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HOUSING DEVELOPMENT AND THE PUBLIC TRANSPORTATION

MISMATCH: THE CASE OF ADDIS ABABA CONDOMINIUMS

BY

MELKAMU DEBAS LAYEW

JUNE, 2019

ADDIS ABABA, ETHIOPIA



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Housing Development and the Public Transportation Mismatch:

the Case of Addis Ababa Condominiums

A Thesis Submitted to School of Graduate Studies of Addis Ababa University,
Ethiopian Institute of Architecture, Building Construction and City
Development (EiABC), in Partial Fulfillment for the Degree of Master of
Science in Urban Planning.

By

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Declaration

I, the undersigned, declare that this thesis is my own and original work and has not been presented for a degree in any other university, and that all sources of material used for the thesis have been duly acknowledged, following the scientific guidelines of the Institute.

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Acronyms

AACPPPO: Addis Abeba City Planning Project Office

AACTA: Addis Abeba City Transport Authority

AALRT: Addis Abeba Light Rail Transit

ABLSE: Addis Ababa bus and LRT service index

ACBE: Anbessa City Bus Enterprise

CSA: Central Statistical Agency

GIS: Geographic Information System

IHDP: Integrated Housing Development Programme

LITA: Local Index of Transit Availability

LRT: Light Rail Transit

PSETSE: Public Service Employees Transport Service Enterprise

SMH: Spatial Mismatch Hypothesis

UN HABIT: United Nation Habit

Abstract

For the last decade, Condominiums were constructed and also in the process of construction in different parts of Addis Ababa. The city is going through condominium booms which partly alleviate the housing problem. Most of these condominiums are constructed at the periphery part of the city, further from the city centers, where most of the jobs and services are located. Yet, the public transportation, that many residents depend on to access their jobs is not available in abundance in those suburban locations. Nowadays updated level of public transit coverage in the city of Addis Ababa is not known. As a result, any intervention in this sector cannot be fruitful unless the level of the gap is known scientifically. The purpose of this research is therefore to evaluate the intensity of transit service availability in relationship to neighborhood socio-economic and demographic characteristics in all parts of the city specifically the suburban condominiums of Addis Ababa. Two methods were used in this study. The first method was Addis Ababa bus and LRT service index (ABL SI), this method analyzed Anbessa, Sheger and LRT transit service availability in terms of transit capacity, frequency and coverage score. After standardizing each capacity, frequency and coverage score the results were summed together to produce transit availability index in each 99 transit analysis zones (Woredas) of the city. The second method was simple regression analysis, using this analysis the magnitude of correlation between transit availability index and socio-economic characteristics were identified. Based on the analysis the first method result were identified, it showed that Low and almost no transit service has been available in the periphery condominium residential Woredas whereas in the inner part of the city Woredas low to high public transit service intensity was identified. The second method result also showed that the intensity of transit service availability index has positive relationship with the socio-economic and demographic characteristics of periphery condominium neighborhoods. The study definitely answered regarding to the intensity of public transit availability difference between inner city and periphery Woredas with condominium residential neighborhoods. It also answered the relationship between public transit availability index and socio-economic characteristics of the periphery condominium residential neighborhoods. Further studies are needed for Woredas that have low and almost no transit availability index route design.

Key words: *public transit availability index, condominium development, public transit mismatch, socio-economic characteristics*

CHAPTER ONE: INTRODUCTION

1.1. Background

Ethiopian government outlined an ambitious vision for low-income urban and housing development, formulated as the Integrated Housing Development Program (IHDP), since 2005 (Dejen, 2017). Addis Ababa was the first city which applies this national program. Ingwan et al. (2010) referred that Addis Ababa City Administration launched ambitious low cost condominium housing projects through the Integrated Housing Development Program (IHDP) in 2006. According to Ingwan and others the aim of IHDP was to minimize housing shortage, clear slums and provide decent shelter to middle and low income groups. Based on Krems (2017) study 180,000 Addis Ababa condominium housing units are transferred to their owners. Addis Ababa city condominium map (2018) shows that; these numbers of housing units are located from 101 condominium sites with around a total of 1806.94hec coverage. According to Ministry of Urban Development and Housing 2019 report, starting from 2006 to 2018 the city administration of Addis Ababa provided the condominium housing units for 176,721 winners of the city dwellers; among the winners 52% are women which are the highest proportion. These communities make trip for different purpose to other part of the city specifically to inner city.

The trip from condominium residential areas to other parts of the city is for social, economic and recreation purpose. To facilitate the trip; public transit services should be available in condominium areas with well coverage of transit routes, accessible stops/stations, acceptable frequency and adequate quantity of the service.

Different public transit services are available in the city of Addis Ababa. According to Addis Ababa city Transport Authority (AACTA) 2018/19 public transport distribution report; Public transit services in the city includes; Anbessa City Bus, Sheger City Bus, Alliance City Bus, Public Service Bus (for civil servant), LRT, Taxi, Minibus and Midi-Bus (Higer &

Isuzu). However, this study focused on only LRT, Anbessa and Sheger city Bus transit services. Because these public transits are financed and administered by the city government which are not profit based transits. In addition, the three transit services are regularly assigned in the provided routes and relatively stick to their schedules than other privately owned public transits that are flexible in their schedules which lacks reliability by the passengers. As a result, for the city of Addis Ababa public transit availability spatial analysis, the three chosen transit services are appropriate to show the intensity of transit service availability at periphery condominiums neighborhoods. These public transit services have their own history, service quality and quantity within city as discussed below.

Among the existing public transit Anbessa bus is the old transit service in the history of the city. Based on Abreha (2007) study Anbessa Bus Organization started in 1935 (1942 G.C.) by the Ministry of work and communication. Abraha stated that in 1994 the company was renamed as Anbessa City Bus Service following the proclamation number 187/1986 E.C. According to Anbessa city bus enterprise 2018 annual report; Anbessa had 441 daily City Buses distribution and transported 293,326 passengers per day which is 13 times larger than Sheger bus. It has 124 routes, 1644 stops, 29 stations and 4 depots (Anbessa City Bus enterprise, 2019).

Like Anbessa City Bus, Sheger Mass Transport service is also government financed public transport service. It was started its operation in 2016 (AACTA, 2016). This city Bus has 51 routes and 240 buses (AACTA, 2019). According to AACTA average frequency of public transport and number of passengers' information from December 15-20/2011E.C. Sheger City Bus transported 21,518 average passengers per day.

In addition to Anbessa and Sheger bus, currently LRT is one of the dominant public transit services in Addis Ababa. The service was started operation in 2016 with 41 trains and transports 120,000 passengers per day in both N-S and E-W direction (AACTA, 2016). The

service has 39 stations with 5 common interchanging stations and two main depots in Hayat and Kality ends.

Public transit services can be a sound solution for cities with increasing private cars (congestion) and mass residential neighborhoods located at the periphery of the city. According to Kenyon et al. (2002), Benefits of Public transport in comparison to individual transport have more effective energy consumption, reduced traffic accident rates, less traffic congestion and less space demand. Public transport also positively contributes to social integration. The spatial distribution of public transport has importance to link spaces with different activities like that of residence and job opportunity areas. The distribution of public transports cross urban spaces will be characterized by quality and quantity of its service provision. The quality and quantity of service also depended on balance of demand and supply related with street infrastructures (route and station or stops) and numbers of public bus availability. The networks of routes across different spaces (route coverage) will play great role for accessibility of public transport by the passengers. Therefore, provision of the public transport route at the required level, will help to bring well coverage of public transport service. The study by George and John (2015) support the idea that transport network has a significant role in the development of sustainable, resilient and livable cities.

Availability of public transport stations or stops within acceptable distance and their spatial locations could be factors for public transport accessibility. Based on Stanislav (2016), accessibility may be characterized as the number of facilities (traffic terminals, stops etc.) available in a certain time or within certain walking distance or for a certain charge. Stanislav also said accessibility of public transport stops may primarily be monitored with consideration of their distribution and location. The availability of adequate public transit on the provided routes increases the frequency of getting public transit service from each stations or stops.

Availability of public transportation at the periphery part of Addis Ababa condominium site communities is vital in getting employment, facilitating social interaction, getting better social services and recreational activities at different part of the city. Overall it helps to facilitate socio-economic and spatial integration of the city.

The study of this research focused on identifying the gaps of availability of public transportation service in the periphery part of Addis Ababa condominium residential areas. The study figured-out the intensity of integration among condominium sites and the availability of public transit by taking into considerations the whole city public transport coverage at woreda level which was the lowest administrative level of the city based on 2007 Addis Ababa city census data. Analyzing the city as whole helped to show where the service gap has been available and at what level of intensity (high, medium and low service coverage). The intensity of the service displayed in maps using GIS from LRT, Anbessa and Sheger transit indexes by correlating with demographic and socio-economic characteristics of woredas. This will help to make informed decisions and interventions in the public transportation sector of the city either by the government or the private sectors.



Figure 1: Anbessa , Sheger and LRT public transit services

Source: site survey, 2019

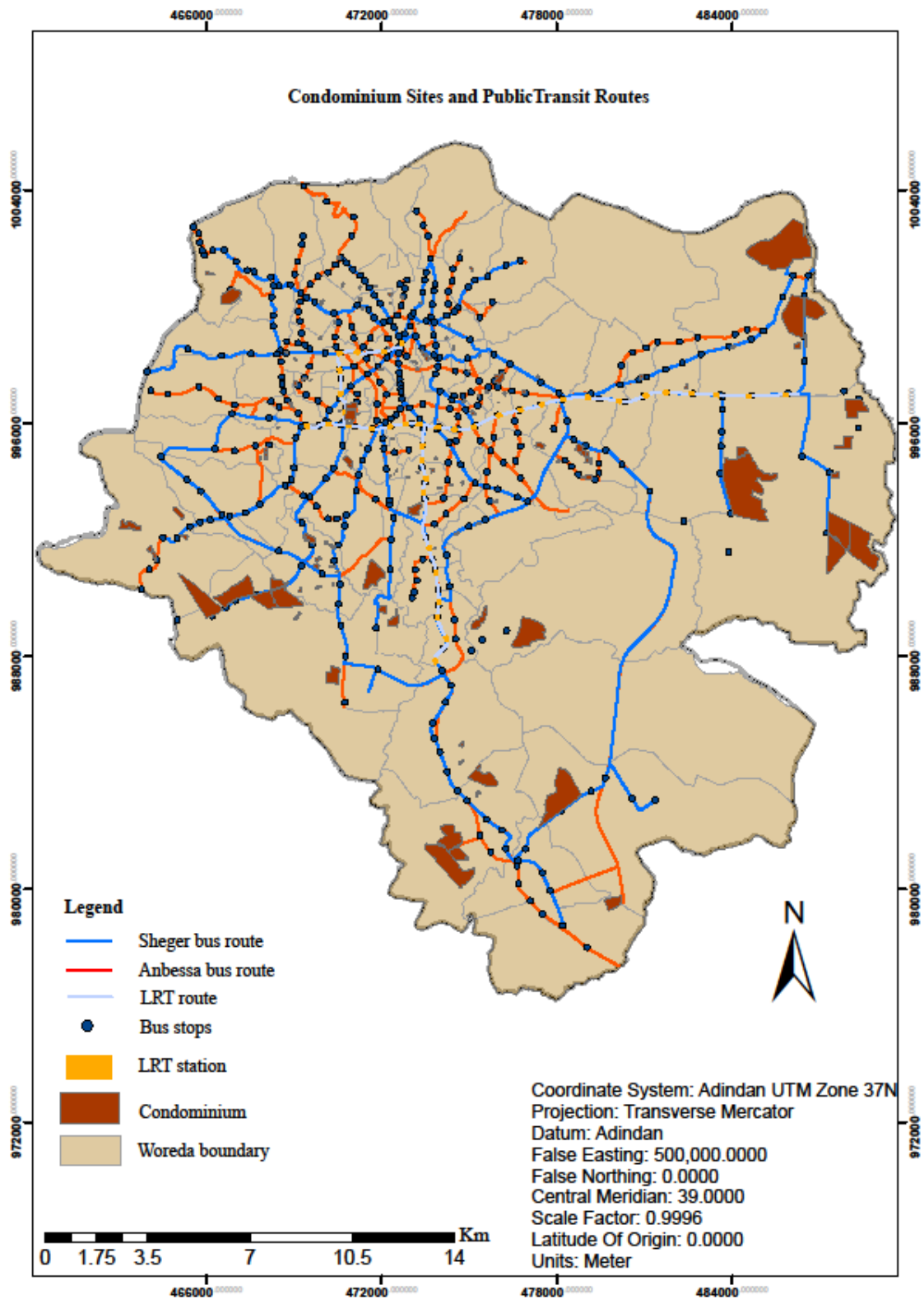


Figure 2: condominium sites and public transit routes

Source: Addis Ababa city transport authority, 2019.

1.2. Problem statement

For the last decade, Condominiums were constructed and also in the process of construction in different parts of Addis Ababa. The city is going through condominium booms which partly alleviate the housing problem in the city. Currently large numbers of communities are living in these condominium sites. Most of the condominiums are constructed at the periphery part of the city, further from the city centers, where most of the jobs are located. According to Hassan et al. (2018) in Addis Ababa, some of the new government-built condominium housing is located near the city center, but much of it has been built on the geographical margins of the city. Yet, the public transportation, that many residents depend on to access their jobs is not available in abundance in those suburban locations.

Communities who are living in the condominium areas are working in the inner part of the city. There were also communities relocated to the periphery condominium sites due to urban renewal programs whose livelihood is directly depend on inner city. The renewal took place in the sub-cities of Lideta, Kirkos, Arada, and Addis Ketema which are part of the inner city (UN- Habitat, 2017). The relocated communities' livelihoods were dependent on these inner city areas (Hassan et al., 2018). When these communities resettled in the periphery part of the city condominiums they lost their social and economic activities because mostly these condominium sites provide dormitory function. As a result, to do their job they move to inner part of the city during the day time and back to home during night time. However, to accomplish their daily task transportation is a great challenge because these residential sites are not well provided with public transportation (Fenta, 2014). According to Hassan and others (2018) study, the periphery condominium residents monthly expenses is rising without secured income and they cannot afford the costs of privately administered transportation services from the condominium to work in the city center. As a result, there is public

transportation demand at the periphery part of the city but the demand and supply of the public transport service is not balanced. According to Fenta (2014) “Addis Ababa faces various problems including insufficient and poor quality of public transport. That means the existing public transport system in Addis Ababa is critically inadequate to provide service for the increasing travel demand of the city, because the number of cars providing the service is not sufficient”. As a result, there is less integration of public transit and condominium development with less accessible and reliable service provision. From the reliability perspective the transit is not available any time, regularity is not satisfactory because of long waiting time at transit stops, operational speed or trip time is long because of congestion and the public transportations not having segregated lane.

This indicates the city has been developed with unplanned housing and transportation service balance that links residents to job, school and shopping area which results spatial mismatch between these different activity spaces. This also has its own negative social and economic influences on condominium dwellers in the suburban area of the city.

1.3. General objective

The purpose of this research is to evaluate the gaps of availability of transit service in relationship to neighborhood socio-economic and demographic characteristics in the city of Addis Ababa specifically in the suburban condominiums .

1.3.1. Specific objectives

- To evaluate availability of transit service in suburban condominium neighborhoods.
- To evaluate the intensity of public transit service difference between the city center and periphery condominium residential areas.
- To identify socio-economic and demographic impact of public transit availability at the periphery condominium residential areas.

1.4. **Research question**

- How public transits (services, route and stops) are spatially distributed and connected to periphery condominium residential areas?
- Are there major differences between the city centers and the suburban condominium neighborhoods related with availability of transit service?
- In what way does the public transit availability affect the socio-economic and demographic aspect of the study area?

1.5. **Significance of study**

The study shows the public transport service gap intensity in periphery condominium residential areas in map, charts and tables. This helps for the city administration, policy makers and private investors to make informed decisions and interventions in the public transportation sector. Therefore, for the city administration the study gives clear image about the availability of spatial coverage of public transit route and the provided service quality and quantity at each transit analysis zone. As discussed on the above the study would also help private sectors to invest in transportation sector to fill the available service gap without hesitation. It also helps policy makers to update the current policy related with existing reality of public transportation based on the recommendation of the study.

1.6. **Scope of the study**

The study evaluated the entire city Anbessa, Sheger and LRT public transport spatial coverage at the woreda level which was the smallest administrative unit of the city based on 2007 census data of Addis Ababa. Much more it focuses on condominium areas specifically the periphery part of the city. These periphery condominiums are Asco, Mikelely Land, Jemo, Mekanissa Kotari, KaraKore, Tulu Dimtu, Gelan, Kilinto, Bole Bulbula, Yeka Abado, Yeka Ayat, Bole Ayat, Bole Arabsa, Bole Lemi, etc. Moreover, it assessed availability of

number of buses and LRT trams, stops, carrying capacity, route coverage and frequency of buses and LRT trams at each stop within each woreda traffic analysis zones. In addition, the transit availability was assessed in comparison with the number of population (socio-economic & demographic characteristics) and area coverage of woreda which was taken as a traffic analysis zone.

1.7. Limitation of the study

The traffic analysis zone (Woreda) limits the study. Because this woreda was based on 2007 census data and there was no recent census data after 2007 that considers the recent woreda administrative level. There is also 2016 socio-economic data limitation because this data was collected at sub-city level by CSA. Therefore, census data is also a major limiting factor in this study. Time is another limiting factor for this research to deal with primary data. As a result, the research used only secondary data.

1.8. Organization of the research

The study contains five chapters. Chapter one provides with an introduction part of the paper. The chapter highlights background of the study, the research problems and questions, purpose of the study, objectives, significance, scope, limitation and organization of the paper. The second chapter provides a literature review which is based on a survey of previous studies in this research field. It mainly focuses on condominium development, public transit availability, spatial coverage and connectivity of transit route as well as transit service in urban areas. This chapter also presents theories and principles that are relevant to the present study. Chapter three discussed about background of the study area. Chapter four focus on research methodology that was used to collect and analyze the data. Chapter five discusses about result and discussion. Chapter six discusses about conclusion and recommendation.

CHAPTER TWO: LITRATURE REVIEW

2.1. General description

The literature review discussed issues that are related with housing (condominium) development and public transit service (transit service availability, spatial coverage and transit mismatch) as well as socio economic and demographic impact of availability of public transit. Important words are defined based on the contextual meaning accordingly.

Condominium: a building for residential or other purpose with five or more separately owned units and common elements (all that are part of the condominium except the units), in a high-rise building or in a row of houses, and includes the land holding of the building (Federal Negarit Gazeta, 2003).

Public transit: it is a motorized mode of transport which includes trains, trams and buses operating on fixed linear routes connecting a number of stops in series that together form a network of transport systems. The size and the capacity of transit system differ according to the particular mode and context (Tesfaye, 2012).

Public transit spatial coverage: is public transit service within reasonable physical proximity to traveler's home/destination (Al Mamun & Lownes, 2011).

Public transit availability: it is how easily passengers can access and use transit service. It is the measure of public transportation service intensity at the local level (Woldeamanuel & Covington, 2010).

Armstrong and Thiriez (1987) stated that, public transportation is a key component of a sustainable transportation system that helps mobility (movement of people, goods and services) without harming the economy and environment. As a result, public transport in urban areas has gained greater attention in recent years for improving sustainability and the quality of urban life (Bok, 2016). The economic and environmental performance of cities can be enhanced by connecting resources to destinations effectively and facilitating mass

mobility (Bok, 2016). Based on Ross (2012) study public transit is a key component of the economic and social fabric of metropolitan areas. According to Armstrong and Thiriez (1987) public transportation also decreases the increased auto ownership and insures long term sustainability in terms of resource consumption by relieving highway congestion and provides a very efficient means of moving large numbers of people. Therefore, commuting to work is one purpose of trip residents may use a transit system (Ross, 2012). According to Ross study commuters make up the largest share of transit trips nationwide. However, to transport people, goods and services without adequate infrastructure is unthinkable.

As Moreno (2016) discussed in his study that, public transportation cannot be functional without transport infrastructure. Based on Yatskiv et al. (2017) study availability of public transport infrastructure is a vital factor in providing an attractive public transport with door to door access as well as the long-distance travel. However, in developing countries the demand of public transport infrastructure has not kept up with the demands of growing populations in cities (Moreno, 2016). According to Woldeamanuel and Covington (2014) study, transportation service may not be constant because of change in service demand as a result of population growth through time. Nowadays in developing countries huge population growth has been recorded (Buhaug & Urdal, 2013). Hence, the Increase in population has caused an increase in the demand for mobility (Samek & Torchio, 2015). Nevertheless, public transport infrastructure is not provided based on the riders demand in developing countries specifically for less affluent areas. As Moreno (2016) discussed in his study “Infrastructure provision has historically been biased against less affluent areas, so access to formal jobs is often difficult and costly for a large part of the lower income population. As a result, low-income workers may be discouraged from commuting to formal jobs, lack information on job opportunities, and face discrimination.” Therefore, development of transportation services is an important factor for social wellbeing (Yatskiv et al., 2017).

Based on Woldeamanuel and Covington (2014) study development of public transit infrastructure requires planning for the future, especially forecasting the effects of demographic changes of both people and jobs. Hence, transit agencies, transportation planners and local government officials should undertake periodic evaluations of the socio-spatial distribution of transit service across neighborhoods (Woldeamanuel & Covington (2014).

2.2. Urbanization and Housing development

Condominium housing is a form of housing tenure where each resident household owns their individual unit, but equally shares ownership and responsibility for the communal areas and facilities of the building (Bewunetu, 2016). It was introduced in the late 1960s in British (Rosen & Walks, 2015). Based on Rosen and Alan (2013) study during the post war period both in US and Canada low-rise single family homes were delivered. However, starting from 1970 population growth, demographic change, regressive rental housing policies and consumer preference change contributed for higher-density condo-living in metropolitan area downtowns (Rosen & Alan, 2013). As a result, Rosen and Walks (2015) stated that, condominiums make up a fast growing form of housing ownership in cities and suburbs across the globe. This fast growing condominium development brought spatial shift from suburbanization and urban dispersion towards concentration, gentrification, and intensification which in turn brought profound changes in urban social life (Rosen & Walks, 2015). The spatial shift happened mainly because of high rise condominium development at the center (Rosen & Alan, 2013). Therefore, Condo-ism is a force that is countering long trends towards dispersion; it is also important factor in the production and reproduction of the contemporary city (Rosen & Alan, 2013).

According to Rosen and Alan urban restructuring and the extensive development of condominium high-rises are dramatically altering the physical environment of many large

cities (Toronto, London and New York) and have been an image of a city of towers. However, other studies shows that rather than densification, centralization and intensification of housing units, suburbanization is promoted because of government housing related policies.

Wang et al. (2011) study indicates, in 1980s, housing units in major Chinese cities were bonded to jobs as they were located together with or very close to places of employment. However, from the 1990s, accelerated suburbanization of population in major Chinese cities driven by urban redevelopment, urban land reform and urban housing reform has fundamentally altered the jobs-housing spatial relation (Wang et al., 2011). It is the urban poor that suffer most from such housing misallocations (Bewunetu, 2016).

