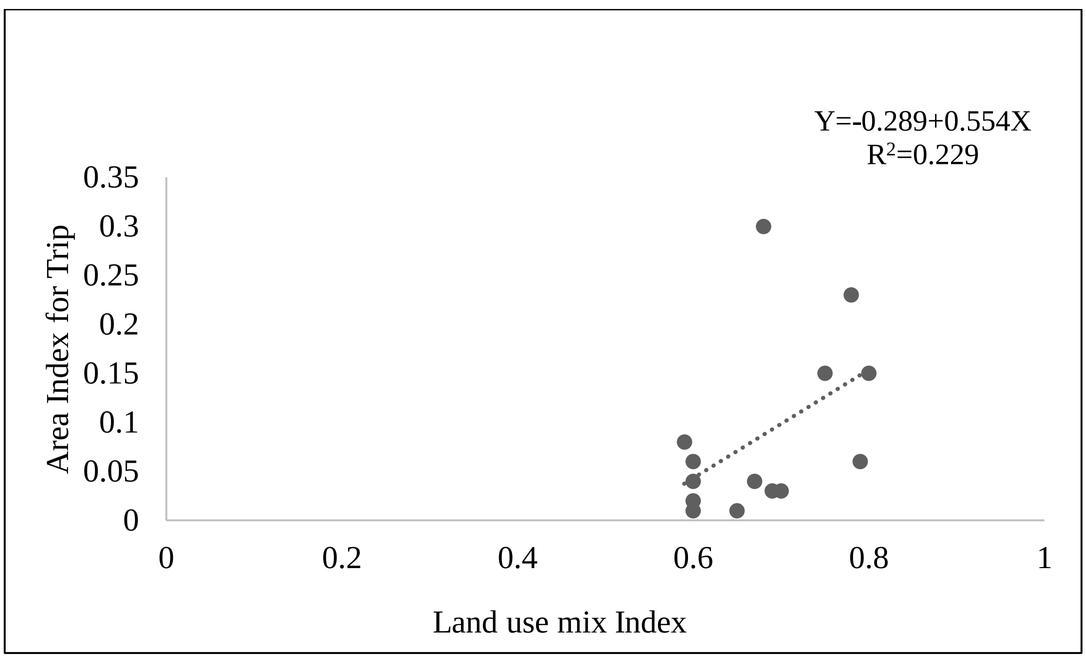


FIGURE 4. 19: Linear association between Area index trip and land use mix index

Correlation between Population density and Area index of trip

TABLE 4. 50: Correlation Coefficient-C

	Coefficients	Standard Error	t	Significant
Intercept	216.7880665	39.263	5.521434	0.000132
Area index for trip	-685.6015955	322.8178	-2.1238	0.00416

It is referred by the t-value or the p-value under significant; the value of ($t= -2.123$, $t \neq 0$) or (0.004 shows $p < 0.05$, of 95% of confidence level) show that the variables are significant. The negative of t-values represents an inversely relationship.

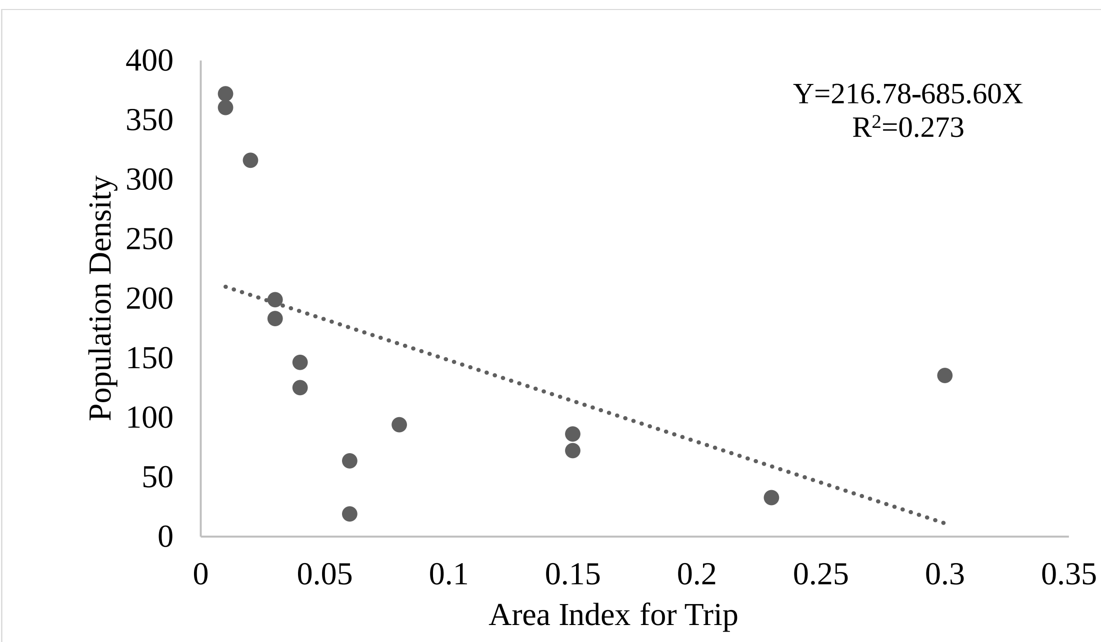


FIGURE 4. 20: Linear association between population density and Area index for index