Wang et al. (2011) discussed that, the spatial bond that existed between urban jobs and urban housing has dissolved and replaced by spatial mismatch when the jobs-housing relationship becomes increasingly imbalanced or separated in space. Therefore, Housing is not adequate if it is cut off from employment opportunities, health care services, schools, child care centers and other social facilities, or if located in polluted or dangerous areas (UNHCHR & UN-HABITAT, 2014) . However, this phenomenon is clearly observed in African cities.

Africa is the most rapidly urbanizing yet economically poorest region of the world, where almost every country experiences housing shortage (Bewunetu, 2016). According to UN-HABITAT (2010) report housing deficit in Ethiopia lies between 900,000 and 1,000,000 units (UN-HABITAT, 2010). Among this deficit Addis Ababa shares 300,000 housing units (UN-HABITAT, 2010). According to Tiemelissan and Pankhurst (2013) the urban landscape in Ethiopia is undergoing a fundamental transformation, with whole neighborhoods in the center of major cities being cleared for urban development. As Dejen (2017) study indicates that Ethiopian government outlined an ambitious vision for low-income urban and housing

development, formulated as the Integrated Housing Development Program (IHDP), since 2005. Addis Ababa is the first city which applies this national program in Ethiopia.

The city of Addis Ababa shares what is studied by Rosen and Alan (2013) (re-urbanize existing built up areas and regulating suburban sprawl) and Wang et al. (2011) (change from spatial bond to spatial mismatch between jobs and housing).

Ingwan et al. (2010) referred that, Addis Ababa City Administration launched ambitious low-cost condominium housing projects through the Integrated Housing Development Program (IHDP) in 2006 to minimize housing shortage, clear slums, and provide decent shelter to middle and low income groups. Particularly 20% to 30% of housing units allocated to female headed households; and youth also have equal opportunity to participate in the programme (MoWUD, 2007). Some of the condominiums are close to central areas that are being redeveloped and a larger number are being constructed on the outskirts of the city (Tiumelissan & Pankhurst, 2013).

Related with periphery condominium residential neighborhoods distance from the city center; although the stated intention of the government was to relocate the poor to new government-built condominium housing, receiving a condominium is not a realistic option for the majority of the low-income inhabitants in the inner city related with the livelihood activity (Hassen et al., 2018). There is limitation of formal and informal jobs availability notably women who were preparing and selling food and beverages in central part of the city could not do from condominium housing (Tiumelissan & Pankhurst, 2013). Based on Hassen et al. (2018) study new government housing, targeted at low- and middle-income inhabitants of the city, has rapidly filled with new residents. Hassen and others also discussed that many relocates lifestyle is forced to change, their monthly expenses rise and they cannot afford the costs of transportation from the condominium to work in the city center.

In addition, these scholars found out that “within the condominiums, home-based enterprises are difficult to establish and maintain. The reasons for this are: potential customers are not willing to walk up flights of stairs to buy the products; neighbors complain about cooking food for commercial purposes or small-scale manufacturing within apartments.” it is also proven by World Bank (2017) study, condominium living forced the community into different lifestyles which were formerly dependent on house rent could not regain this source of income and these households are now in Poverty unable to meet their basic needs. Based on this fact Hassen et al. (2018) pointed out that transportation channels are vitally important for the well-being and survival of the poor in cities to get jobs. According to Addis Ababa city planning project office (2016) study residential development in expansion areas are not adequately provided with mass transport to city core. Centers, market areas, working places are not well connected with residential areas by public transport (Addis Ababa city planning project office, 2016).

2.3. Housing policy in Ethiopia

Ethiopian Constitution article 41(3) states that every Ethiopian national has the right to equal access to publicly funded social services while article 41(4) imposes obligation on the state to allocate its ever increasing resources to provide to the public social services. Based on these articles the MUDHCo has issued a National Housing Development Policy and Strategic Framework in 2014. The policy has identified key problems and their manifestations along with causal factors and pin pointed policy directions to deal with the problems. The following summarizes the key challenges in enhancing access to housing in urban areas along with policy options devised by government to overcome the key challenges (Tsefalem , 2017).

Factors for condominium housing development

- proliferation of squatter and informal settlements

- high proportion of slum dwellers
- homelessness limited supply of houses by the public and private developers
- high cost of construction
- low income levels of urban households
- limited serviced land supply
- lack of clarity in taxes and levies
- shortage of public housing finance
- high rate mortgage interest rates

Policy directions

- improving the income of urban households through various income generating programs and packages
- enhancing and improving the supply and production of construction materials
- boosting production of high quality and low cost local construction materials by
- enhancing housing and construction research and development;
- improving construction materials through technology transfer
- construction of additional houses by
- ensuring access of low income households to public condominium houses;
- devising a dynamic organizational system that facilitates housing credit and efficient land supply that will support private saving societies so as to expand production of new houses;
- supporting high income private and real estate developers to construct increased
- numbers of houses with improved land management procedures;
- supporting banks and financial institutions to enhance their capacity of availing mortgage facilities to house builders through enhancement of housing finance schemes and sources;

- effecting a systematic transfer of publicly owned houses to private owners
- Enhancing the implementation capacity of urban administrations to enable them to efficiently deliver serviced urban land for housing development;
- Improving the implementation capacity of urban administrations to enable them deliver improved land registration and management systems, efficient implementation of the lease hold system and to withstand illegal and informal land development.

Therefore, based on the above factors and policy direction of the national housing development; Addis Ababa was the first city which applies this national program in 2006.

2.4. Urbanization and Public transportation

Aljoufie (2014) stated that, rapid urban growth causes enormous and continued challenges to many cities in both developing and developed countries. As Tesfaye (2012) referred, provision of competent and efficient transportation system is important for the cities in the modern era of globalization where cities are the centers of urbanization and propellers of national and global economies. Transportation system is also the engine of social and economic activities (Tefaye, 2012). However, urban sprawl, lack of integrated planning framework and dramatic land use changes have caused a significant impact on the daily share of travel modes that add burden on the transportation system (Aljoufie, 2014). To confront these challenges encouragement of effective public transport is vital.

Based on Kumar and Barrett (2008) study access to public transport services in Africa's cities can be assessed on several levels. Kumar and Barrett stated that the low density of paved roads, coupled with unplanned growth, poor road surfaces, and narrow streets suggests that the geographic reach of bus services is seriously restricted. In Africa cities on average, passengers walk for around 10 minutes to reach a bus and typically waiting around 30 minutes at the bus stop before being able to start their trip (Kumar & Barrett, 2008).

According to Addis Ababa city planning project office (2016) Addis Ababa transport policy give emphasis on issues such as integration between urban transport and land use, promoting mass transit facilities and transport infrastructures which includes non-motorized transport facility ,traffic safety and management to reduce congestion and traffic accidents are the major ones.

Addisu (2010) stated that, the public transport of Addis Ababa is composed of three main systems:

1. Anbessa City Bus Enterprise which is owned and subsidized by the city government.
2. Privately owned taxis, with fixed tariff rates and partially defined paths and stops.
3. Midi bus transport service, with fixed paths and stops.

Based on Addis Ababa city Transport Authority (AACTA) (2018/19) public transport distribution report; currently public transit in the city of Addis Ababa includes Anbessa City Bus, Sheger City Bus, Alliance City Bus, Public Service Employees Transport Service Enterprise (PSETSE), LRT, Taxi, Minibus and Midi-Bus (Higer & Isuzu ktk).

Fenta (2014) explained that, Addis Ababa faces various problems including insufficient and poor quality of public transport. Fenta found that existing public transport system in Addis Ababa is critically inadequate to provide service for the increasing travel demand of the city, because the number of cars providing the service is not sufficient.

Addis Ababa City Planning Project Office (2016) study indicates, the total travel demand of the city has reached 3.2 million person trips per day in the year 2010. From this travel demand only 73 percent is covered by public transport. However, this could not meet the present transport demand of the city, as the city's population is increasing and its surface area has been stretched out to about 54,000ha (Addis Ababa City Planning Project office, 2016).

According to Addis Ababa city planning project office (2016) study, despite the increase in number and quality of roads and number of passenger vehicles, the transport problem of the city has not yet been alleviated because of lack of integration between land use and transport plan and delay in the installation of mass transit. As a result, according the project office study 55% from the total modes of mobility is covered by walking due to low income level of urban dwellers and inaccessibility of public transport.

2.5. Public transportation availability for low income and commuters

Transit availability is the measure of public transportation service intensity at the local level (Woldeamanuel & Covington, 2014; Pulugurtha et al, 2011). As Al Mamun and Lownes (2011) referred “the Local Index of Transit Availability (LITA), developed by Rood (1998), measures the transit service intensity or transit accessibility in an area by integrating three aspects of transit services: route coverage (spatial availability), frequency (temporal availability), and capacity (comfort and convenience).” According to Woldeamanuel and Covington (2014) study the spatial distribution of transit services availability, particularly, transit capacity, coverage, and frequency of service are essential to determine transit service availability and quality. McKenzie (2013) stated that, “as the nation’s low-income population has become more sub-urban in recent decades; transit access may become an increasingly valuable, yet scarcer link to opportunity for those with the fewest resources and housing options.”

Based on Woldeamanuel and Covington (2014) study a portion of Americans relies on various modes of public transit for commuting. As they discussed great portion of members in low-income, elderly and minority households are depend on public transit. According to Moreno (2016) employers are not confident to higher lower-income workers residing in areas with poor transport accessibility. As Moreno discussed it is because of formal employers may be concerned about the consequences of long commutes on workers

performance. This can be happen when there are no large employment centers absorbing low-skilled workers in urban peripheral areas and availability of poor public transport accessibility (Moreno, 2016).

According to McKenzie (2013) the changing socio demographic makeup of suburbs present new planning opportunities and challenges, including associated with transportation and mobility. As a result, public transit service provides a positive social benefit in transportation of low-income residents (Scott, 2014). Compared to compact urban centers or inner cities, transit availability in suburb communities is relatively poor in most metropolitan areas (McKenzie, 2013). As a result, suburbs developed around inadequate public transit Service, placing a burden on low-income residents relies heavily on public transportation (Scott, 2014).

According to Scott (2014) study public investment in additional transit service can reduce commuting times, relieve the transportation burden on low-income suburban residents and help alleviate poverty. Therefore, as Woldeamanuel and Covington (2014) study indicates in order to develop convenient transportation service expansion plans and policies for an area; transit accessibility, availability and intensity measures should be properly identified. Woldeamanuel and Covington (2014) found that, neighborhood transit availability index can be created from transit capacity, frequency and service coverage to determine the level of intensity of service (high, medium and low) in the study area.

2.6. Spatial coverage and mismatch of public transportation in urban areas

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 (Michael, 1993). But if the distributed transport infrastructure not integrated with well public transit system then activity spaces cannot be linked which results spatial mismatch. Spatial mismatch is an old problem that still impacts workers in metropolitan areas (Woldeamanuel & Covington, 2014). As Moreno (2016) discussed in his study, the spatial mismatch hypothesis (SMH) was inspired by the rapid residential suburbanization around metropolitan areas of the US in the second half of the 20th century. Moreno stated that, as people moved from the cities to the suburbs, firms also dispersed from central areas to suburban areas. According to Moreno because of housing market discrimination and zoning regulations low income communities were not able to move to the suburb residential areas. As a result, there was an increase in the concentration of minorities in inner-city areas, where low-skilled job creation was slow (Moreno, 2016). The SMH is supported by the fact that many of the jobs created in the large metropolitan areas were in suburbs with poor or non-existent public transit service; these jobs are practically inaccessible to city residents who either do not own vehicles or own vehicles that demands long commute to the suburbs (Alam, 2005).

In the other way as Scott (2014) referred, spatial mismatch research has found that transportation access has a positive relationship with employment outcomes whereas housing and employment discrimination have a negative relationship with the spatial mismatch of jobs and housing (Scott, 2014). Therefore, Woldeamanuel and Covington (2014) found that effective public transportation is important in solving the gap between the residence and job locations. Considering residence in designing routes could not be the only solution but the transit systems should also consider transit accessibility from job locations (Woldeamanuel & Covington, 2014). Therefore, the accessibility factor is important in designing the public transport infrastructures (Ross & Svajlenka, 2012).

According to Abreha (2007) study when the transit accessibility is increased then the spatial coverage also will increase. The higher the spatial coverage of the service the shorter will be the walking distance to the service (Abreha, 2007). Transit coverage varies by neighborhood characteristics; including proximity to the urban core and neighborhood income levels (Ross, 2012). Tomer (2012) finds that, across large metropolitan areas job is accessible by public transit and accessibility is even lower in the suburbs, where transit coverage is typically poor. In contrast, peripheral areas of large cities in developing countries are the locus of dense housing settlements, with a predominance of informal employment and low availability of formal jobs (Moreno, 2016). According to Moreno study low-income workers are particularly dependent on public transport; better access to public transport can reduce inequality by improving labor market outcomes (Moreno, 2016). According to Kraft (2016) accessibility is characterized as the number of facilities (terminals, stops etc.) available in a certain time or within a certain walking distance or for a certain charge. Based on Kraft study spatial accessibility of public transport stops with the distance of 400 meters and 5 minutes travel time represents a comfortably accessible walking distance. Accessibility of public transit stops are also considered with their distribution and locations (Kraft, 2016).

2.7. Public Transit Spatial Mismatch in Los Angeles Suburbs (Empirical literature)

The spatial distribution of transit services, particularly, transit capacity, coverage, and frequency of service were used to determine transit service availability and quality. Major inconsistencies in the spatial distribution of available transit services were a great challenge. The aim of the study was to evaluate the spatial distribution and essential characteristics of transit service within the San Fernando Valley, the northern suburbs of the Los Angeles metropolitan area. This area was approximately 30 to 40 miles from the center of Los Angeles City. The neighborhoods were examples of second and third rings of suburbs and

overall, the development had a suburban character in terms of density and type of housing. Using Geographical Information System (GIS) and multivariate statistical models for the analysis, a comprehensive neighborhood level transit availability index was created as a function of transit capacity, frequency and service coverage (Woldeamanuel & Covington, 2014).

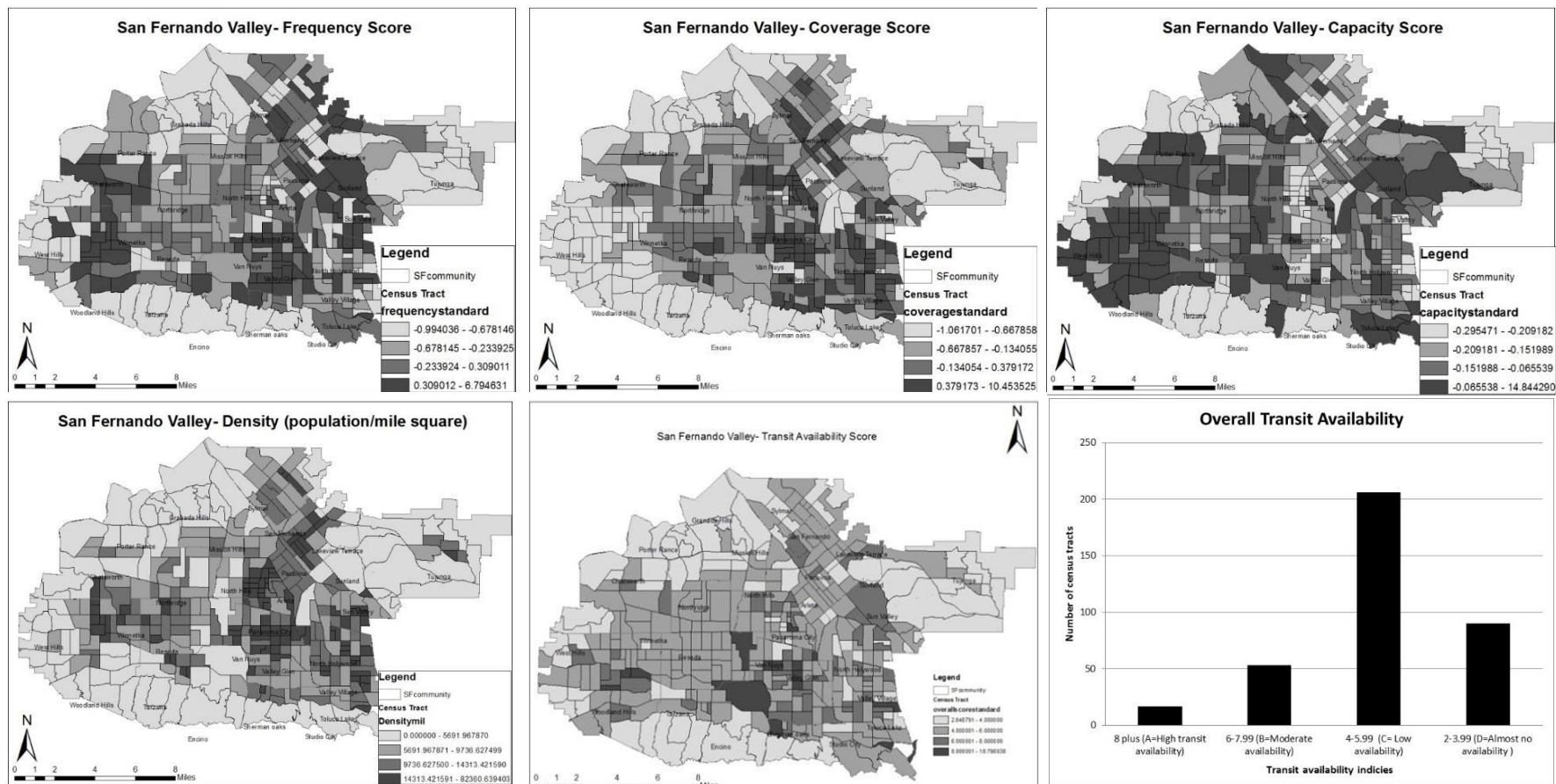


Figure 3: Transit Intensity Maps and Population Density

Source: Woldeamanuel and Covington, 2014

The index results showed that a significant portion of the study area has low transit availability. At the tract level, an aging population and minority population characteristics were negatively related to transit availability; indicating that on average, there are slight inconsistencies in the demand and the supply of transit services.

2.8. Summary of the literature

Public transportation helps for mass mobility of passengers. It gains attention in recent years as a result of its role decreasing auto ownership, relieving highway congestion and transporting mass population (Armstrong & Thiriez ,1987)). Among different purpose of trips commuting takes the largest share worldwide. To facilitate this tripe adequate infrastructure is a big constraint in developing world. Infrastructure provision is biased in less affluent or low income communities (Moreno, 2016). As a result, low income communities are discouraged to get jobs (Yatskiv et al., 2017). In addition to provision of adequate infrastructure; transportation service may not be constant related with population dynamics. Therefore, periodic evaluation of socio spatial distribution of transit service is needed (Woldeamanuel & Covington, 2014).

High density condominium residential neighborhoods were contributed by population growth, demographic change, and regressive rental housing policies. Fast growing of housing ownership in cities and suburbs brought spatial shift. The shift is from sub-urbanization and dispersion towards concentration, gentrification and intensification in America and Europe cities (Rosen & Alan, 2013). Other studies also promote from densification, centralization and intensification of housing units to suburbanization because of policies change (Wang et al., 2011). This shift was happened in Chinese cities because of urban redevelopment, urban land reform and urban housing reform. As a result of the spatial shift, the spatial bond that existed between urban jobs and urban housing is decreasing.

In Africa this thing is clearly observed. Ethiopia is one of the countries which condominium housing development is existed (Bewunetu, 2016). The aim of IHDP of the city administration was to minimize housing shortage, clear slums and provide decent shelter to middle and low income groups. Addis Ababa which is the capital of Ethiopia constructed mass residential condominium housing specifically at the periphery part of the city. Most of condominium housing units are located at the periphery part of the city. City centers, market areas, working places are not well connected with residential areas by public transport. Transportation system is engines of social and economic activities. In order to confront these challenges encouragement of effective public transport is vital (Scott, 2014).

Lack of integration between land use, transport and delay in the installation of mass transit creates mismatch. Transit availability is a measure of public transportation service intensity. The transit availability is measured by integrating three aspects transit services route coverage (spatial availability), frequency (temporal availability) and capacity (comfort and convenience) (Woldeamanuel & Covington, 2014). Low income population has become more sub-urban residents in recent decades. Therefore, the public transit service availability should be known in these areas in order identify the level of intensity of the service and to intervene accordingly.

2.9. Conceptual framework

The following conceptual framework illustrates the interrelated entities in which one can feed the other to evaluate public transit availability in the core and periphery of Addis Ababa city.

Typical issues of the study that of intensity of public transit availability, socio-economic and demographic characteristics are identified. Based on the issues inner and periphery areas of the city are evaluated. The result of the evaluation anticipated either high intensity or low intensity of the public transit service with its negative or positive socio-

economic characteristics. As a result, Low intensity of the public transit service with negative socio-economic areas are recommended for possible solutions

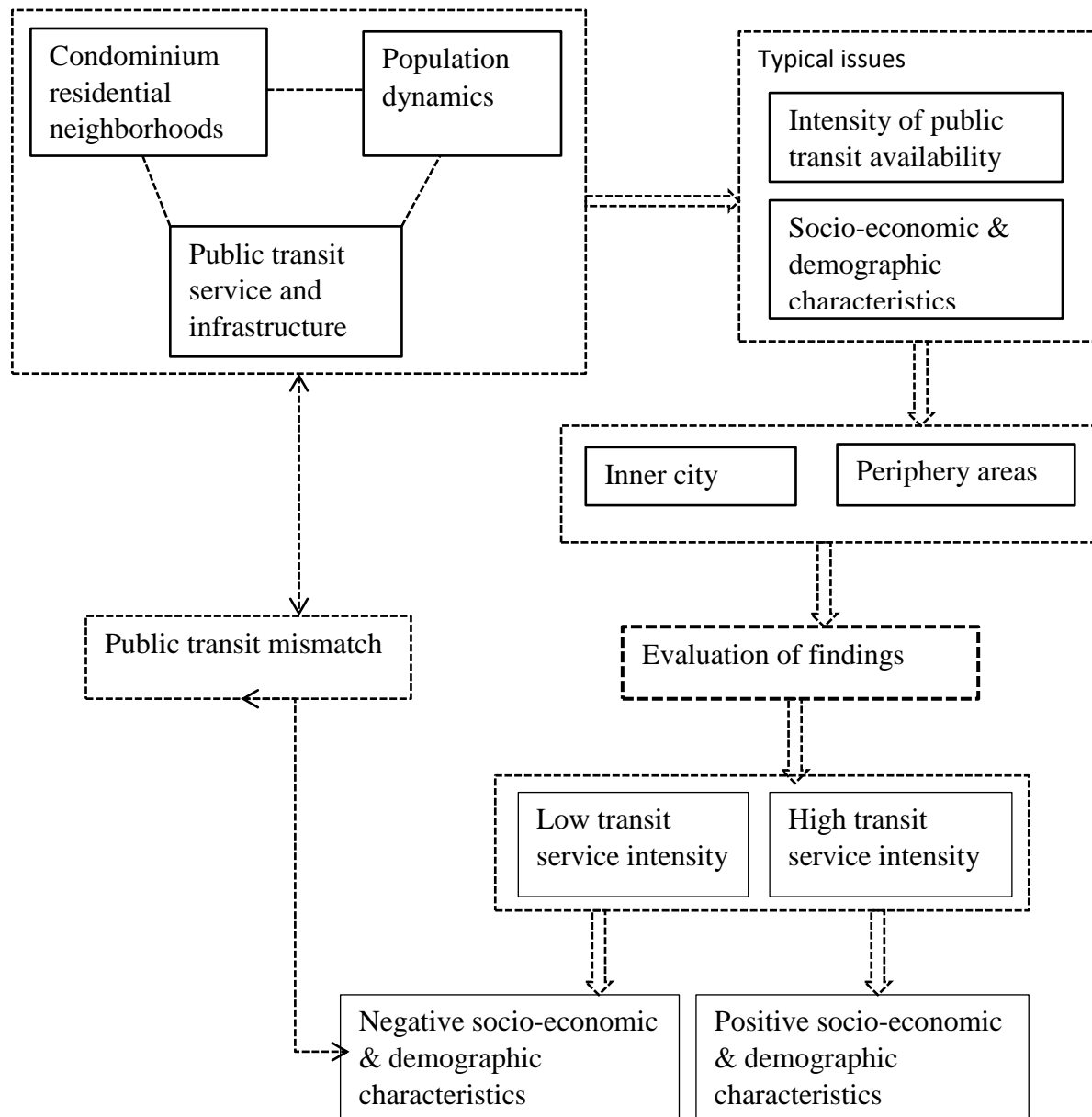


Figure 4: Conceptual Framework of the Study

Source: Computed by Author, 2019

2.10. Research gap

According to the literature review which was done on the above international experience shows that spatial mismatch (specifically segregation of jobs and residence) is happening in metropolitan areas. Because of the segregation low incomes, aged people and

women are affected. This experience (spatial mismatch) is clearly observed in the city of Addis Ababa because of the spatial segregation between suburb condominium residences and the city center where more of formal and informal jobs are available. Based on the above literature review studies were done related with public transit and residential neighborhoods mismatch in US metropolitans. In Ethiopia specifically in Addis Ababa transportation studies were done related with measuring and evaluating the performance, accessibility, efficiency and quality of public transit service and the transit route. But no studies are done yet in Addis Ababa to show the extent (transit availability) and impact (socio-economic) of mismatch among city periphery condominium neighborhoods and the city public transit service.

This study fill the gap through analyzing the demographic characteristics and spatial coverage of public transit availability by taking into account caring capacity, frequency and transit coverage of the service within Addis Ababa city specifically in the city periphery condominium areas. The result displayed graphically using GIS to show the extent of service gap in each study woredas. This also enables the city transport authority to act on the public transit service gap based on tangible fact.

CHAPTER THREE: BACKGROUND OF THE STUDY AREA

3.1. Introduction

The study of this research evaluates public transit availability (carrying capacity, frequency and coverage of the service) at the periphery residential condominium neighborhoods of Addis Ababa city. This section focuses on general description of the city, condominium development, transport infrastructure, public transportation service and challenges of integration between public transportation service and periphery condominiums.

Addis Ababa

Addis Ababa is the capital city of Ethiopia which is located in the center of the country. It was emerged in 1886 as a military camp in the strategic area of Entoto hills. In 1888, it was moved to the hot springs (Filwoha) located near the present day city Centre (Hassan et al., 2018). According to Hassen and others, the early primary historical elements of the formation of the city were the palace, the churches, the marketplace (Arada) and the houses of the nobility. Currently the city extends over 540 square kilometres at an altitude of 2,500 meters above the level of the Mediterranean Sea. The city is also the seat of government, center for education, industry and service. It is a chartered city with status of a city and state, the current governance structure of the city has three administration tiers, city level (central), sub city level and woreda (district) level (AACPPPO, 2016). The three tiers of the city administration includes; one city administration, 10 sub-cities and 116 woredas. As the Federal Ministry of Transport (2011) referred that, the 2007 national census data, having a growth rate of 2.1%, the population of Addis Ababa was 2,738,248 which accounted for 32.27% of the total urban population of the Country. Recently Different studies indicated that the population size of Addis Ababa is growing fast. Based on the 2007 census data, the city population growth in 2016 with 3.8 growth rate is indicated 4.6 million (UN-habitat, 2017). As result of population increase the city demands sufficient infrastructures such as that of

transportation system and housing provision. The city government tries to alleviate these challenges by providing public transits (such as Buses & LRT) and condominium housing.

3.2. Condominium development in Addis Ababa

The city of Addis Ababa encompasses a complex combination of planned and unplanned elements of the city, it can be viewed as the original old city, the industrial city, the informal city, the market city, the condominium city, and so forth (Hassan et al., 2018). As a condominium city; these communal housings are the result of population growth, space constraint and redevelopment strategies which are promoted by the federal government. The Federal Democratic Republic of Ethiopia enacted the condominium law under the proclamation No.370/2003 (FEDERAL Negarit Gazeta, 2003). Based on this proclamation number the Ministry of Urban Development, Housing and Construction has been providing the policy framework and detail norms for government initiated and implemented housing program since 2004. In addition to the housing program policy framework WUB Consult (2015) stated that, the 2005 urban development policy brought radical change to the way housing is to be developed; government took the lead to develop houses in mass and transfer it to owner-occupiers.

The condominium housing program was launched first in Addis Ababa in 2004 and then scaled up in other major urban centers of the country. In Addis Ababa the housing program was expanded from the 20/80 financing ratio to 10/90 and 40/60 of housing productions (Hassan et al., 2018). According to WUB Consult (2015) total housing demand in Addis Ababa based on registered households is about 994,344. If we assume all registrants are able to pay, the serviced land demand would be over 7,500 hectares (WUB Consult, 2015). Since 2004 to 2014 a total of more than 2486 ha of land were used for the construction of low and middle rise condominium housing, including social services and other investment activities (WUB Consult, 2015). The land was produced both in the expansion and inner city

redevelopment areas of Addis Ababa. The expansion areas of Addis Ababa are primarily being filled with government sponsored condominium apartment housing neighborhoods (Hassan et al., 2018). Recent studies revealed that more than 160,000 housing units have been transferred to beneficiaries since 2004, the year the program started and more than 100,000 housing units are under construction (Hassan et al., 2018). According to Ministry of Urban Development and Housing 2019 report, starting from 2006 to 2018 the city administration of Addis Ababa provided the condominium housing units for 176,721 winners of the city dwellers. Therefore, condominium housing provision is increasing through time.

3.3. Public transport service in Addis Ababa

The expansion of the city, increasing population size coupled with the economic growth has required respective transport service supply for the increasing mobility needs of the People. (FDREMT, 2011). As a result, the city administration developed Transport Policy of Addis Ababa in 2011 that upgrades Anbessa City Bus Enterprise, introduce Bus Rapid Transit /Light Rail Transit System along major corridors, and promote Minibus Taxi Services (Fenta, 2014).

In order to introduce viable transportation service transport infrastructures should be developed. The existing Addis Ababa street network is composed of four different types of streets; principal Arterial Street, Sub Arterial Street, Collector Street and Local Street. At present, existing road density is below the universally accepted standard of 25% which is 18% of the built-up area (29,000ha) and 10% of the total urban space (54,000ha) (AACPPO, 2016). Therefore, the road infrastructure is insufficient for carrying the transit of the city.

Based on Addis Ababa city Transport Authority (AACTA) (2018/19) public transport distribution report; public transit in the city of Addis Ababa includes Anbessa City Bus, Sheger City Bus, Alliance City Bus, Public Service Employees Transport Service Enterprise (PSETSE), LRT, Taxi, Minibus and Midi-Bus (Higer & Isuzu ktk). These public transit

services facilitate trips in the city. According to Abreha (2007) study the modal share of vehicle transport; private car takes 2%, 72% by taxi, 26 % by city bus. Tesfaye (2012) referred that, there are around 2.25million public transport trips per day in the city of Addis Ababa which is more 85% are carried out by the informal sector. Minibuses account for 1.4million trips/day, midi-buses and other taxis 0.55million trips and city buses 0.3million trips/day.

This study focused on only three mass transportation systems that are scheduled, administered and financed by the city government of Addis Ababa; LRT, Anbessa and Sheger city Buses.

Based on Abreha (2007) study Anbessa Bus Organization started in 1935(1942G.C.) by the Ministry of work and communication. Abreha stated that in 1994 the company was renamed as Anbessa City Bus Service following the proclamation number 187/1986E.C. Addisu (2010) discussed that, Anbessa was serving up to 700,000 passengers per day within 93 routes of the city. In 2016, Anbessa bus transported a total of 396,000 passengers per day with 650 busses in 123 different lines in the city (Addis Ababa City Planning Project Office, 2016; Tagagne, 2018). According to ACBE 2018 annual report; Anbessa had 441 daily City Buses distribution and transported 107,064,171 passengers throughout the year which means it transported 242,776 passengers per day. As Tagagne (2018) mentioned, ACBE in 2018 the service is provided with a total of 440 active buses which is almost closest to the enterprise report. A single Anbessa bus passenger carrying capacity ranges to 100-150 persons (Addis Ababa City Planning Project Office, 2016). The Anbessa bus service has 124 routes, 1644 stops, 29 stations and 4 depots (Anbessa City Bus enterprise, 2019). Addisu (2010), Addis Ababa city planning project office (2016), Tegegne (2018) and Anbessa City Bus enterprise (2019) studies and reports shows, the spatial coverage of Anbessa city bus routes are increasing but the number of buses distributed and the number of passengers transported are

decreasing time to time. Kenea (2017) study indicates, Anbessa city bus has only four depots (Piassa, Legehar, Mercato and Bole Anbessa garage) projecting from the city to the sub-cities and the Oromia towns within a 40 km radius. As Kenea explained, compared with the size of the city and surrounding Oromia towns, the number of existing bus terminals, planning and operation are inadequate.

Sheger Mass Transport service started its operation in 2016 (AACTA, 2016). This city Bus has 51 routes and 240 buses (AACTA, 2019). According to Addis Ababa City Transport Authority (AACTA) average frequency of public transport and number of passengers' information from December 15-20/2011E.C. Sheger City Bus transported 21,518 average passengers per day.

AACTA (2016) stated that, Addis Ababa Light Rail Transit (LRT) service started operation in 2015 with 41 trains and transports 120,000 passengers per day in both N-S and E-W direction. The service has 39 stations with 5 common interchanging stations and two main depots in Hayat and Kality ends (AACTA, 2016). According to Tagagne (2018) study, the AALRT serves an average of 97,002 passengers per day. Abdlemalik (2017) stated that, Major residential and real estate development locations at Ayat, CMC, Gurdshola and the transportation center Torhailoch are accessed through the east west LRT route. Abdlemalik (2017) discussed that, the North-South corridor is a heavily-used route; it access Africa's largest open market Merkato. This route starts from Giorgis (Piazza) in the north and heads a little distance to the west to access Merkato and Autobus Tera (the Intercity Bus Terminal) (Abdlemalik, 2017). Tagagne (2018) referred that; at the beginning AALRT office had a plan of 6-minute headway. However, due to a number of problems the headway extended up to 16-18 minutes due to lack of spare parts; shortage of electric supply; very high passenger loadings. Continuous rail crossing of vehicle and pedestrian; lack of skilled personnel and

shortage of supply decreases the frequency of the service availability in the stations (Tagagne, 2018).

3.4. Challenges of public transport service at the periphery condominium

Different challenges of the urban transport are observed in the city of Addis Ababa. Insufficient public transport service provision and limited coverage of the service are major public transport service constraints which results poor access to residence and work place, education, health and other services (FDREMT, 2011). The city has been undergoing horizontal expansion as the major form of development throughout its history including condominium residential areas (Fenta, 2014). Residential development in expansion areas are not adequately provided with mass transport to city core (AACPPPO, 2016). This is due to lack of integration between expansion areas and urban transport which is the result of poor transport planning and implementation (Hassan et al., 2018; FDREMT, 2011). In addition to lack of integration, lack of provision of appropriate road infrastructure is also a challenge for the periphery residents not access the public transport (Fenta, 2014).

According to FDREMT, (2011) the Transport Policy of Addis Ababa has outlined eleven key policy issues to address the transportation service challenges. Among these key issues which related with developments in expansion areas and transport service are;

- Integration of Land-use and Transport Plan: according to this issue expansion of residential land use development without considering the necessary transport infrastructure and services resulted inefficiencies in the transport system.
- Expansion of transport infrastructure: the coverage of transport network is inadequate compared to international standard and the existing road network is not properly utilized.
- Enhance transport service provision: the service is limited to major roads and its coverage is very low. These trends indicate that the government gives emphasis for

transportation challenges which are seen at the periphery part of the city. But to provide functional solutions for the challenges by the government, there has to be detail scientific studies to identify the intensity of the gap and to intervene accordingly. This study contributes by identifying the gabs of transit availability across the city specifically at periphery part of condominium areas using GIS as a spatial analysis tool.

CHAPTER FOUR: METHODOLOGY

4.1. Introduction

This chapter discusses about how to answer research questions and address objectives of the study. The methodology of the study includes study area selection criteria, research approach, data type and source, data collection techniques, data analysis and presentation technique. The study area selection criteria are listed why the study is undertaken in the selected city and its periphery part. In the research approach what type of research method should be used is discussed. The data type and source method describes the type of data collected from governmental and non-governmental offices .The data collection technique describes how the data was collected. Data analysis technique stated the type of method used to analyze the collected data.

4.2. Study area selection Criteria

The study was done in Addis Ababa city related with condominium areas which emphasized more on suburb part of Addis Ababa. The reason behind the study area was undertaken in Addis Ababa is that:

- The city has more number of condominiums at the periphery part
- The condominium areas have few job options
- Periphery condominium areas are located long distance to the city center
- There is high number of residents in condominium neighborhoods which demands high of public transit service and still the residents are increasing in this area
- There is limited infrastructure provision and service distribution across the city
- Condominium is built for low income, who are heavily dependent on public transportation

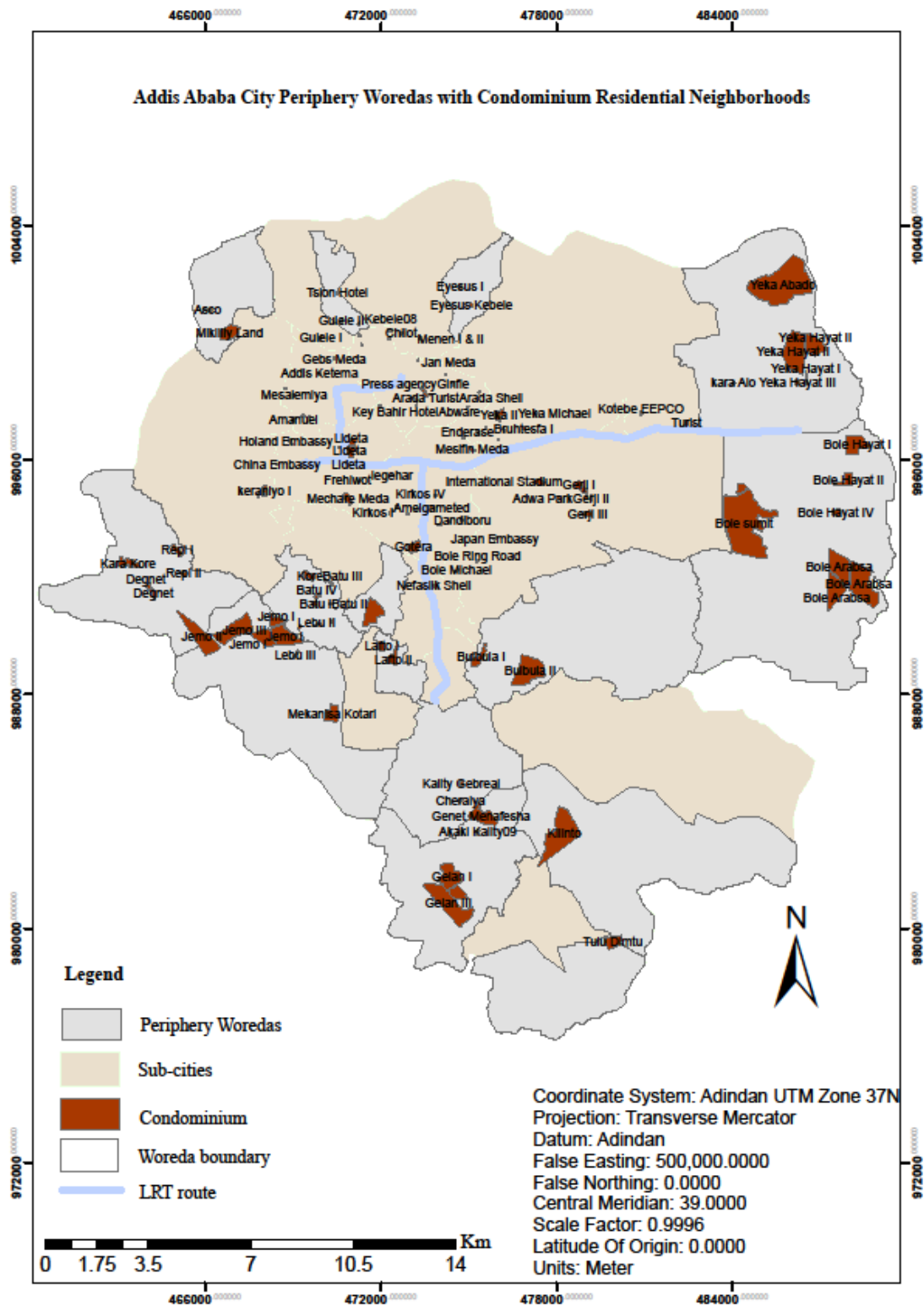


Figure 5: Addis Ababa city periphery condominium sites

Source: Addis Ababa city Transport Authority, 2019.

4.3. Research design

The outline of the research design has been illustrated in Figure below. The research problem and the objectives stated above are followed by the literature review. Next, identification of data required to deal with and solve the problem was indicated. Secondary data were acquired from different documents available at the government offices. For the collected data spatial and statistical analysis has been undertaken. After analysis the result has been discussed and based on the result conclusion and recommendation were formulated.

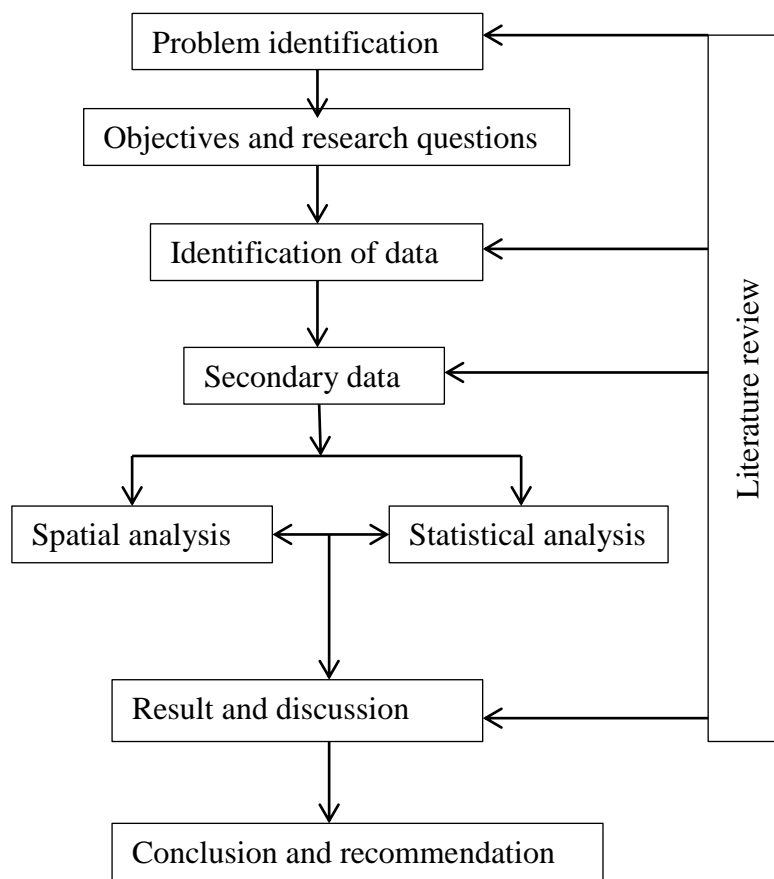


Figure 6: Research design

4.4. Research approach

The study was based on quantitative type of research. It quantifies the availability of public transit service by using caring capacity, route coverage, service frequency, number of bus and LRT, number of routes and number of transit stops. It also quantifies neighborhood

characteristics in terms of number of population, number of labor force, income level of Woreda communities and area coverage.

4.5. Data Type and Source

The study used secondary data type. The secondary data were spatial and non-spatial. Spatial data types were maps of Woreda boundaries, condominium site, transit network (Anbessa, Sheger and LRT routes) and transit stops collected from various sources. Whereas non-spatial data were demographic and socio-economic characteristics of the Woreda collected from CSA. Detail data types and sources are listed below.

Table 1: Data type and sources

Types of data	sources
Woreda boundaries map (GIS)	AA. city planning commission, 2007
Number of woredas boundary	From AutoCAD or GIS, 2007
Area coverage of each woreda	From AutoCAD or GIS, 2007
Number of populations in each Woreda	CSA, 2007
Number of labor force in each Woreda	CSA, 2016
Public transit routes (GIS file)	From LRT, Anbessa and Sheger administrative office and Addis Ababa city government transport authority office,2019
Public transit routes covers each Woreda	From public transit routes (GIS file), 2019
Public transit route length in each Woreda	From public transit routes (GIS file), 2019
Number of public transit stops in each Woreda	From public transit routes (GIS file), 2019
Number of Anbessa , Sheger and LRT services in each transit route of the city per day	From Anbessa , Sheger and LRT administrative office or Addis Ababa city transport authority office, 2019
Number of seats per Anbessa , Sheger and LRT transit services	From Anbessa, Sheger and LRT administrative offices or Addis Ababa city transport authority office, 2019

As it is listed on the above table the baseline data was prepared to calculate transit availability indexes. In order to calculate the indexes; transit vehicles per day per route (total buses arriving at a typical stop per day), design capacity, population, Woreda area, route length and the number of transit stops per Woreda were used. The correlation and regression analysis were done using variables such as income level, gender, age, and percentage of labor force participants of each Woreda in relation with transit availability indexes. The method helps to identify public transit service availability impact on the socio-economic and demographic characteristics of the Woreda. For the purpose of this study the 2007 of Addis Ababa lowest administrative units which were 99 Woredas taken as traffic analysis zone with census data. The baseline data were collected accordingly.