The result concluded that the integration between land use and public transport system could be understood through the relationship definition between the population density, land use mix index and area index of trip, when population density of a given TAZ increase, both Area index of trip and land use diversity will decrease, when the land use diversity degree increase the value of area index of trip will also increase meaning that value of AIT near to 1 indicates that there is short travel distance or walking distance activity with in vicinity of the TAZ.

4.4. Discussion

The land-use mix index is a way to quantify the mixture of land-use patterns. Mixing land use provides the possibility of locating homes, jobs, shopping, and public services close together, which may help public transport users overcome dependency on vehicle use and promote non-motorized transit mode sharing (public transit, walking, and cycling) in neighborhoods. The benefit of mixed land-use is the ability to locate multiple types of function (residential, commercial, institutional, and recreational) within a walkable or cycling-friendly distance (Liu.et.al, 2021).

First, land-use policies highlighted that mix-use design is an effective way to promote non-automobile travel modes (Lung.et.al, 2013). (Goodman.et.al, 2014), suggested that mixed land use, as a strategy, has a significant relationship with walking at the micro level. Furthermore, other studies mentioned a positive association of active commuting, accessibility, and walkability through mixed land use (Cai.et.al, 2017).

There are several directions for the quantitation of land-use mix. One way is the Shannon diversity entropy index applied for the ecological species' diversity analysis while other way is the quantification of land-use mix degree and exploration of the correlation between the built environment variables in order to determine both land use mix and its integration with transport system (e.g., urban density, distance, destination accessibility, and the transportation network structure) and personal trips in cities (Linglin.et.al, 2018). Cervero and Kockelman, (Linglin.et.al, 2018), discuss the relationship between density, travel demand, and land-use diversity in their findings in the 1990s. The evidence they present on San Francisco indicates that compact development has a substantial influence on personal business trips. Density, diversity, and design (the 3Ds) affect travel demand and mode choice. For instance, the high level of land-use mix will promote the pedestrian mode choice of non-work trips. (Kang.et.al, 2012), questioned the relationship between commuting mode choice and density, diversity, design, destination accessibility, distance to transit (the 5Ds) in 2018.

The results established that density and diversity of land-use affect mode choice and reduce the individual mile travel (VMT) and station-based average travel distances (ATDs).Heinlein et al. and Yang et al. stated that mixed land use is a factor contributing to shortening travel distances and has a positive effect on cycling. Yang et al. also considered the impact of terrain slope and the availability of cycling paths on cycling behaviors with respect to land-use mix. Finally, the land-use mix has also been related to neighborhood satisfaction, neighborhood crime, and housing price.

In order to implement land use mix index measurement the seven land use category of Adama city was sub categorized in to four main land use categories. According to the (Konopinski, 2020), land use mix index value is classified in to three group in determining the land use diversity level. The result from land use mix measurement of Adama city showed that TAZ 1, 2, 3, and 14 have a value of below 0.45, while TAZ 4, 5, 6, 7, 8, 9, 10, 11, 12, and 13 have a value of between 0.45-0.65. This indicates that more than half of TAZ (kebele) have low land use mix level.

The value of land use mix level indicate the degree of balance spatial distribution of activities throughout a given a TAZ. Low value of land use mix index below 0.45 show that TAZ have one dominant use or above half portion of the TAZ is covered by one activity or use. Most of the TAZ with low land use mix value is found to be residential and peripheral zones. This show that residents of those TAZ are supposed to have long travel distance in order to get access to different facilities and services. The other factor that has been determined in Adama city is that when the distance between TAZ location and nearby PT route, land use mix level decrease, this show that mixed land use development is not applied to the most residential dominated TAZ.

According to a map of the land use mix index of Adama city, TAZs with medium land use mix level are located approximately in the center of the city. This showed that the most dominant economic, social, and other activity which attract and demanded by residents are not evenly distributed throughout the city.

In order to understand the integration of land use with public transport system, variable that encounter both the public transport system and the users should be taken in consideration. Population density is one of the variable that is considered as user character, were as Area index of trip is other variable considered to characterized the public transport system by including the travel distance, travel time to work or other areas, origin and destination of travel and it show land use lined with travel were within adequate proximity.