Bus and LRT frequency and capacity baseline data: number of buses and LRT per day per route (total buses and LRT arriving at a given stop per day) and design capacity (allowable number of passengers). Once the database for the total buses arriving at a stop per day prepared, the capacity of the bus and LRT line calculated using the following formula:

Total daily seats = Buses or LRT per day at a given stop x buses' or LRTs' number of seats (design capacity)

Route length = [length of route completely within the Woreda] + [1/2 x (length of route bordering the Woreda)]

Bus or LRT stops: the bus or LRT stops in each analysis Woreda counted in such a way that bus or LRT stops laying in the Woreda were counted as 'one'. In addition to this, stops falling along a boundary counted as a half stop in each of the bordering Woredas or it was counted as one fourth if the bus or LRT stop located at the cross intersection of Woredas.

Number of stops = [Number of bus or LRT stops completely within tract] + [1/2 x (Number of bus or LRT stop bordering the Woredas)] + [1/4 x (Number of bus or LRT stops touching 4 Woredas)]

Population and Woreda area (population density) baseline data: the 2007 Census

demographic data collected from CSA at Woreda level, and then the population is projected to 2019 without changing the 2007 administrative Woreda boundaries in order to identify the current public transit demand.

Socio-demographic data (such as gender, age, expenditure and labor force participation): the 2016 socio-economic data of the city were collected at sub-city level. In this study each sub-city socio-economic character was distributed to its smallest administrative units (Woreda) based on the current projected population proportion. Simple Regression analysis was done in relation with transit availability index. The spatial representation of socio-economic variables (expenditure level and labor force) and demographic variables (age and gender) included in the analysis using GIS.

4.6. Data Collection Techniques

The study was depended on secondary data. The techniques used to collect the data were: identifying and organizing the variables what should be collected from where; the researcher went to the sources of data which were governmental and non-governmental offices to collect hard copies and soft copies that has been related with the research variables.

In the process of data collection the researcher evaluated the suitability (contextually), reliability (level of accuracy), adequacy (availability in the desired quality and quantity) of secondary data.

4.7. Data Analysis and Presentation Technique

The study used local index of transit availability (LITA) analysis method which was introduced by the Local Government Commission of the United States to understand the

spatial distribution of transit in small communities (Woldeamanuel & Covington, 2014). This method used to show public transit service intensity or spatial distribution of transit service in Addis Ababa city specifically in the periphery part of condominium neighborhoods. The reason behind to use this method for this research was first it helps to analyze public transit quantitative data and next it helps to present the analyzed data in maps using GIS software. The method was used for Addis Ababa city Anbessa, Sheger and LRT transit services. Each of transit service route length, number of stops, frequency and number of buses or LRT were studied at Woreda level and encode in excel to produce transit availability index. For the case of this study the public transit availability in each Woreda of the city was represented as Addis Ababa bus and LRT service index (ABLSI). The analysis covered all parts of the city in Woreda unit level. For each part of the city Woreda units the ABLSI components that of public transit capacity (design capacity), frequency and coverage of the service analyzed by using census and transit data.

1. Capacity score

Capacity can be defined in different terms such as vehicle capacity; person capacity, maximum capacity, and design capacity (Gebeyehu & Takano, 2008). In this study, the design capacity of the transit vehicle was used for the analysis. The total amount of daily bus or LRT seats was calculated as a product of the total number of bus or LRT arrivals at a specific stop in the Woreda, and the number of seats on the bus or LRT.

$$C_{Wi} = \frac{BS \times l_{Wi}}{Pop_{Wi}}$$

Where, C_{Wi} = Capacity score in the i th Woreda (W); BS or LRT = Total daily bus or LRT seat (the design capacity); l_{Wi} = Route length in W_i ; and Pop_{Wi} = Population in W_i

2. Frequency score

This component referred to the headway between two consecutive buses (the waiting time for the travelers). Frequency measure was based on the total daily number of buses on all the routes that have at least one stop in the Woreda (W).

$F_{Wi} = TB \text{ or } TL$, if l_{Wi} has at least one stop in Wi ; 0, otherwise

Where, F_{Wi} = Frequency score in the i th woreda (W); and TB = Total number of buses,

TL =Total number of LRT

3. Coverage score

The bus or LRT coverage component of the transit availability analysis focused on the spatial distributions of the existing bus or LRT service, and was calculated based on the density of transit stops or stations.

$$CO_{Wi} = \frac{S_{Wi}}{A_{Wi}}$$

CO_{Wi} = Coverage score in the i th W; S_{Wi} = Number of bus or LRT stops in Wi ; and A_{Wi} = Area of the Wi

After calculating each transit availability components the next step was standardizing the scores. Since the units of measurement for each of the three scores were different, the mean and the standard deviation were calculated for every attribute (capacity, frequency and coverage) in to standardize/normalize the scores order to standardize/normalize the scores.

Standardized score for capacity = ([capacity score] - [mean of distribution])/ [standard deviation]

Standardized score for frequency = ([frequency score] - [mean of distribution])/ [standard deviation]

Standardized score for coverage = $([\text{coverage score}] - [\text{mean of distribution}] / [\text{standard deviation}]$

After standardizing the calculated values it was added together to give each Woreda transit availability index. The result converted to a spatial map using GIS to visually display the distribution of high, medium and low serviced areas by the existing bus or LRT services. The three components of transit availability were equally weighted by considering the relative importance they have to each other.

Overall score/index = standardized capacity score+ standardized frequency score + standardized coverage score

The result of each Woreda transit availability index correlated with Woredas demographic and socio-economic characteristics spatially using GIS. The strength of relation between transit availability and socio-economic characteristics of Woredas with condominium residential neighborhoods identified based on simple regression analysis method.

CHAPTER FIVE: RESULT AND DISCUSSION

5.1. Introduction

The data used for this research was secondary data and it was quantitative. The collected quantitative public transit and socio-economic data were analyzed using excel, SPSS and GIS. This chapter discusses about data description, result and discussion. It shows the evaluation of each public transit services (Anbessa, Sheger and LRT) capacity, frequency and coverage analysis (result and discussion) .The evaluation of total result of each of the transit service availability and the standardized score has been calculated at Woreda level all over the city. Finally it has been evaluated the relationship between socio-economic characteristics of periphery woredas with condominium residential neighborhoods and the standardized transit availability index of the city. As result, tables, percentages, graphs and maps were intensively utilized in presenting the findings.

5.2. Data description

In this chapter the base line data used for the analysis were public transit service, socio-economic and demographic data. For public transit service each transit services (Anbessa, sheger and LRT) route length, stops and number of transit services assigned in the provided routes with their frequency have been collected at Woreda level. These transit data were collected from GIS line map by measuring route length and counting stops from each transit route within Woredas but the number of bus assigned and its frequency were collected from each public transit offices and Addis Ababa city transport authority. For socio-economic and demographic data expenditure, labor force, age and gender have been collected and analyzed. These data are collected from 2007 CSA census and 2016 CSA socio-economic of Addis Ababa city. The 2007 census data of Addis Ababa population at Woreda level were projected using geometric increase projection method to 2019 with 3.8 annual growth rates.

5.2.1. Baseline data for capacity and frequency

Table 2: Baseline data of Anbessa bus capacity and frequency

Baseline data of Anbessa bus capacity and frequency							
	Route ₁	Route ₂	Route ₃	...	Route ₁₂₂	Route ₁₂₃	Route ₁₂₄
Buses per day(frequency)(B)	20	18	40	...	21	16	16
No. of seats per bus(S)	70	70	70	...	70	70	70
Total daily seats (BxS)	1400	1260	2800	...	1470	1120	1120

Source: Addis Ababa city transport Authority, 2019

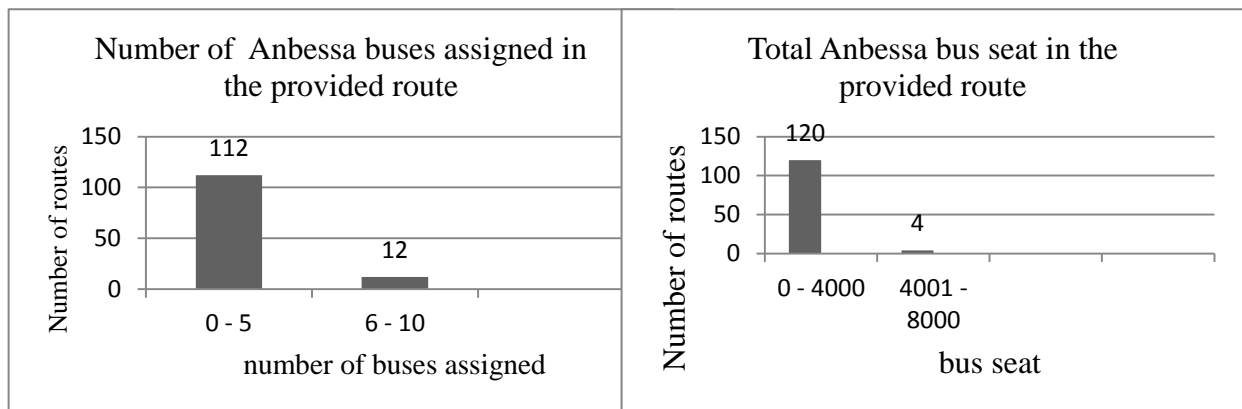


Figure 7: Number of buses assigned and total bus seat in the provided route

The above figure shows that highest number routes have 0 to 5 bus distributions whereas lowest numbers of routes have 6 to 10 bus distribution. The figure also shows the total number of bus seat per route; as it is shown 120 routes have 0 to 4000 total bus seat and 4 routes have 4001 to 8000 total bus seats.

Table 3: Baseline data of Sheger bus capacity and frequency

Baseline data of Sheger bus capacity and frequency							
	Route ₁	Route ₂	Route ₃	...	Route ₅₁	Route ₅₂	Route ₅₃
Buses per day(frequency)(B)	6	6	36	...	40	18	20
No. of seats per bus(S)	70	70	70	...	70	70	70
Total daily seats(BxS)	420	420	2520	...	2800	1260	1400

Source: Addis Ababa city transport Authority, 2019

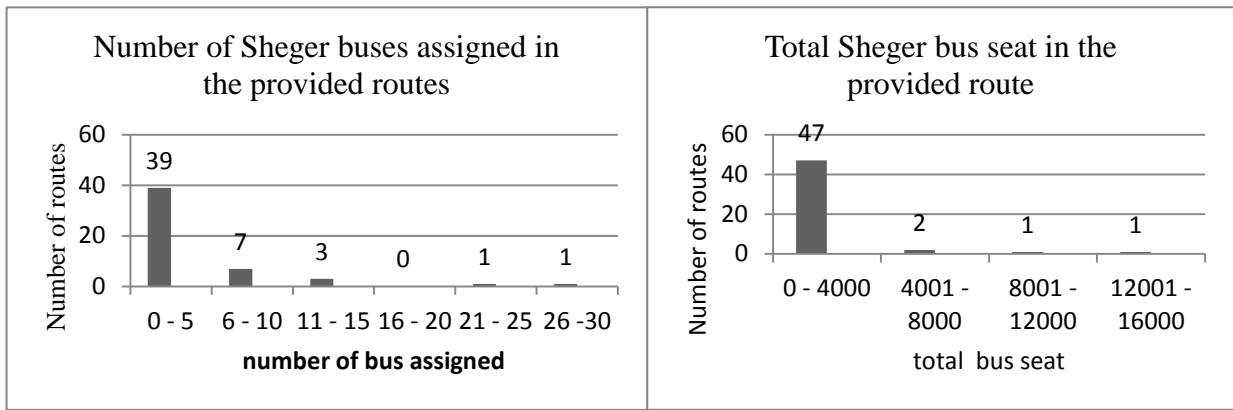


Figure 8: Number of bus assigned and total bus seat in the provided

Table 3 and figure 8 shows that 0 up-to 5 numbers of Sheger buses are assigned for 39 numbers of routes but few numbers of routes have high number of buses distribution. Again 47 routes have between 0 to 4000 total Sheger bus seat and the rest of routes have relatively high number of total bus seat.

Table 4: Baseline data for LRT capacity and frequency

	Route ₁ (E-W)	Route ₂ (N-S)
LRT per day(frequency)(L)	64	63
No. of seats per LRT tram(S)	572	572
Total daily seats(LxS)	36608	36036

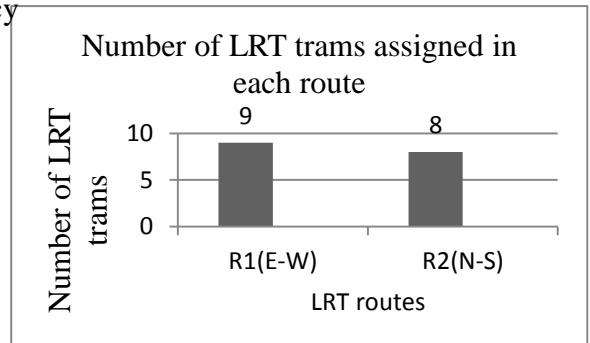


Figure 9: number of LRT trams assigned in each route

Source: Addis Ababa Light railways and railways corporation office, 2019

The data presented in table 4 shows that the east – west direction of the route has relatively high number of frequency than north - south direction and figure 5 displays the east – west direction of the route has 9 numbers trams whereas the north – south is 8.

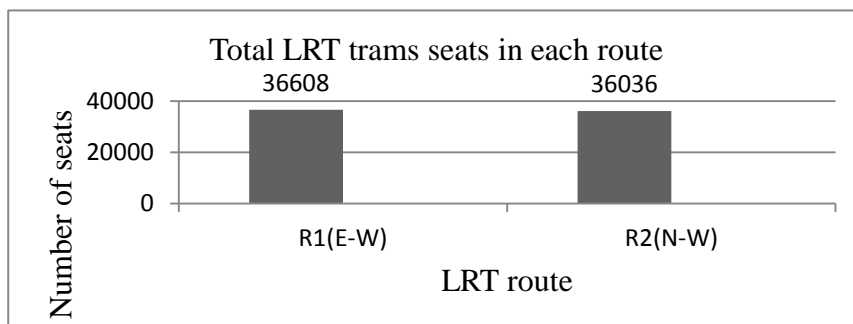


Figure 10: Total LRT tram seat in each route

Figure 10 presents that total seat of the trams for east – west direction is 36608 and north – south direction is 36036.

5.2.2. Baseline data for bus and LRT route length, stops and frequency within Woredas

Table 5: Baseline data of Anbessa bus route length, stop and frequency

Baseline data of Anbessa bus route length, stop and frequency						
Woreda ID	population	Area (sq.km)	Density (pop/area)	Route length within woreda	No. of bus stop within woreda	Total frequency within woreda
01	37120	5.26	7057	2.62	5.75	99.5
02	38322	4.42	8670	2.76	3.5	48.5
03	40869	3.23	12653	0	0	0
...
97	39844	6.11	6521	6.1	6.3	102.5
98	21860	13.47	1623	3.08	2.3	104
99	8013	29.09	275	3.18	2	24

Source: computed by the researcher, 2019

The above table 5 illustrates sample of the 99 woredas data; mainly it shows Anbessa bus route length, stops and frequency.

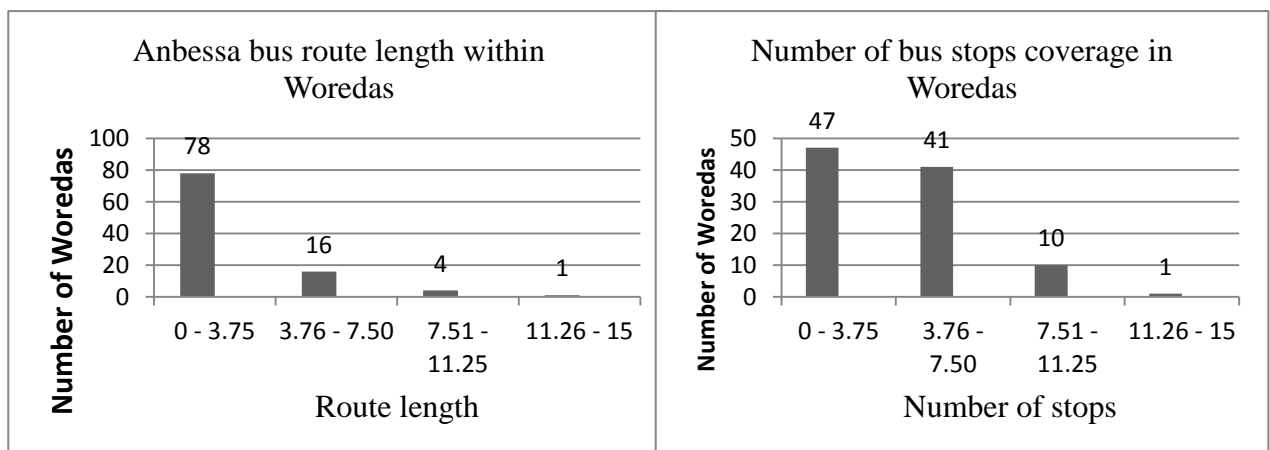


Figure 11: Anbessa bus route length and coverage in woredas

The above figure 11 data shows that 78 numbers of Woredas which is the highest proportion have route length within 0 to 3.75 range whereas the remaining woredas have relatively high route coverage. Related with number of stops the figure shows that 47 woredas have 0 to 3.75 numbers of stops which is relatively low than the remaining few woredas number of stops coverage.

Table 6: Baseline data of Sheger bus route length, stops and frequency

Baseline data of Sheger bus route length, stop and frequency						
Woreda ID	population	Area (sq.km)	Density (pop/area)	Route length within woreda	No. of bus stop within woreda	Total frequency within woreda
01	37120	5.26	7057	0.62	1.3	665
02	38322	4.42	8670	0.34	1.5	19.5
03	40869	3.23	12653	0	0	0
...
97	39844	6.11	6521	4.67	3.5	69
98	21860	13.47	1623	0.32	0.5	34.5
99	8013	29.09	275	5.66	4	58

Source: computed by the researcher, 2019

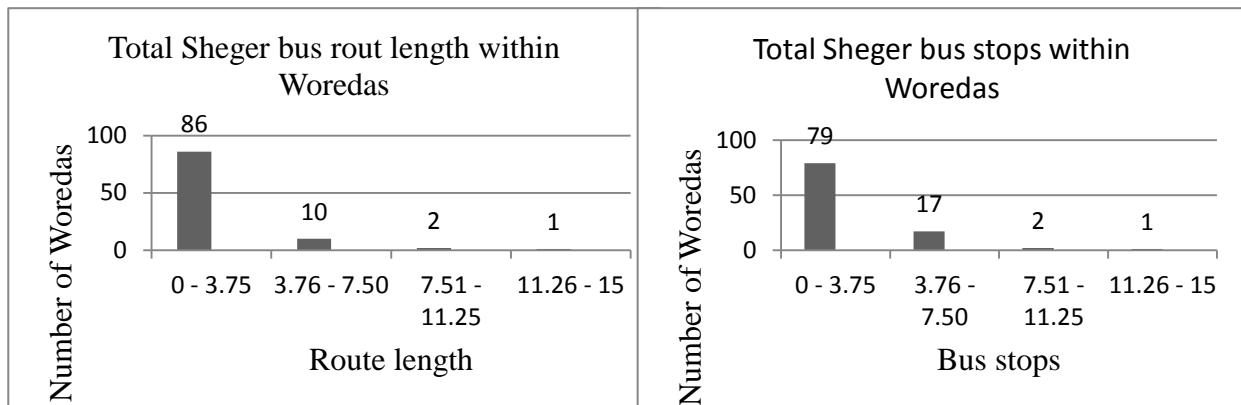


Figure 12: sheger bus route length and bus stops within Woredas

Table 6 describes about mainly the 99 woredas of Sheger bus route length and bus stops coverage. Based on figure 12 around 86 woredas have route length between 0 and 3.75 range, 10 woredas have route length between 3.76 up-to 7.50 range whereas the remaining woredas have relatively high route length. Related with Woredas bus stop coverage; 79

woredas have 0 to 3.75 stops and 17 woredas have between 3.76 up-to 7.50 range stops coverage. The rest woredas have relatively high number of stops coverage.

Table 7: Baseline data of LRT route length, stop and frequency

Baseline data of LRT route length, stop and frequency						
Woreda ID	population	Area (sq.km)	Density (pop/area)	Route length within woreda	No. of LRT stops within woreda	Total frequency within woreda
01	37120	5.26	7057	0	0	0
...
25	38322	4.42	8670	1.71	1	32
26	40869	3.23	12653	0.59	1.5	32
...
83	39844	6.11	6521	0.77	0.5	32
84	21860	13.47	1623	1.58	1.5	32
...
99	8013	29.09	275	0	0	0

Source: computed by the researcher, 2019

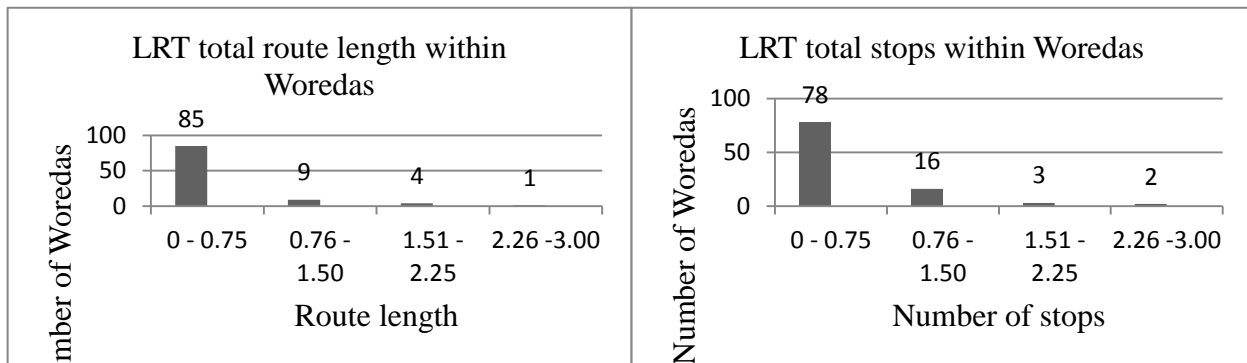


Figure 13: Total LRT route length and stops within woredas

Table 7 describes mainly LRT route length and stops data within 99 woredas. The figure 13 shows that 85 Woredas have between 0 and 0.75 route length, 9 Woredas have between 0.76 and 1.50 route length; whereas the remaining Woredas have relatively high route length. The figure also shows total LRT stops within Woredas; 78 woredas have between 0 – 0.75 number of stops, 16 Woredas have between 0.76 – 1.50 stops and the remaining woredas have relatively high number of stops coverage.

5.2.3. Baseline data of statistical analysis

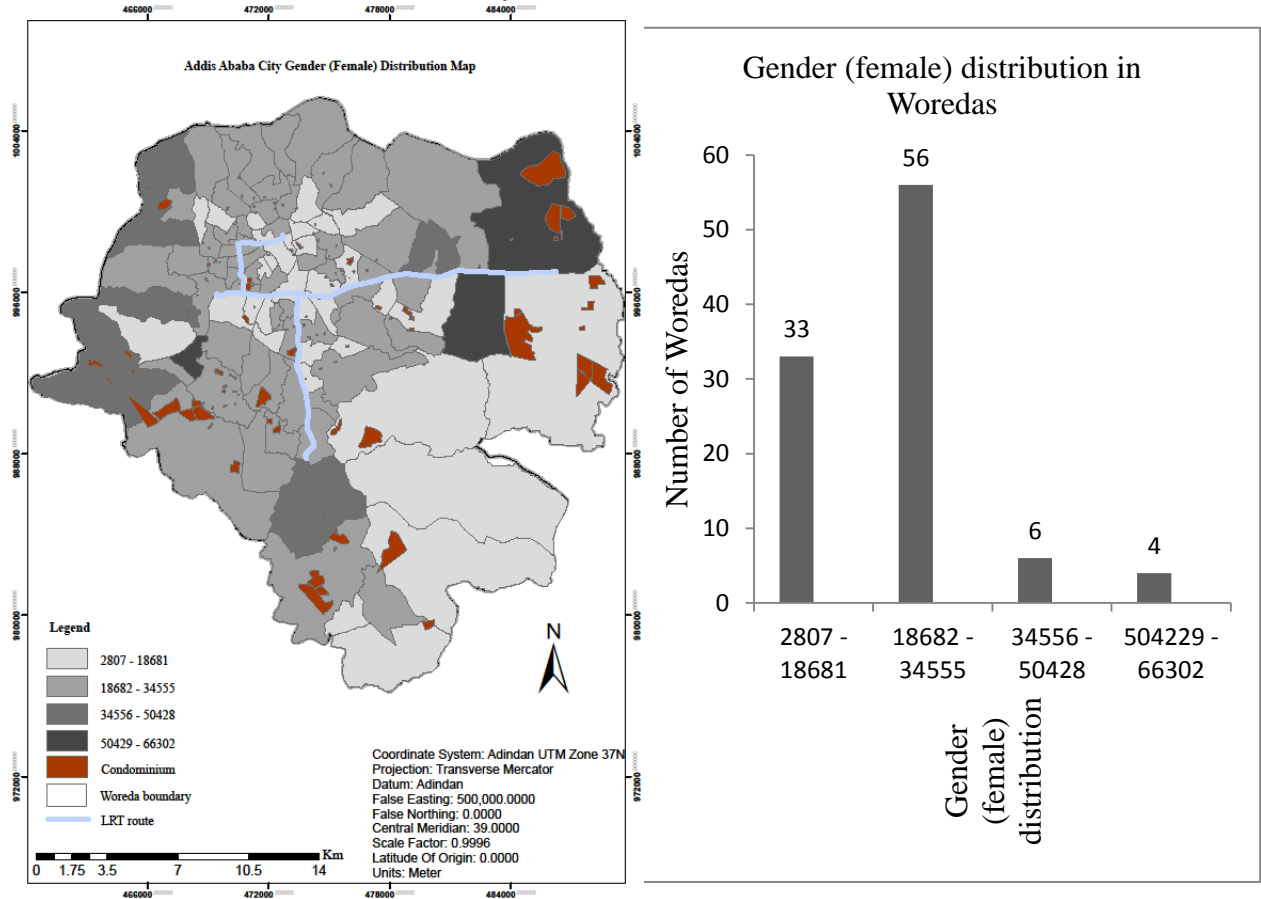


Figure 14: Gender (female) distribution in woredas

The map and bar graph (figure 14) shows that 56 woredas have 18682 - 34555 female distribution which is presented on the map with light grey color, 33 woredas have 2807 - 18681 female, 6 Woredas have 34556 - 50428 female and 4 Woredas have 504229 - 66302 number of female distribution which is indicated on the map with dens black color. The map color intensity shows that some periphery woredas have medium and high gender (female) distribution whereas the remaining part of the city indicated on the map have low and very low female distribution intensity. In the other way low and very low female distribution intensity indicates that there is high male distribution.

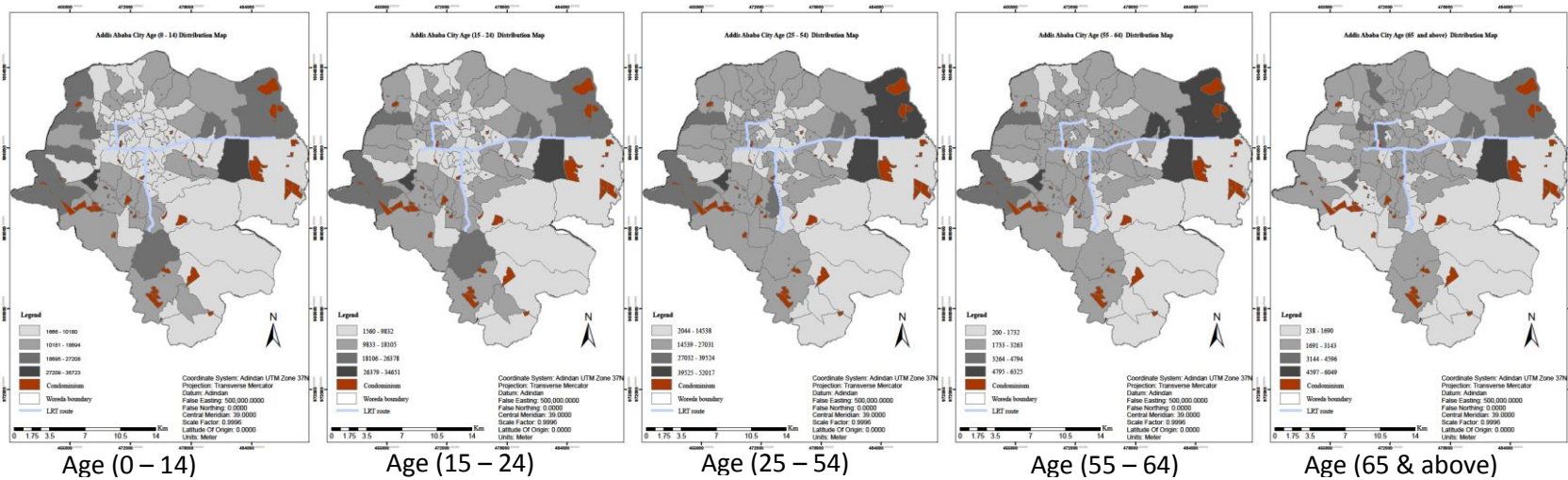
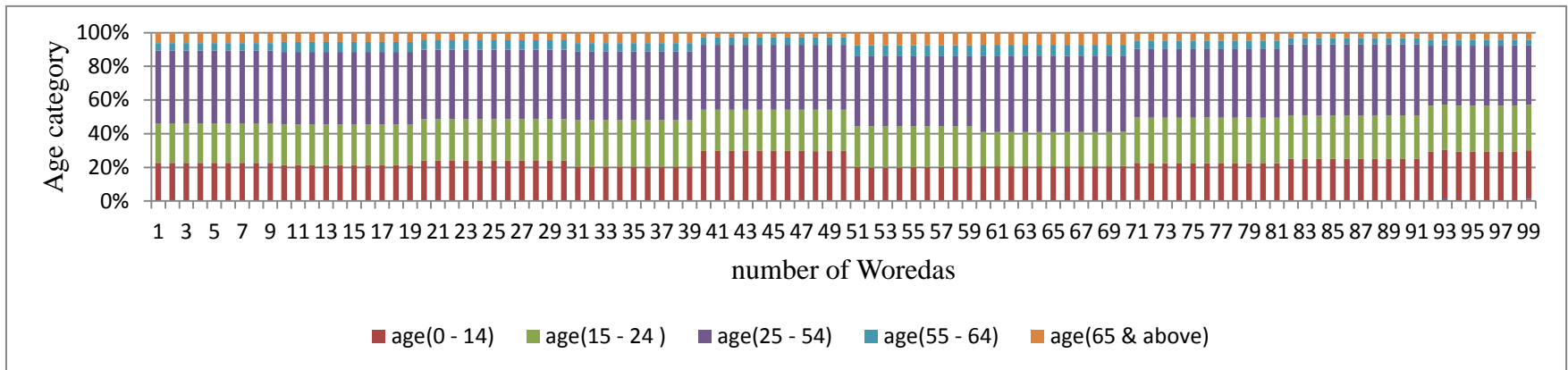


Figure 15: Age distribution within Woredas

The map shows distribution and intensity of each age category in all Woredas. The bar graph (figure 15) presents that age between 25 to 54 category populations covers highest proportion, age between 0 to 14 and age between 15 to 54 categories takes the next proportion; the rest age categories takes small proportion relatively.

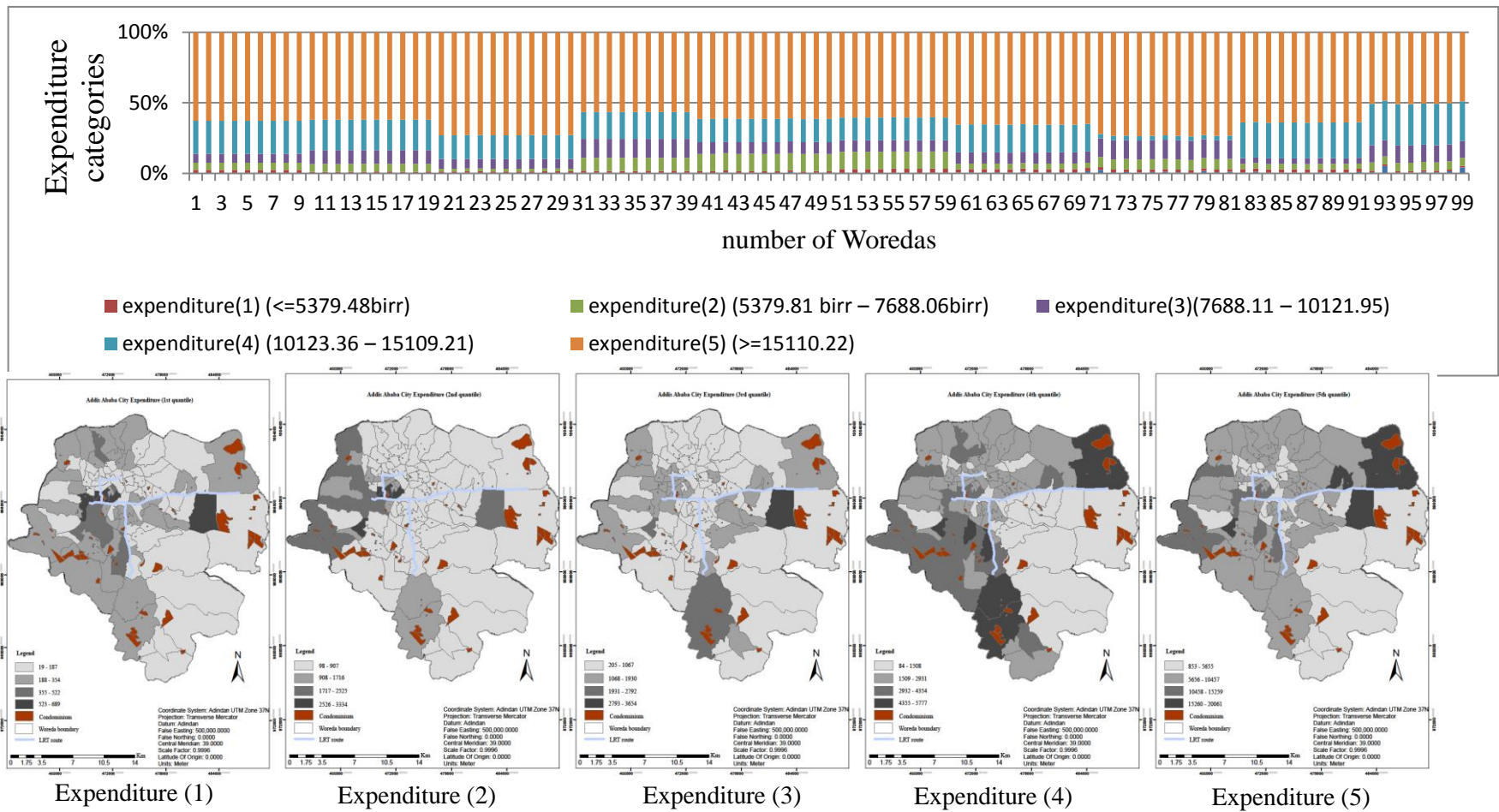


Figure 16: Expenditure distribution in Woredas

The map describes about intensity of each expenditure category distribution across the Woredas and the bar graph shows expenditure proportion of the population in each Woredas. According to the bar graph (figure 16) expenditure (5) takes the largest proportion and expenditure (4) takes the second proportion which indicates high income population whereas the rest expenditures which indicate medium and low income group are small in proportion.

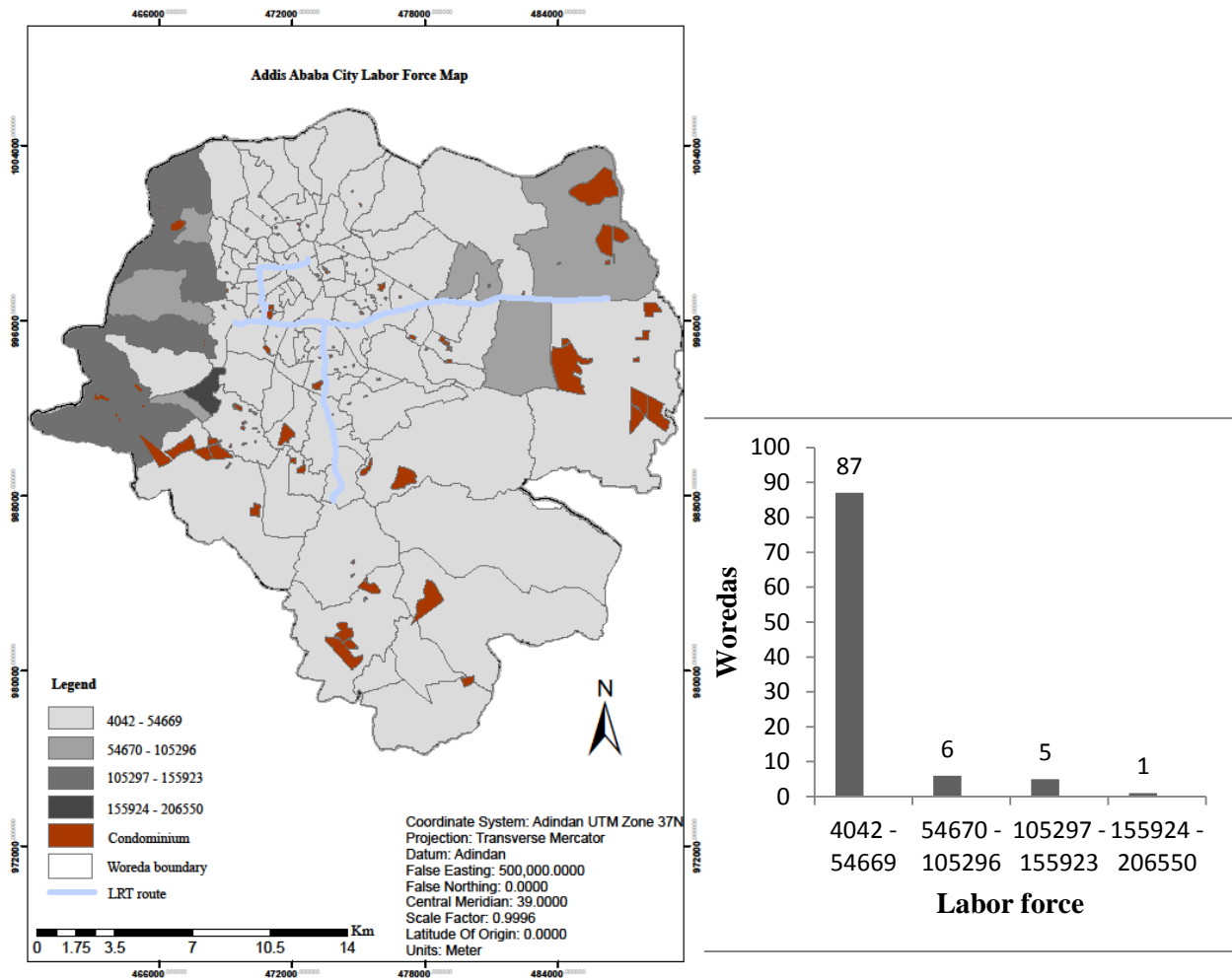


Figure 17: Labor force distribution in Woredas

In Figure 17 the bar graph shows that 87 woredas have 4042 to 54669 labor forces, 6 Woredas have 54670 to 105296 labors force, 5 Woredas have 105297 to 155923 labor force and one woreda has the maximum labor force distribution. The map also displays intensity of labor force distribution across woredas. According to the map west and east direction of the city Woredas have low, medium and high intensity of labor force whereas the rest part of the city woredas have very low labor force intensity.

5.3.Result on capacity, frequency and coverage

The spatial analysis includes the three public transit services frequency, capacity and coverage within the city of Addis Ababa at Woredas level. In the spatial analysis maps were produced Using GIS to show the service distribution across the city woredas. The maps were displayed in four equal interval quantities of graduate colors to show the public transit service intensity. The graduate colors starting from dense black to light gray represents high service intensity, intermediate service intensity, low service intensity and almost no service in the traffic analysis zone (woreda). The spatial analysis also presented by graphs in addition to maps.

The result of transit availability index is compared with socio economic and demographic characteristics of woredas using graphs with simple regression equations to show the relationships of each two variables. In addition to that periphery woredas with condominium residential neighborhoods are identified and this Woredas are analyzed in-terms of transit availability index and socio-economic characteristics of Woredas. The result of relationship between socio-economic characteristics of periphery woredas with condominium residential neighborhoods and public transit availability index of the city are compared and contrasted each other. Therefore, the result of relationship shows the positive and negative impact of the index over the Woreda demographic and socio-economic characteristics.

The analysis clearly responds the three objectives of the study. The first objective was to evaluate public transit availability; the second objective was evaluating the intensity of public transit availability difference between the city center and periphery city areas and the last objective was about the socio-economic impact of the public transit availability at the suburb condominium neighborhoods of Addis Ababa. The result of the objective are presented and discussed as follows.

5.3.1. Anbessa bus frequency, capacity and coverage score

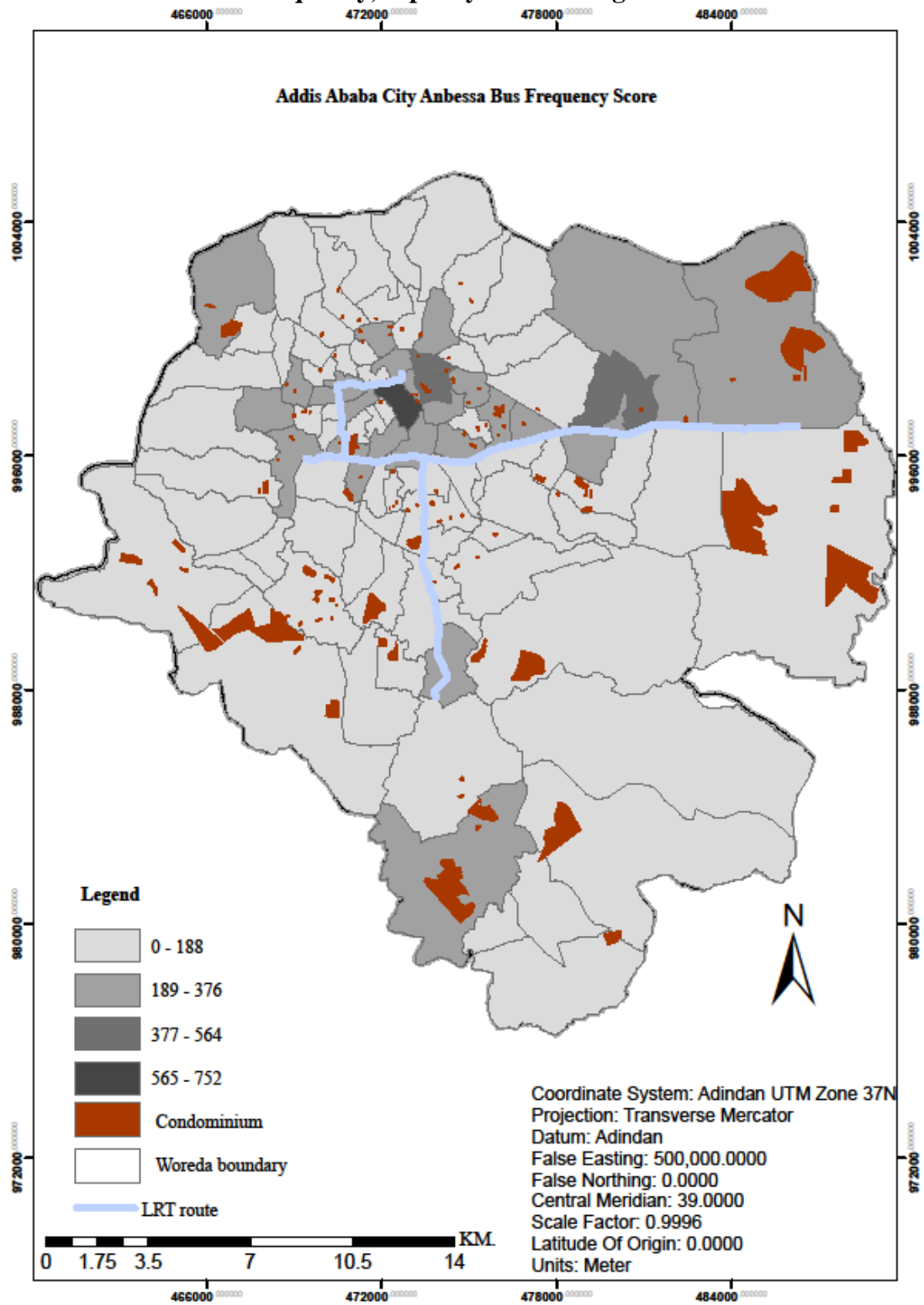


Figure 18: Anbessa Bus Frequency Score Distribution across Addis Ababa city Woredas

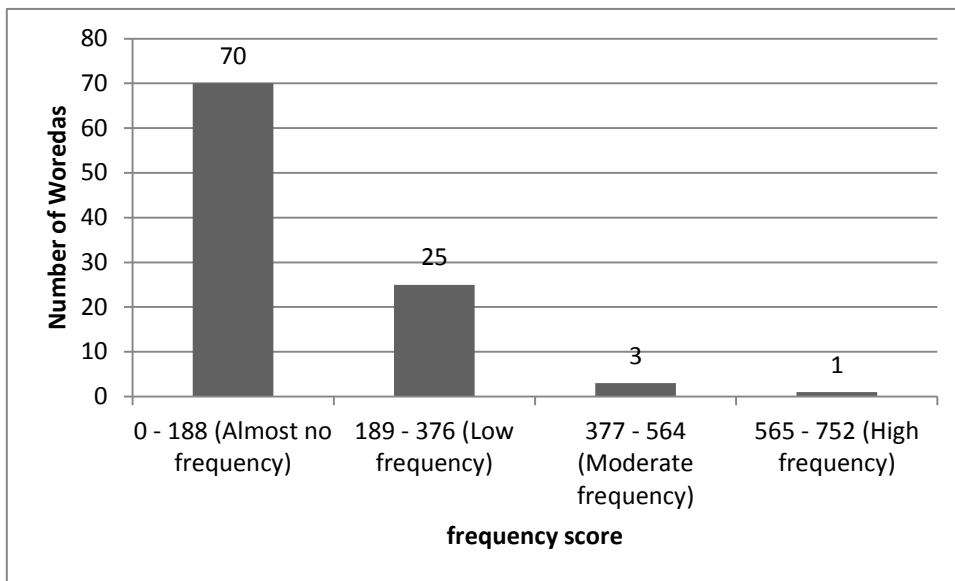


Figure 19: Anbessa Bus Frequency Score Distribution across Addis Ababa City Woredas

According to figure 18 and 19 Anbessa bus frequency map and bar graph shows large part of the city woredas as presented on the graph (70 woredas) has less or almost no transit frequency. Low frequency of the bus service availability is dispersed in 25 woredas of the city. These low frequency of the service showed in south part of the city around Saris and Kality, in the North - East part of the city around Yeka Abado, in North - West part of the city around Torhayloch and Asco, in the North part of the city around Addisu Gebeya, the rest low frequency service are visible in inner part of the city. Moderate frequency of the service showed around Shiromeda and Karalo. High frequency service is showed around Piassa.