According to the result from the Pearson correlation between variable determined to describe the integration of land use with public transport system, population density is correlated with land use mix level with a value of r= -0.454.this show that the two variable are inversely related to each other, meaning if the TAZs have equally stronger level of land development attract more people to the local areas and it reduce population of adjacent areas which were the only mixed areas. When it come to the correlation between population density and Area index to trip, both are related with a value of r = -0.522, this show that the relation is inverse relationship, meaning that in a given TAZ having high PD, the Area index of trip will decrease. When the Area index of trip value decrease or value near to 0, show that residents are required to travel long distance in order to get the facility due to lack of accessibility and low spatial distribution to all demand with in a given vicinity as result of high PD, because high PD means high number of people in a given small area.

The other correlation between and use mix level Area index of trip show that land use mix index which show land use diversity level and the Area index of the trip which shows the level of travel, choice of mode of travel are directly related to each other with a value of 0.478. This show that when land use diversity of TAZ increase, the Area index of trip increase. When the Area index of trip value increases or a value near to 1, it showed that most activity areas lie in the buffered zones within shorter travel distance and time.

5. CONCLUSION AND RECOMMENDATION

5.1. CONCLUSION

Generally, according to the study, Adama city has one of the lowest levels of public transport coverage with just 4.575% of its total area being covered by public transport routes. The spatial coverage of bus and taxi service routes in Adama city is very low, at just 41.926 km. In Adama city, Ethiopia, 13 buses and 500 taxis (mini busses) are now in service. Samples were taken at neighborhood block boundary level based on the population density along 14 kebeles (TAZ) as traffic analysis zone (TAZ) in Adama City. The origin and destination of public transportation routes imply that both public buses and taxi routes have a common and set destination zone. This is due to the low spatial coverage of public transport routes and the low number of public vehicles. Franko and Abba Gada, also known as TAZ 8 and TAZ 6, are popular destinations for both public buses and taxis. TAZs with high population density and land use are dominant with commercial and service character rather than being areas for living purposes, indicating that this TAZ has a high number of HBW, HBNW, and NHB journeys for both public buses and taxis. In Adama city, the public transport system TC of public bus service is relatively more affordable than TC of taxi (minibus), while TT of taxi (minibus) consume good or moderate in contrast to public bus. According to the standard stated in (UN Inhabitatnt, 2015) WT for public transport is below the standard which is 5min, because according to the data collected from the respondents, the average WT of public buses and taxis (min bus) is 25 min and 20min.

According to the travel demand model prepared by this study for Adama city public transport system, it is determined that TAZ 02, 06, 07, 08, 09, and 12 are the relatively common trip production TAZ in Adama city, while TAZ 01, 02, 03, 04, 05, and 14 are the common trip attraction TAZ in Adama city. According to data collected from the respondents about their mode of choice according to their perception towards to the public transport in travel time, travel cost, and level of comfort, the result concluded that taxis (min-bus) have a high probability of choice in regard to its travel time and level of comfort than the public bus, while public bus has a high probability of choice in regard to travel cost than taxi (min-bus) and is affordable for low-income group.

This study compares the two public transport types in Adama city namely, Public bus and taxi (mini-bus) level of service or modal choice using utility function and Multinomial Logit(MNT) model. The final result of the model shows that Adama taxis have a 95.6363% of probability of being chosen, while public buses have a 4.3636% of choice. This shows that the taxi is the most preferable public transport system in both public transport users' perception evaluation and utility function analysis. As result the level of service of public transport in Adama city is in good status in regarding to taxi (mini-bus) service.

The value of land use mix index indicate the degree of balance spatial distribution of activities throughout a given (TAZ) in Adama city. Low value of land use mix index below 0.45 show that TAZ have one dominant use or above half portion of the TAZ is covered by one activity or use. The distance between TAZ location and nearby PT route shows that mixed land use development is not applied to the most residential dominated TAZ. According to the result, TAZ 1, 2, 3, and 14 have a value of below 0.45, while TAZ 4, 5, 6, 7, 8, 9, 10, 11, 12, and 13 are at least 0.65. This indicates that more than half of TAZ (kebele) have low land use mix level.

In order to understand the integration of land use with public transport system, variable that encounter both the public transport system and the users should be taken in consideration. Population density is one of the variable that is considered as user character, were as Area index of trip is other variable considered to characterized the public transport system by including the travel distance, travel time to work or other areas, origin and destination of travel and it show land use lined with travel were within adequate proximity. The result showed that, Population density is negatively associated with land use mix level (TAZs) - meaning that if TAZs have an equivalent amount of land development, they will attract more people to the local area while reducing the population of surrounding areas. High PD indicates a large number of people in a small space. When the Area index of trip value decreases or approaches zero, it indicates that residents must travel a long distance to access facilities. This is due to lack of accessibility and low spatial distribution to all demand within a given vicinity as a result of high PD. As the land-use diversity of TAZ increases, so does the Area Index of Trip. When the Area index of trip value climbs or approaches 1, it indicates that the majority of activity areas are located within the buffered zones and need less travel distance and time. This shows that the land use mix index and the choice of mode of transport are directly related to each other.