Most Woredas of the city with condominium residential neighborhood as shown on the map have almost no Anbessa bus service frequency. However few Woredas with condominium residential neighborhood around North – East, North - West and south direction of the city have low Anbessa bus service frequency.

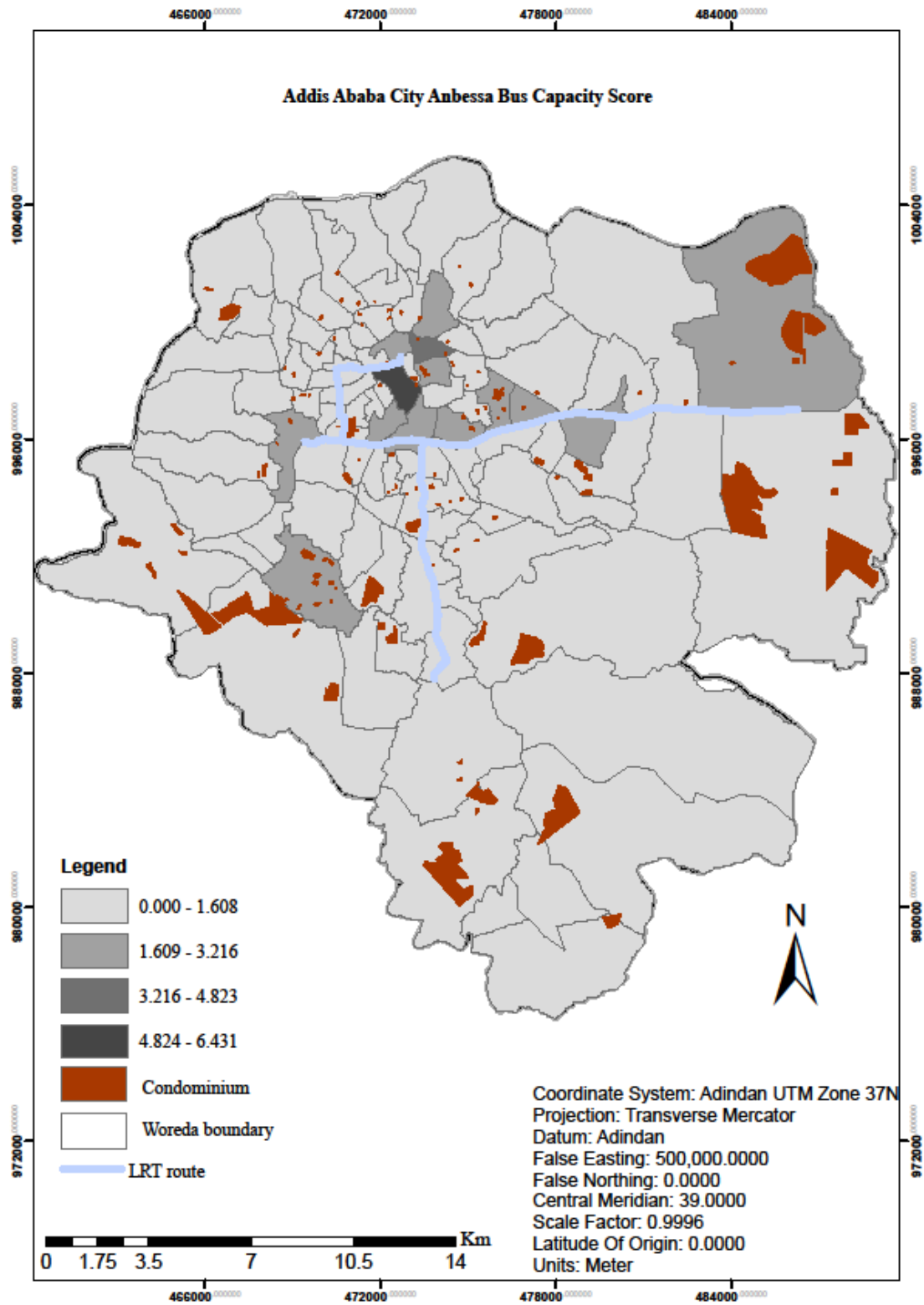


Figure 20: Anbessa bus capacity score distribution in the city Woredas

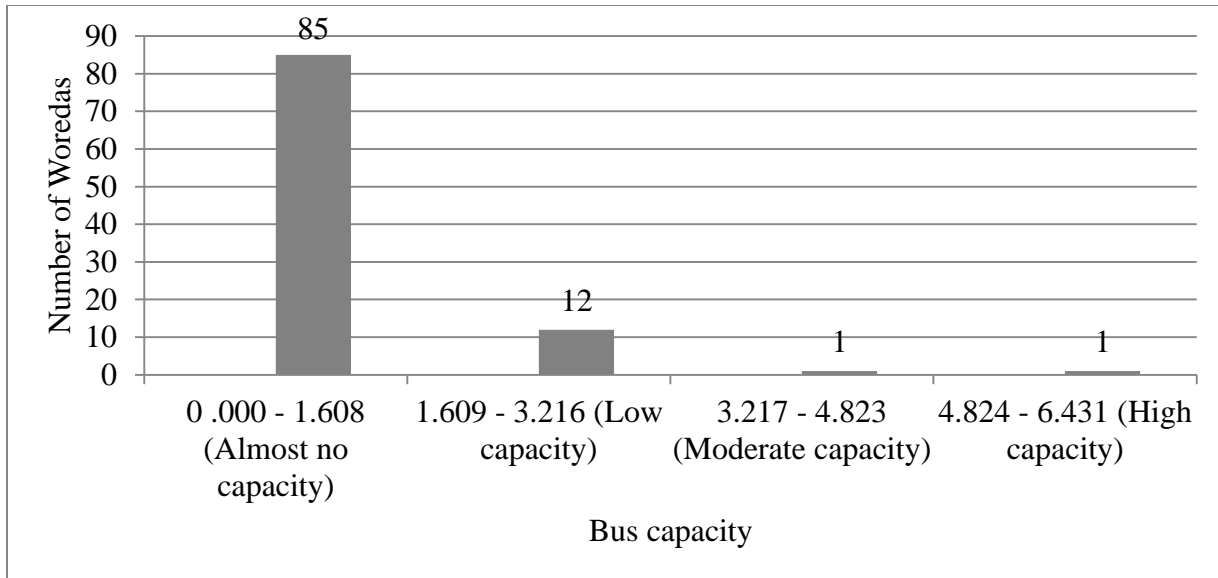


Figure 21: Anbessa bus capacity score distribution in Addis Ababa city Woredas

The bus capacity score is the amount of relationship between public transit service and population in woredas. According to the map (figure 20) and bar graph (figure21) 85 Woredas have almost no capacity score which is presented on the map with light grey color , 12 Woredas have low capacity score , one Woreda has moderate capacity score and one Woreda has high capacity score with dense black color which is located around Piassa on the map.

Periphery woredas with condominium residential areas have almost no Anbessa bus capacity score except Woredas around Jemo and Yeka Abado condominium residential neighborhoods.

The result indicates that most Woredas of the city including periphery residential neighborhoods have high population proportion with low total number of anbessa bus distribution. Hence the existing quantities of Anbessa buses are less in providing the transit service for the available population size in most woredas.

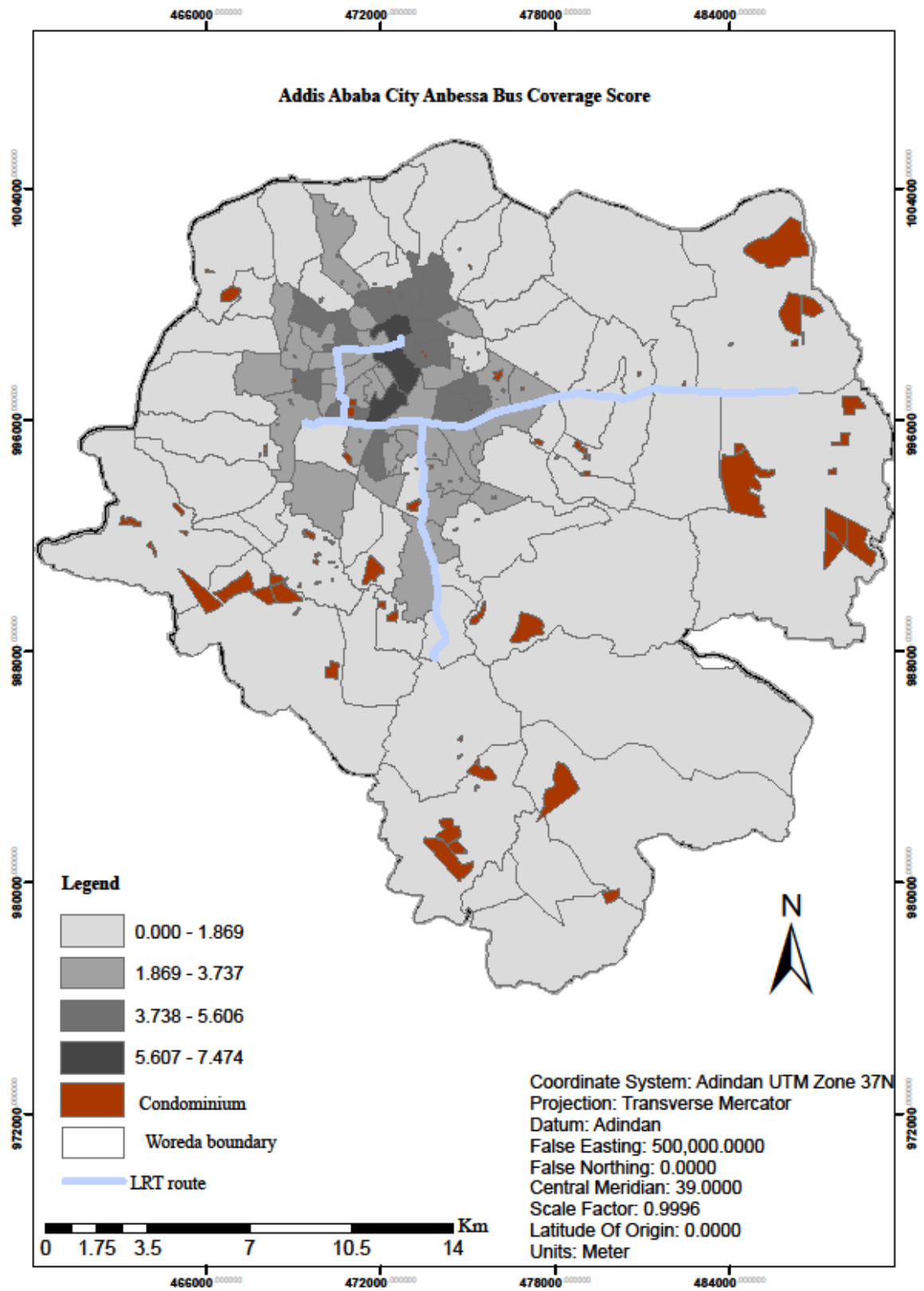


Figure 22: Anbessa bus capacity score distribution in Addis Ababa city Woredas

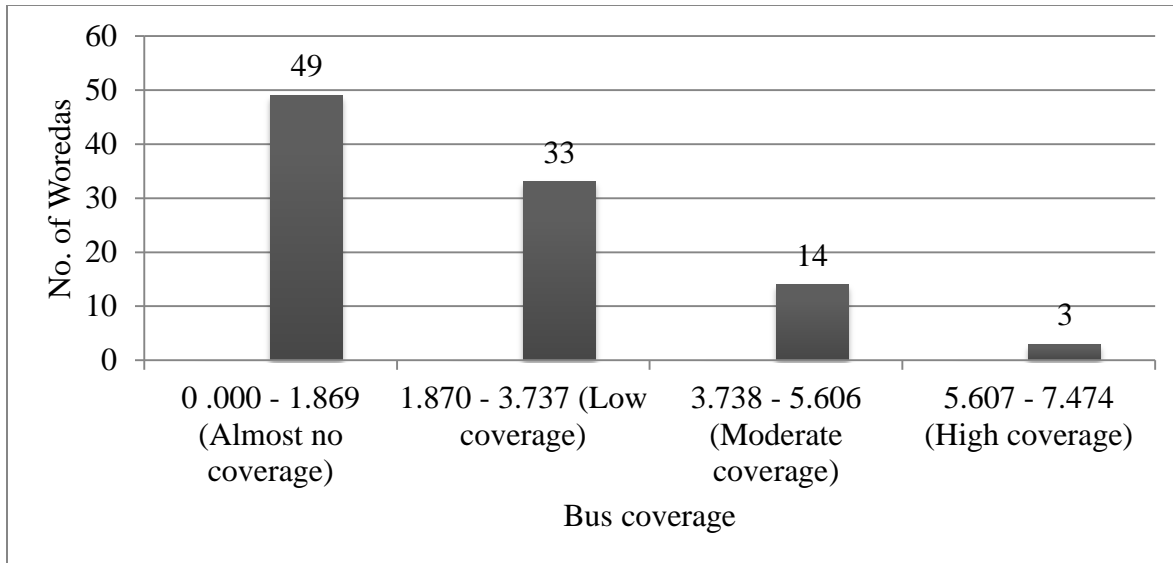


Figure 23: Anbessa bus coverage score distribution in Addis Ababa city Woredas

Bus coverage score shows density of transit services in each woredas or it explains how much numbers of stops are available in square kilometer within transit analysis zone (Woreda). Based on this fact the map (figure 22) and the bar graph (figure 23) shows that 49 Woredas have almost no Anbessa bus coverage, 33 Woredas have low coverage and 14 Woredas have high coverage.

The map clearly presents the inner part of the city Woredas have low to high Anbessa bus coverage score whereas the rest of the city Woredas have almost no service coverage. Therefore there is no periphery woredas with condominium residential neighborhoods lays in low to high Anbessa bus coverage score.

The result of Anbessa bus coverage indicates that the numbers of stops within periphery woredas are low. These periphery Woredas are not well covered in number of stops in relation with its size. However, the inner city's Woredas relatively have better Anbessa bus service distribution in-terms of density of stops.

5.3.2. Sheger bus frequency, capacity and coverage score

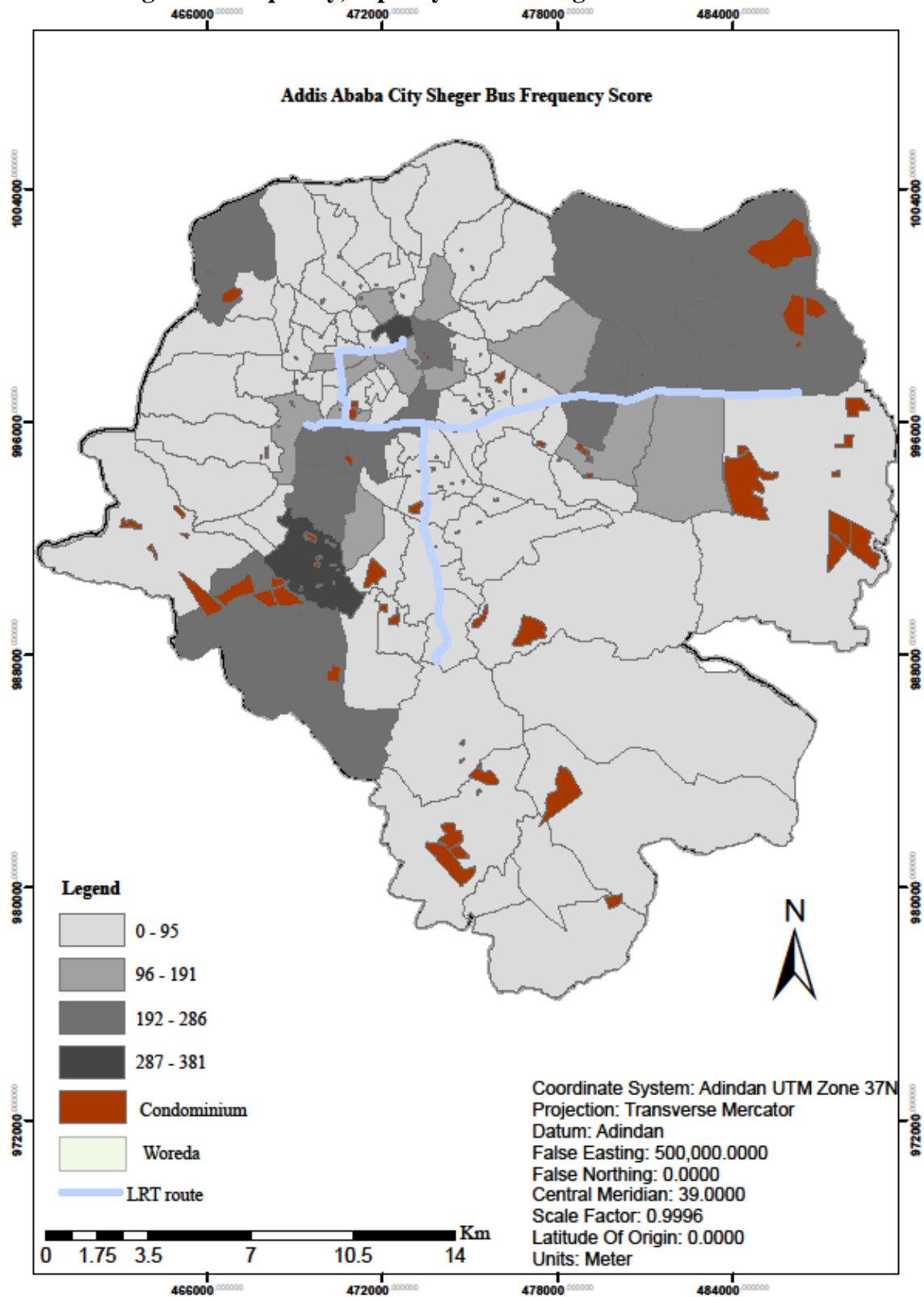


Figure 24: Sheger bus frequency distribution in Addis Ababa city Woredas

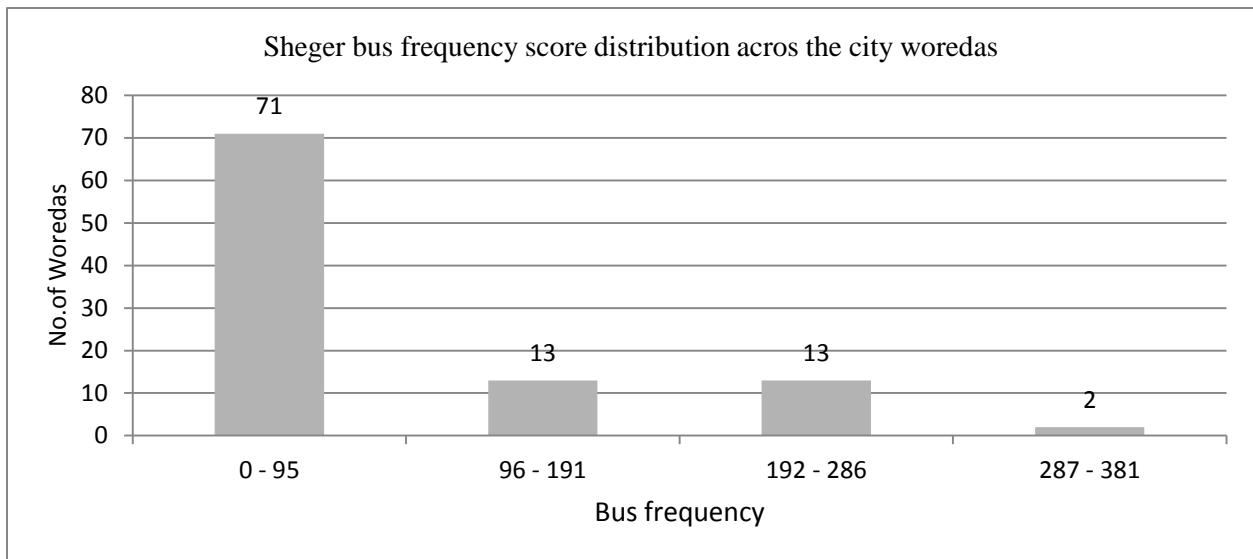


Figure 25: Sheger bus frequency score distribution in Addis Ababa city Woredas

According to the bar graph (figure 25) 71 Woredas presented almost no frequency, 13 Woredas have low frequency and moderate frequency and two Woredas have high frequency. The bar graph results are also shown on the map (figure 24); according to the map most Woredas are displayed in light grey color which represents almost no Sheger bus frequency. However few Woredas in North – East and South – West direction of the city Woredas have Moderate bus frequency distribution.

Sheger bus has better frequency distribution in Jemo and Yeka Abado condominium residential neighborhoods which are located in the city Periphery Woredas. Nevertheless, the rest condominium residential neighborhoods are almost not covered by the bus frequency distribution as presented on the map (figure 24).

Sheger bus frequency score result indicates that, the number of buses arriving in Woredas where Yeka Abado and Jemo condominium residential neighborhoods located are Moderate. However, Sheger bus in the remaining woredas has less movement.

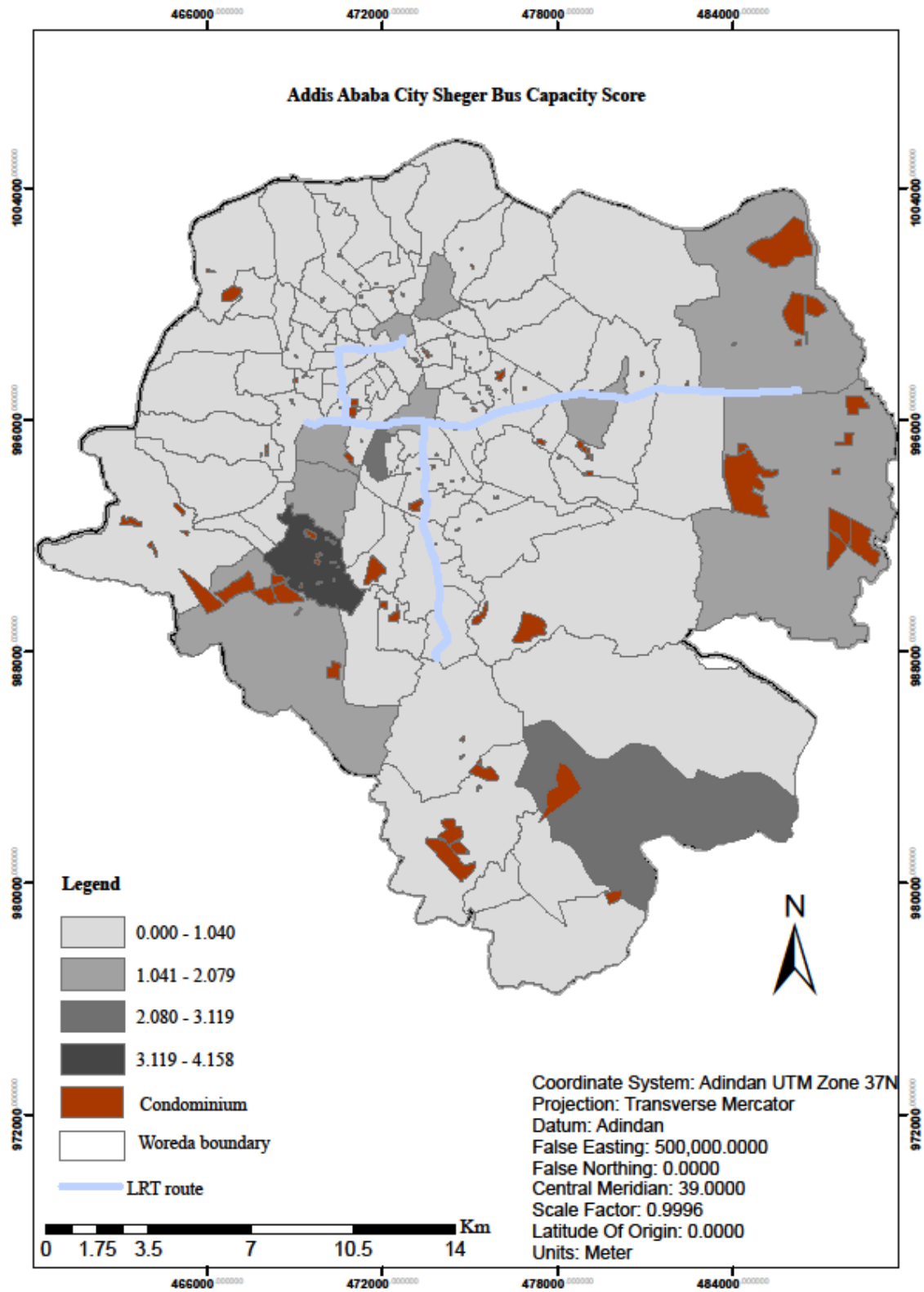


Figure 26: Sheger bus capacity score distribution in Addis Ababa city Woredas

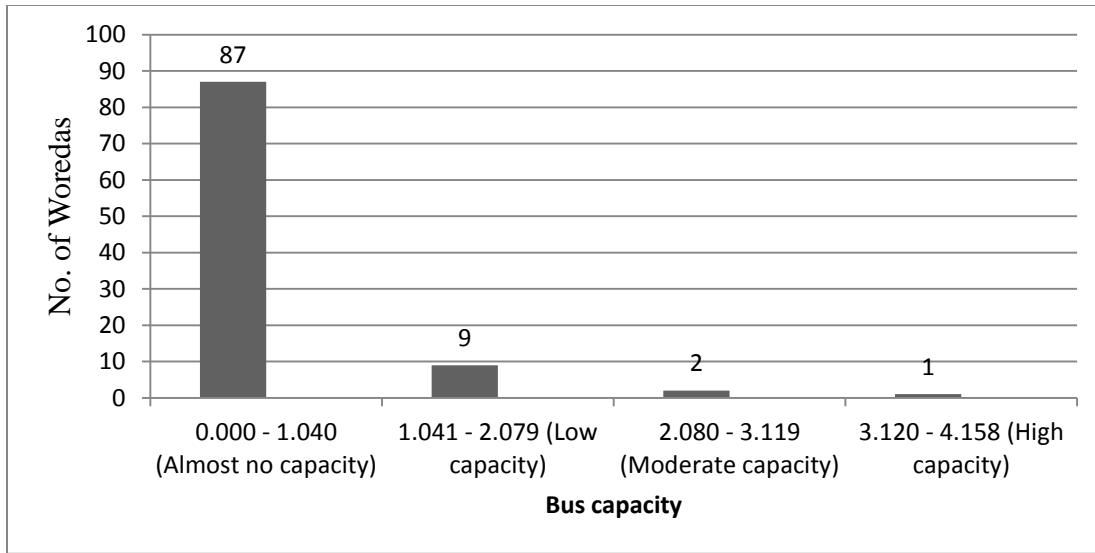


Figure 27: Sheger bus capacity score distribution in Addis Ababa city Woredas

The figure 27 shows that 87 Woredas are identified with almost no capacity score, 9 Woredas have low capacity, two Woredas have moderate capacity and one Woredas has high capacity score of Sheger bus service. The result is also presented by the map (figure26); it shows most Woredas are within light grey colors which are high in proportion, the East and south - west direction of periphery Woredas are within low bus capacity score. Moderate capacity score distribution is observed on the map in the south direction of the city.

According to the map (figure26) most periphery condominium sites are covered with low capacity score and one condominium residential neighborhood have moderate capacity score. The remaining Woredas with condominium residential neighborhoods lay with almost no capacity score distribution.

Therefor Sheger bus capacity score result indicates that relatively better numbers of bus are available in periphery Woredas than in the inner city woredas. Nevertheless, these Woredas are still has low capacity score.

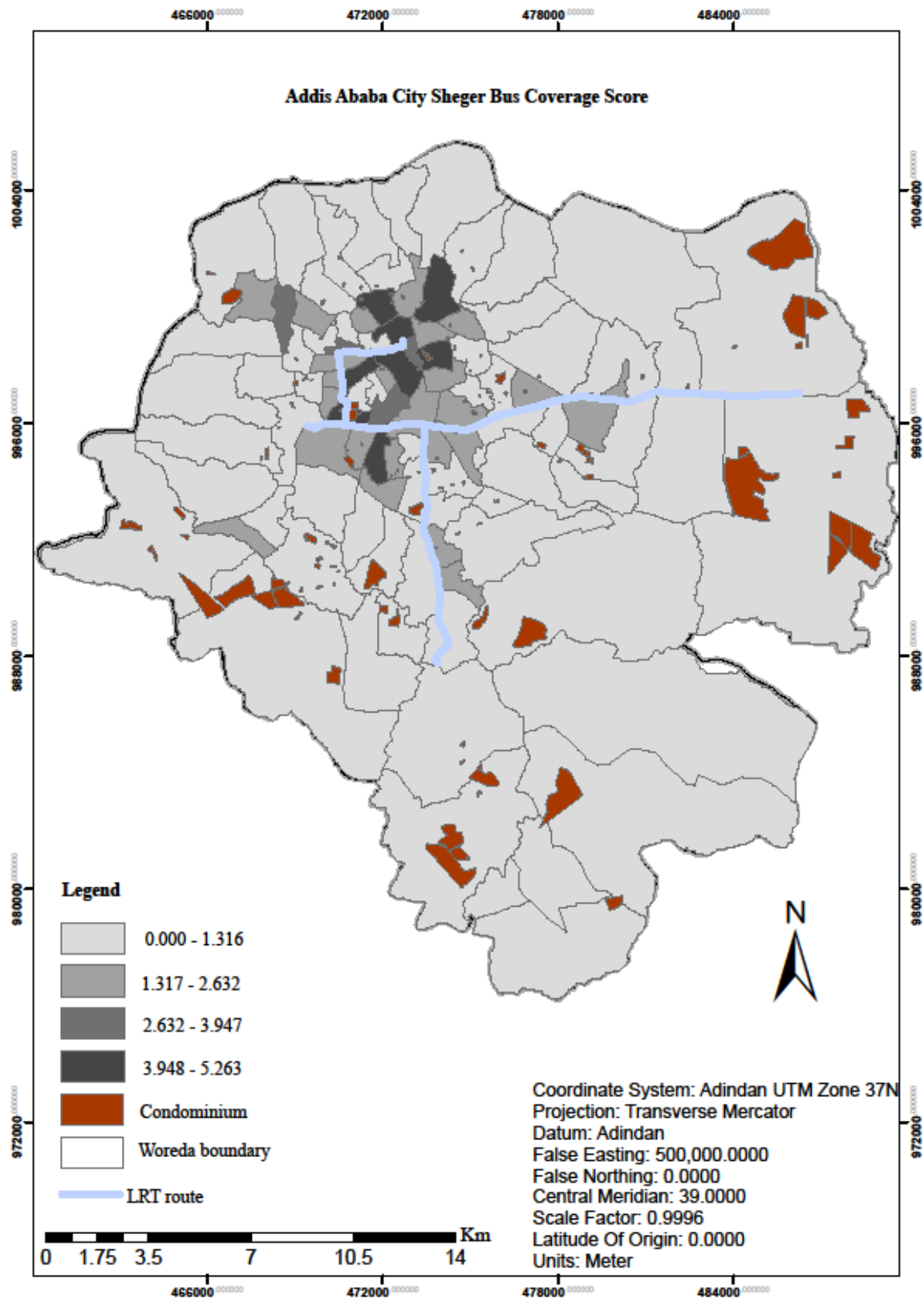


Figure 28: Sheger bus capacity score distribution in Addis Ababa city Woredas

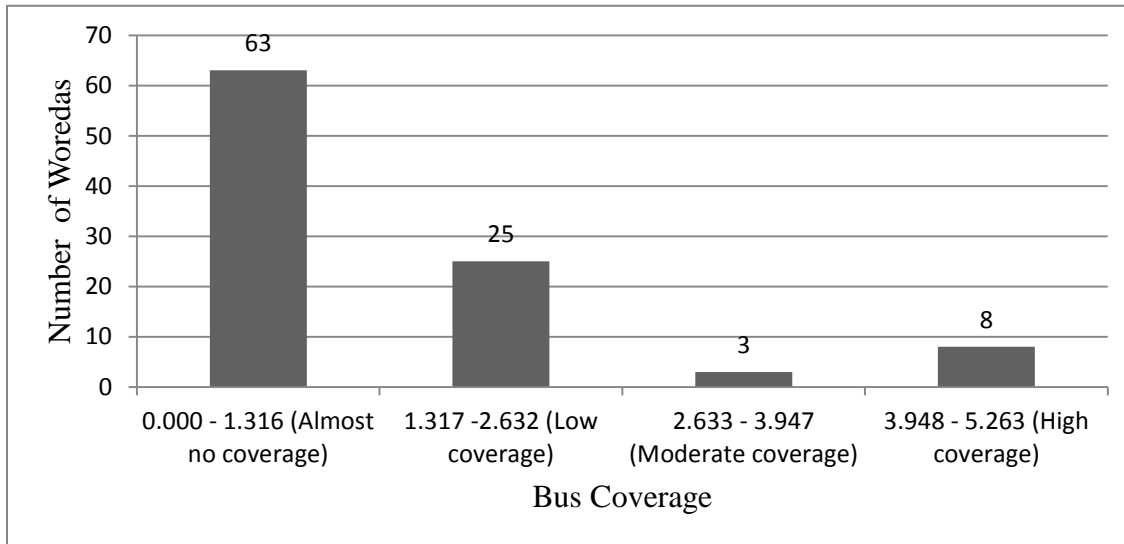


Figure 29: Sheger bus coverage score distribution in Addis Ababa city Woredas

The coverage score of sheger bus as it is shown on the graph (figure 29) 63 woredas lay in almost no frequency, 25 Woredas have low frequency score, three Woredas have moderate frequency score and 8 Woredas have high frequency score.

The map (figure 28) presents the coverage score distribution in graduate color from light grey to dense black. According this map better coverage score is shown in inner city Woredas whereas the rest of the city woredas including the periphery woredas lay in light grey color which represents almost no coverage score. As a result, condominium residential neighborhoods within these Woredas have very low coverage score.

The result of Sheger bus coverage score indicates that the density of bus stops in relative with the sizes of Woredas is very low in periphery Woredas of the city. Nevertheless, the bus service coverage in inner city Woredas has better intensity.

5.3.3. LRT frequency, capacity and coverage score

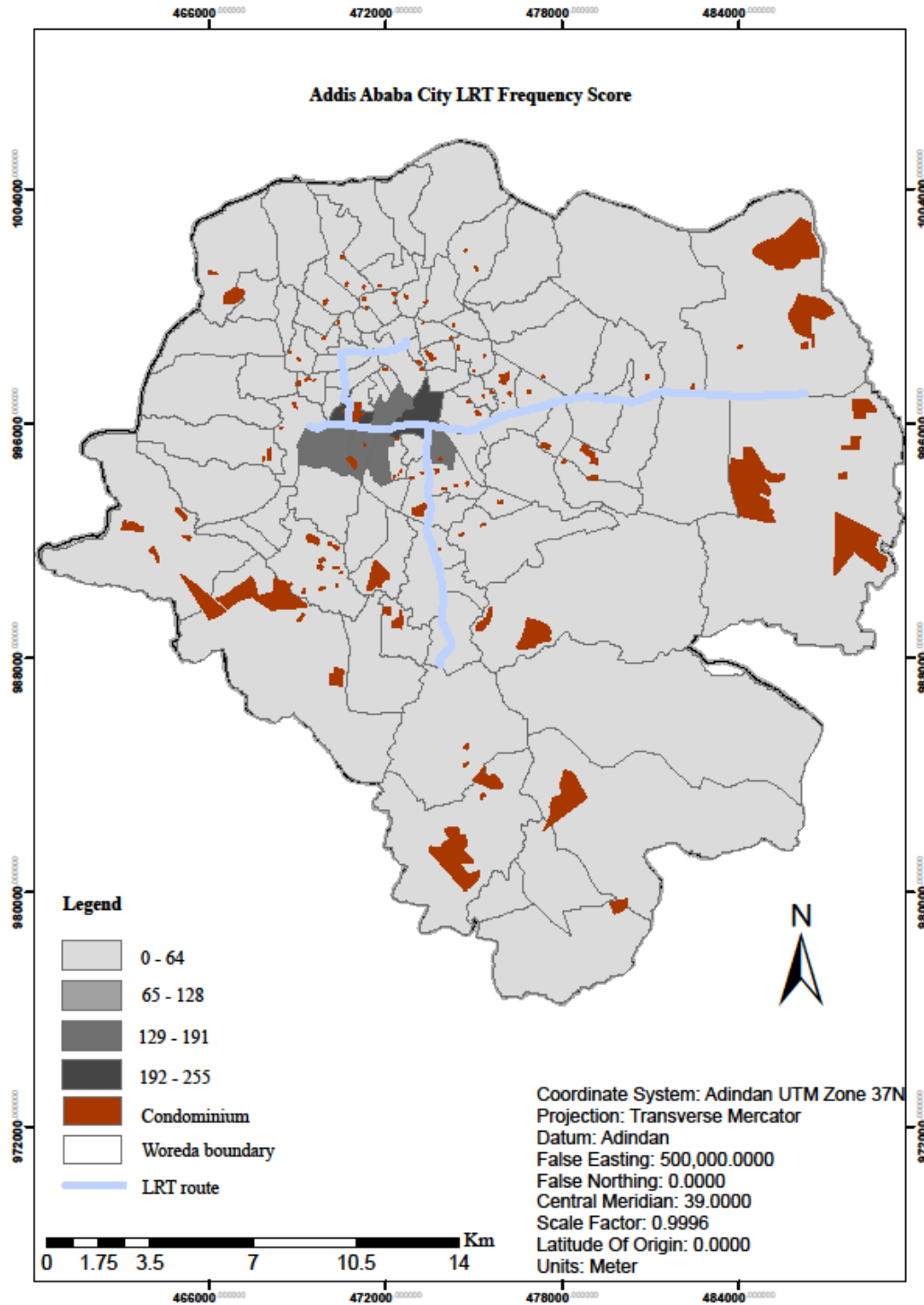


Figure 30: LRT frequency score distribution in Addis Ababa Woredas

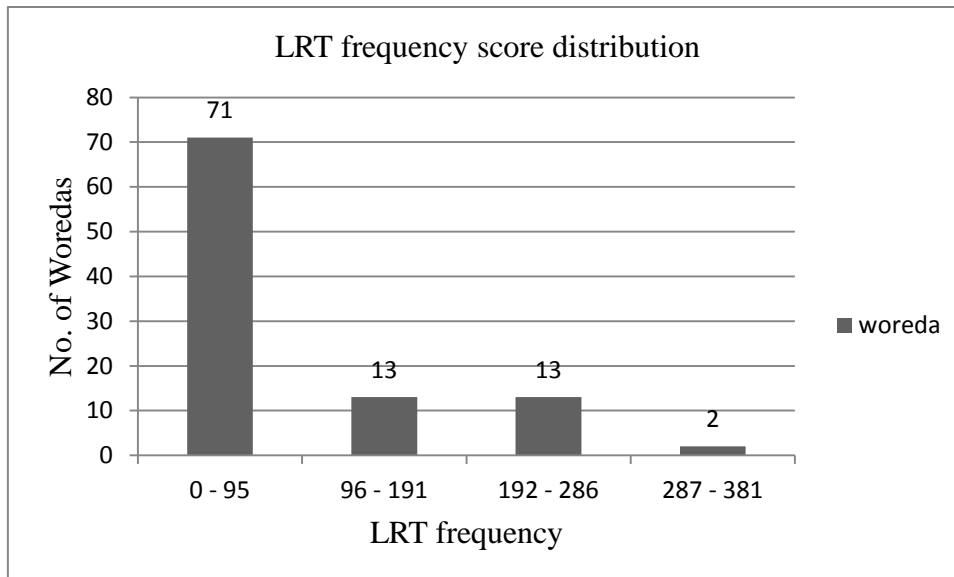


Figure 31: LRT frequency score distribution in Addis Ababa Woredas

According to figure 31 the LRT frequency score result indicates that 92 Woredas are represented in very low or almost no frequency score, 4 Woredas have low frequency score, one Woreda has moderate frequency score and two Woredas have high frequency score. The bar graph (figure 31) LRT frequency result is also displayed in the map (figure 30) except few Woredas in the inner city all Woredas lays in light grey color which represents almost no LRT service frequency. The LRT frequency score which are represented in high and low values in the inner city Woredas are observed. These observable frequency score distribution is found in the overlapped route from Stadium to Lideta.

The East – West LRT route is a bit close to periphery Woredas residential condominium neighborhoods than North – South route. However, the LRT frequency score is very low in these Woredas like most Woredas of the city.

The LRT frequency score distribution result indicates that the number of LRT trams with its headway time arrived in each station is not sufficient.

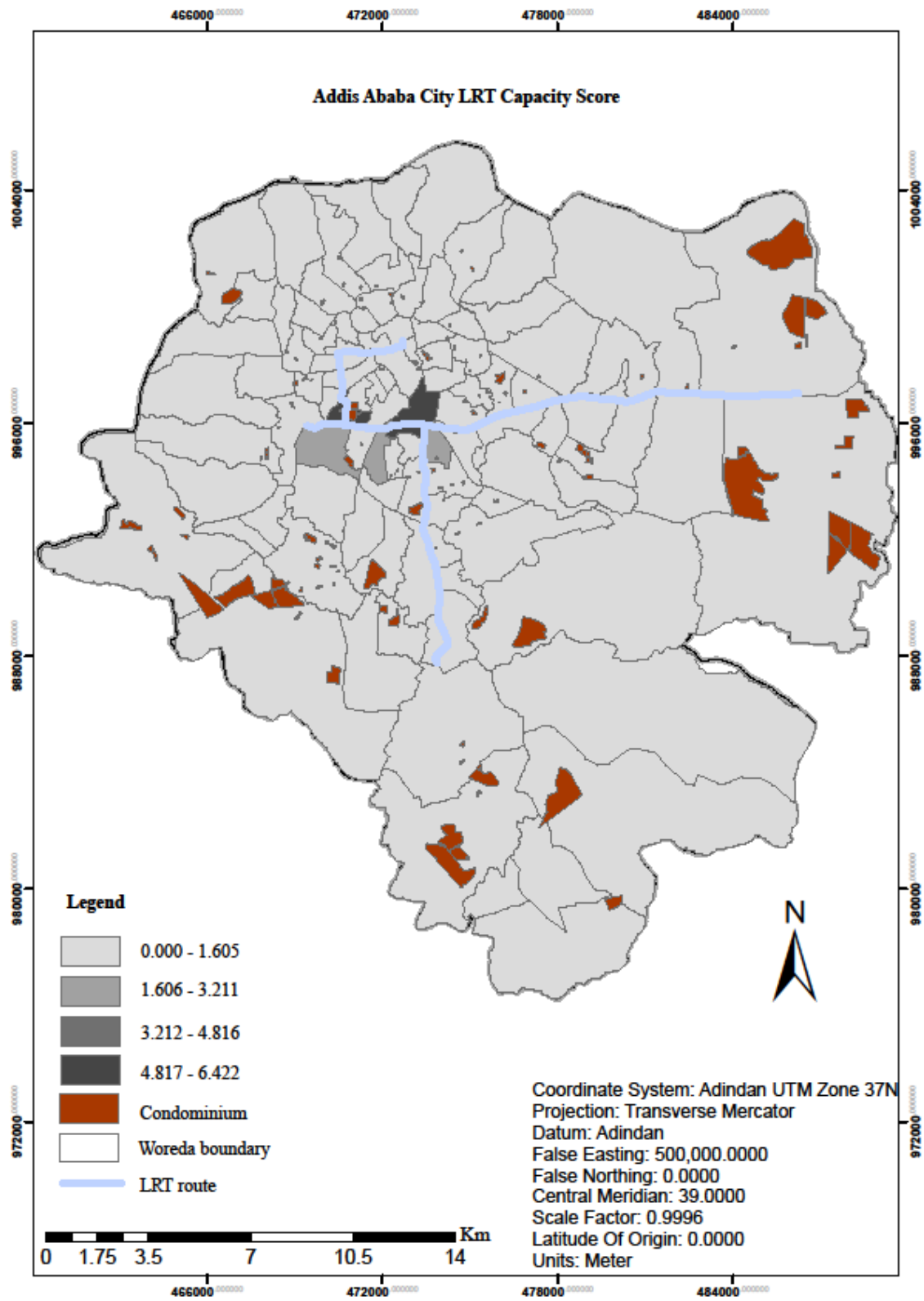


Figure 32: LRT capacity score distribution in Addis Ababa city Woredas

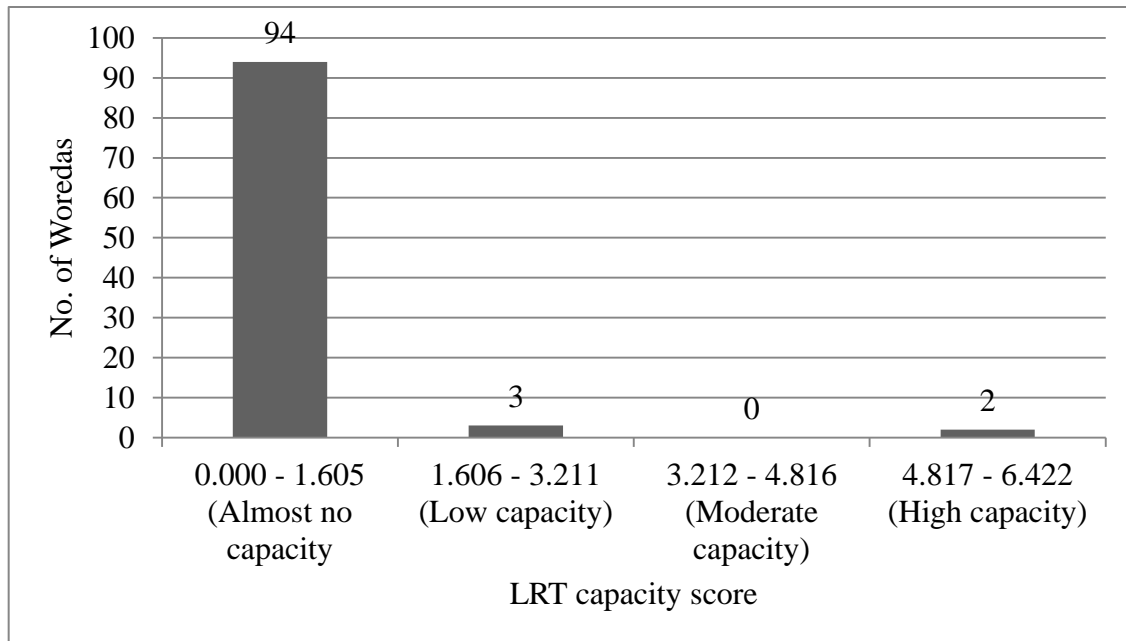


Figure 33: LRT capacity score distribution In Addis Ababa Woredas

The capacity score of LRT transit service as shown in the bar graph (figure 33) almost 94 woredas have very low or no capacity score, three Woredas have low capacity score and two Woredas have high capacity score. The LRT capacity score which are indicted in high and low capacity score (figure 32) are easily observed in inner city Woredas around the overlapped route. Specifically high capacity score of LRT displayed on the map (figure 32) are around Stadium and and Lideta junctions.