5.2. RECOMMENDATION

Relying on the results of the study and discussions made above the researcher forwards the following recommendations.

- Promotion of perfect land use mix and TOD (Transit Oriented Development) in urban planning practices and policies. This involves the insertion of all the possible or target activities or land use types into the area to be planned. Either or both of the horizontal and vertical mixings can be used as a method.
- In regard to the public transport routes, Adama city should afford additional public transport routes with in standard of spacing in order to address the demand for it.
- Re-planning of the city through an extensive land-use readjustment, a fundamental reorganization of infrastructure networks as well as revitalizing of run-down urban basics. By promoting the perfect/ better land use mix, or heterogeneous distribution of activities, it can be clearly known that Adama city would have a balanced population density here and there and can also bring about a shift in the urban center (downtown) .at this stage, in Adama city it would be expected very less change in demand to and from a zone in such arrangements and developments. This will in turn come with the following changes.
    - Reduction of the need to travel o Modal shift.
    - Balanced demand to and from TAZs within the city (Lesser change in demand)
- With the above-listed changes at hand, the following social, environmental, and economic benefits would be harvested. These are;
    - Lesser investment in transport developments. This happens whenever there is a lesser need to travel and there is a modal shift from the Motorized vehicles to the non-motorized ones.
    - Better Utilization of Roads.
    - Lesser gas emission. If there is less number vehicles on the roads, it would experience lesser emission

- Better service quality (LOS) on the urban streets. Related to the travel time, travel cost level of comfort or convenience.

- Incentives like subsidizing the public transport sector in Adama city to increase the proportion of large public transport users should be considered by the government as mode choice is highly affected by the cost of the transport. The government should also work on the quality of large public transport in order to gain more users. The environmental benefits and congestion minimization effect of using large buses instead of Minibus should be investigated in more detail. Public transport modes as a whole will benefit if modal shift can be achieved from private cars while benefiting the environment as well.

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APPENDIX

Appendix A- Field observation checklist

Mode Type	Origin	Destination	Station	Stop Over	Route Code	Description
Public Bus						
Taxi (mini-bus)						

Appendix B- Field observation checklist

Mode Type	Carrying Capacity	Average Travel Time	Travel Cost
Public Bus			
Taxi (mini-bus)			

Appendix C - **Questioner One**

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF CIVIL ENGINEERING AND ARCHITECTURE

DEPARTMENT OF URBAN PLANNING AND DESIGN

MSC PROGRAM

Dear respondent, thank you in advance for your time.

This questionnaire is designed to gather data for research purposes to the fulfillment of MSc in the field of Urban Planning and Design Accordingly, your genuine responses are extremely important for this research, so please be free and respond to all the open-ended and closed questions.

Survey TAZ: .... N. Block NO: ....

1. What is your employment status?
   A. Employed B. Unemployed
2. How much is your average monthly income (in birr)?
   A. <500br B.500-3000br C. >3000br
3. How much is your average monthly expenditure on public transportation?
   A. <600br B.600br-1200br C. 1200br-2400br
4. What is your major purpose of trip-making?
   A. Home Based Work (HBW) B. Home Based Non-Work (HBNW) C. Non-Home Based
5. Where is your trip destination kebele?

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6. What is the major mode of public transport you use?

A. Public bus B. Taxi

7. What is your perception about the mode frequency (Give rank from1-10?)?

A. Very Low (3/10) B. Low (5/10) C. High (7/10) D. Very High(10/10)

8. What is your perception about the mode convenience (Give rank from1-10)?

A. Inconvenient(3/10) B. Less Convenient(5/10) C. Convenient(7/10

D. Very Convenient (10/10)

9. What is your perception about the travel cost? (Give rank from1-10?)

A. Very Costly (3/10) B. Costly (5/10) C. Less Costly (7/10)

D. Not Costly (10/10)

Appendix D- Interview Questioner

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DEPARTMENT OF URBAN PLANNING AND DESIGN

MSC PROGRAM

Interview questioner prepared for Adama transport office workers.

1. What are the dominant mode of public transport system in Adama city?
2. How many buses and taxi (mini-bus) are currently giving service for Adama city residents?
3. How much is the carrying capacity of both public bus and taxi (mini-bus)?
4. What kind of strategy is applied in order to control the public transport system distribution in the city?
5. Is there any public transport route map or direction map? If not, can you direct it verbally?
6. What is the maximum and minimum number of stops in one route?
7. How long does it take for a single trip using both bus and taxi (mini-bus) to go from one station to the next (on average)?
8. How much is the average travel cost payment for both bus and taxi (mini-bus) single trip?