The LRT capacity score from high to low value is not observed in other Woredas except few Woredas in the inner city. As a result all periphery Woredas with condominium residential neighborhoods are not accessed by the LRT service.

The result of LRT capacity score distribution indicates that the number of LRT trams assigned and route length is not proportional with available population density of Woredas.

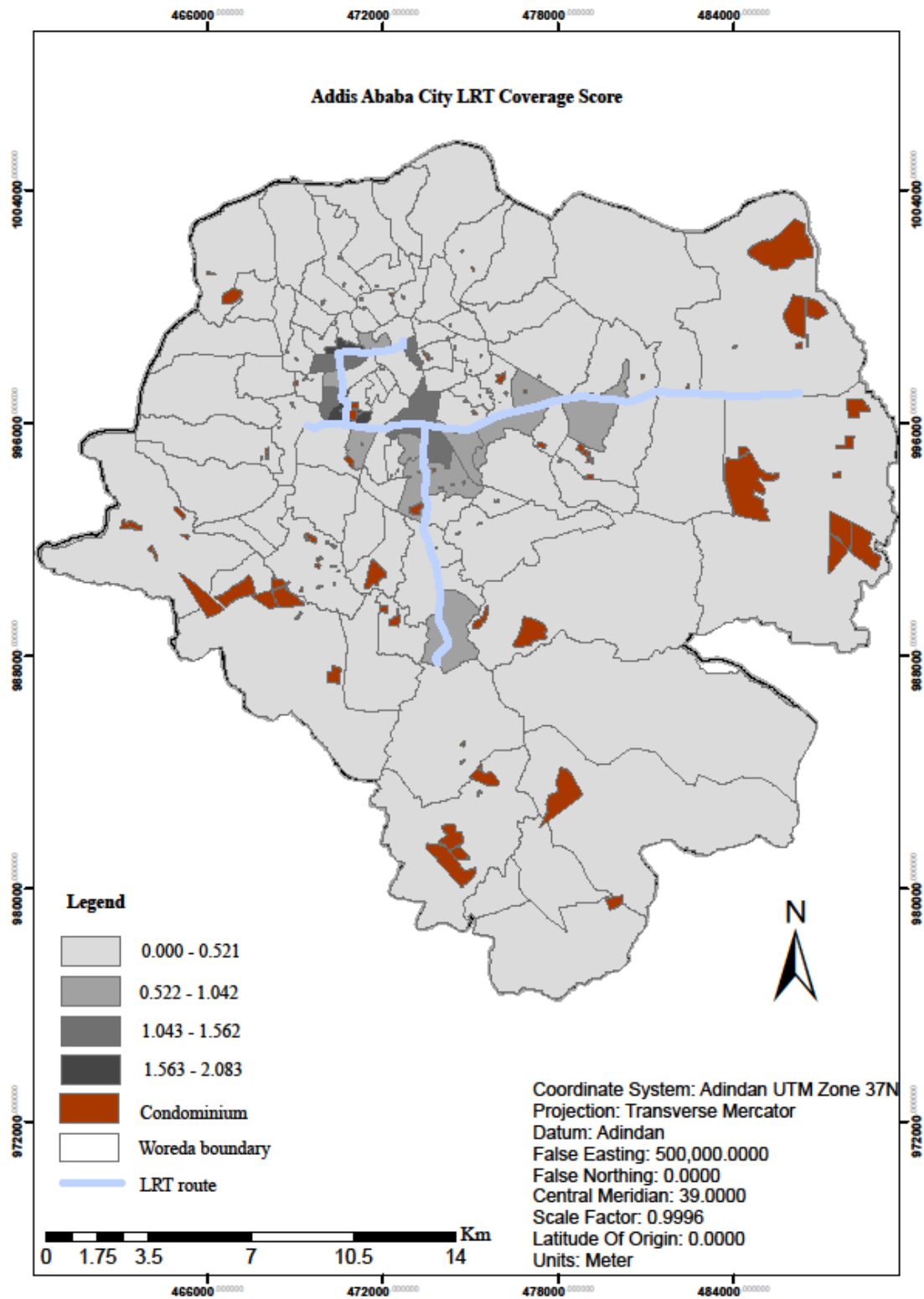


Figure 34: LRT coverage score distribution in Addis Ababa city Woredas

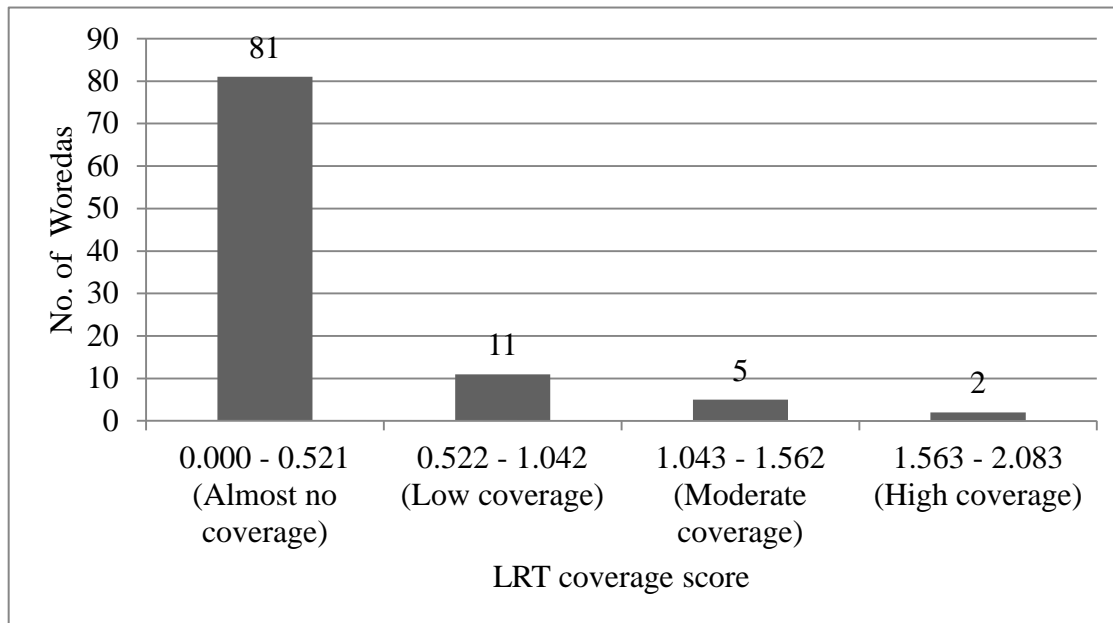


Figure 35: LRT coverage score distribution in Addis Ababa city Woredas

According to bar graph (figure 35) 81 Woredas are under very low or no coverage score, 11 Woredas have low coverage, 5 Woredas have moderate and two Woredas have high coverage score. The result is also presented in the map (figure 34); except few woredas that the LRT route passes through other Woredas touched by the route have low to high coverage score. The intensity of coverage score of Woredas with LRT route increases towards the inner city.

According to the map (figure 34) periphery Woredas with condominium residential neighborhood have very low or no coverage at all.

The result indicates that LRT service coverage in the inner city is relatively proportional with Woredas boundary area than Woredas to the periphery.

5.3.4. Total frequency, capacity and coverage score of the three public transit services

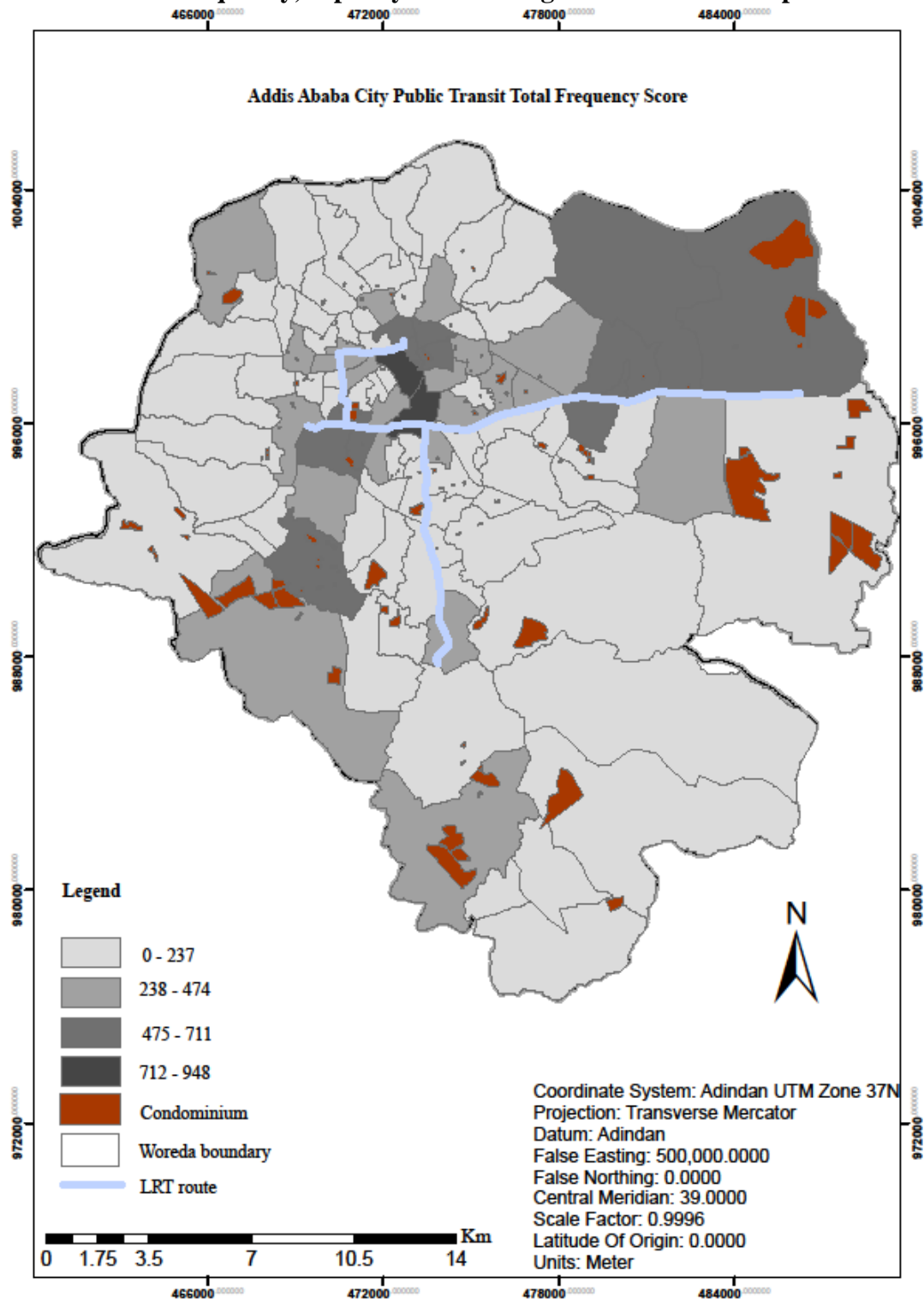


Figure 36: Public transit total capacity score distribution in Addis Ababa city Woredas

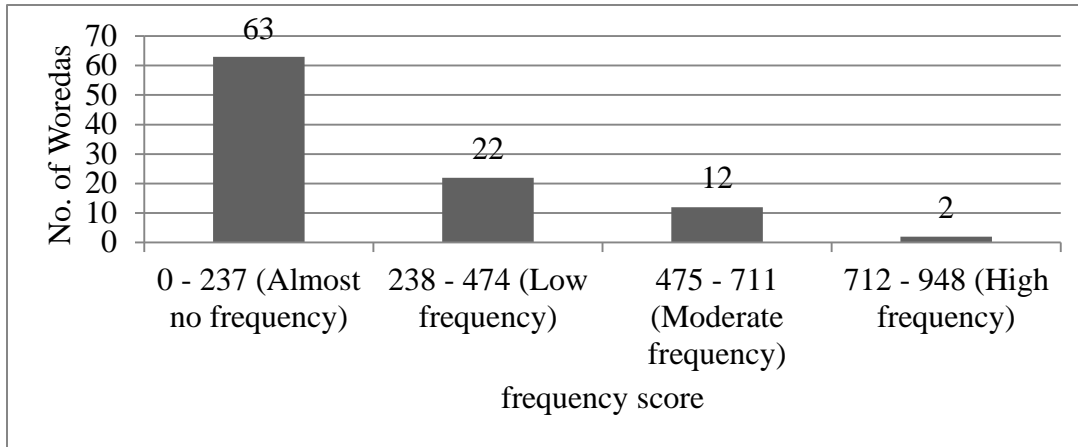


Figure 37: Public transit total frequency score distribution in Addis Ababa city Woredas

The total frequency score according to the bar graph (figure 37) shows that 63 Woredas represented in very low or almost no frequency, 22 woredas have low frequency, 12 Woredas have moderate frequency and two Woredas have high frequency score. According to the map (figure 36) Woredas with high frequency score are located in inner city and Woredas with moderate frequency are located in North – East direction of the city and low frequency score are shown in the South – West as well as in inner city Woredas. The remaining Woredas with highest proportion lay under very low or almost no frequency score.

The frequency score in Woredas with periphery condominium residential neighborhoods as shown on the map (figure 36); North – East direction of the city Woredas have moderate frequency score whereas South – West and North direction of the city Woredas have low frequency score distribution.

The total frequency score distribution result indicates that high number of total daily buses arrived from Stadium to Piassa transit corridor Woredas. There is moderate total daily number of buses arrived in North – East direction of the city Woredas and low number of total daily buses in South – West direction of the city Woredas. Nevertheless, the remaining Woredas of the city have very low or almost no total number of daily bus arrived.

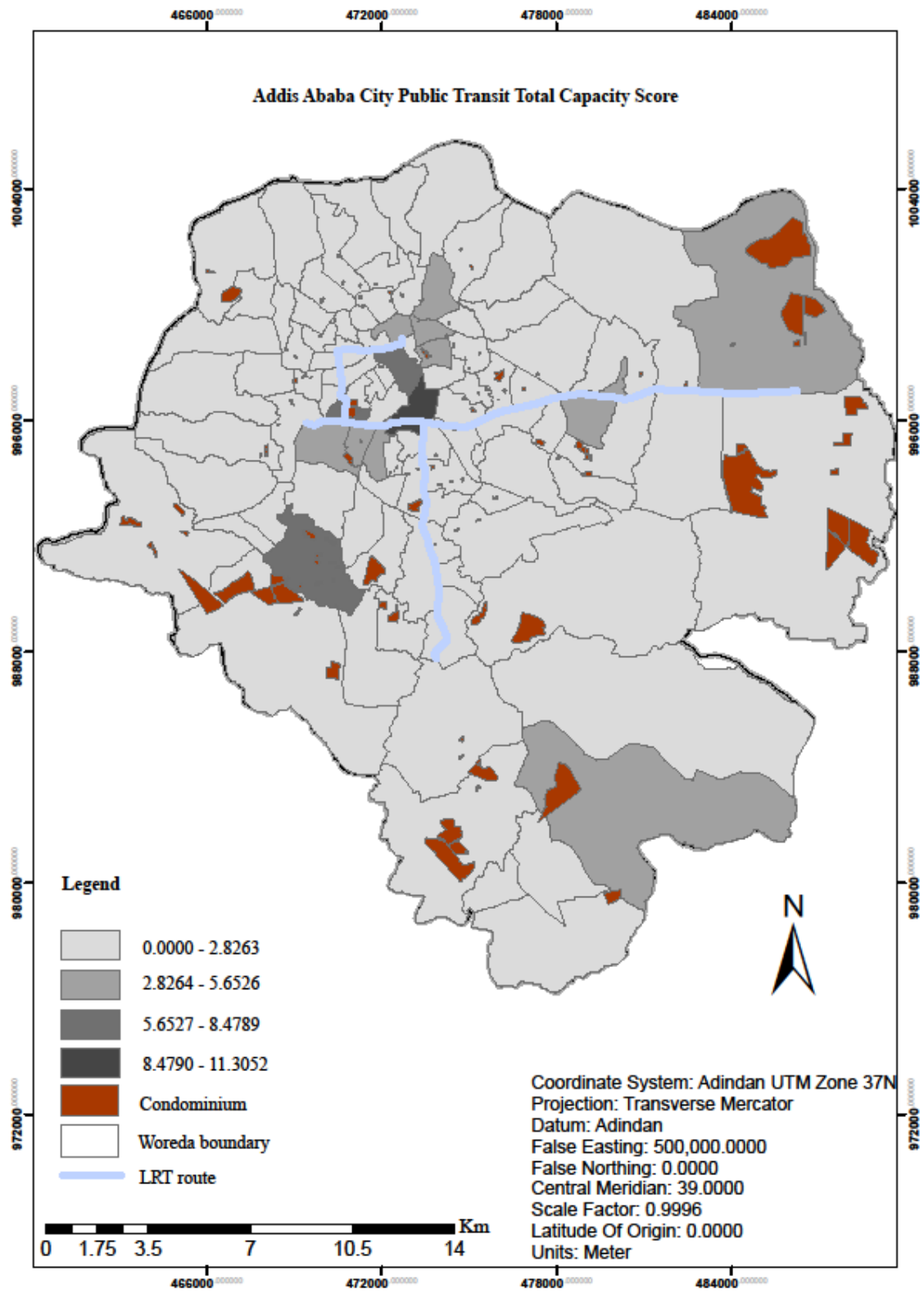


Figure 38: Public transit total capacity score distribution in Addis Ababa Woredas

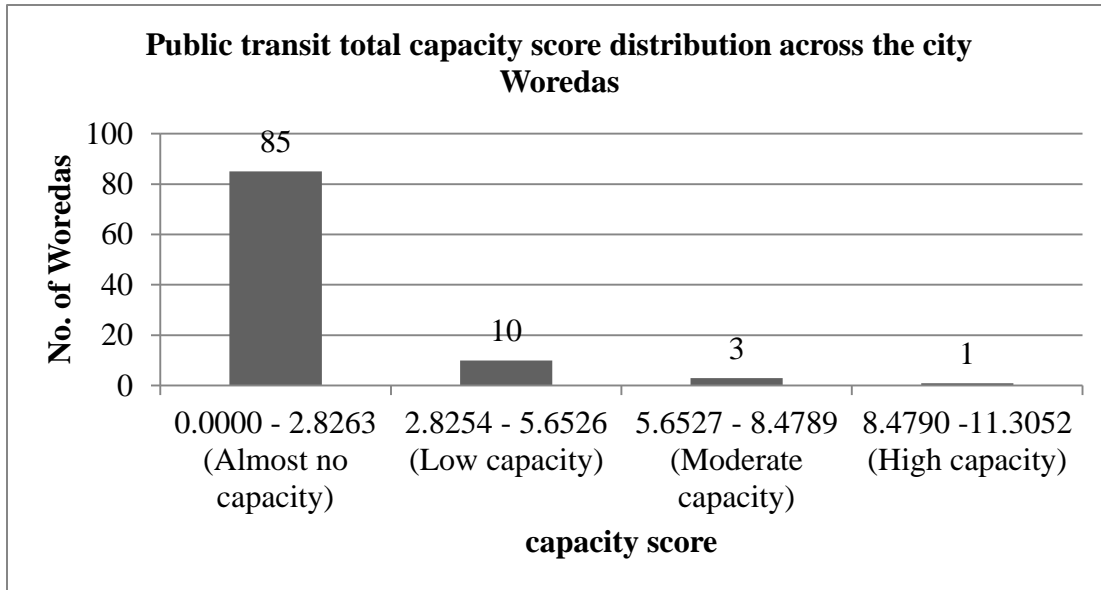


Figure 39: Public transit total capacity score distribution in Addis Ababa city Woredas

The total capacity score as shown on bar graph (figure 39) 85 Woredas of the city lies in very low capacity score, 10 woredas have low capacity score, three Woredas have moderate capacity and one Woreda has high capacity score. These result presented on the map (figure 38) also shows high capacity score in inner city woredas around Stadium and Beherawi and Moderate capacity score distribution is shown around Mekanisa. The map shows low capacity score around South – West and North – West part of the city Woredas. The rest part of the city Woredas are within very low or almost no capacity score.

The capacity score in periphery woredas with condominium residential neighborhoods is low in the North – East and South – East part of the city Woredas whereas the rest periphery woredas with condominium residential neighborhoods of the city are very low.

The result shows that in most part of the city Woredas the number of population and the number of total daily buses availability is not balanced. As a result, the number of total daily bus assigned in each route is low. It also shows that there is limited route length in Woredas.

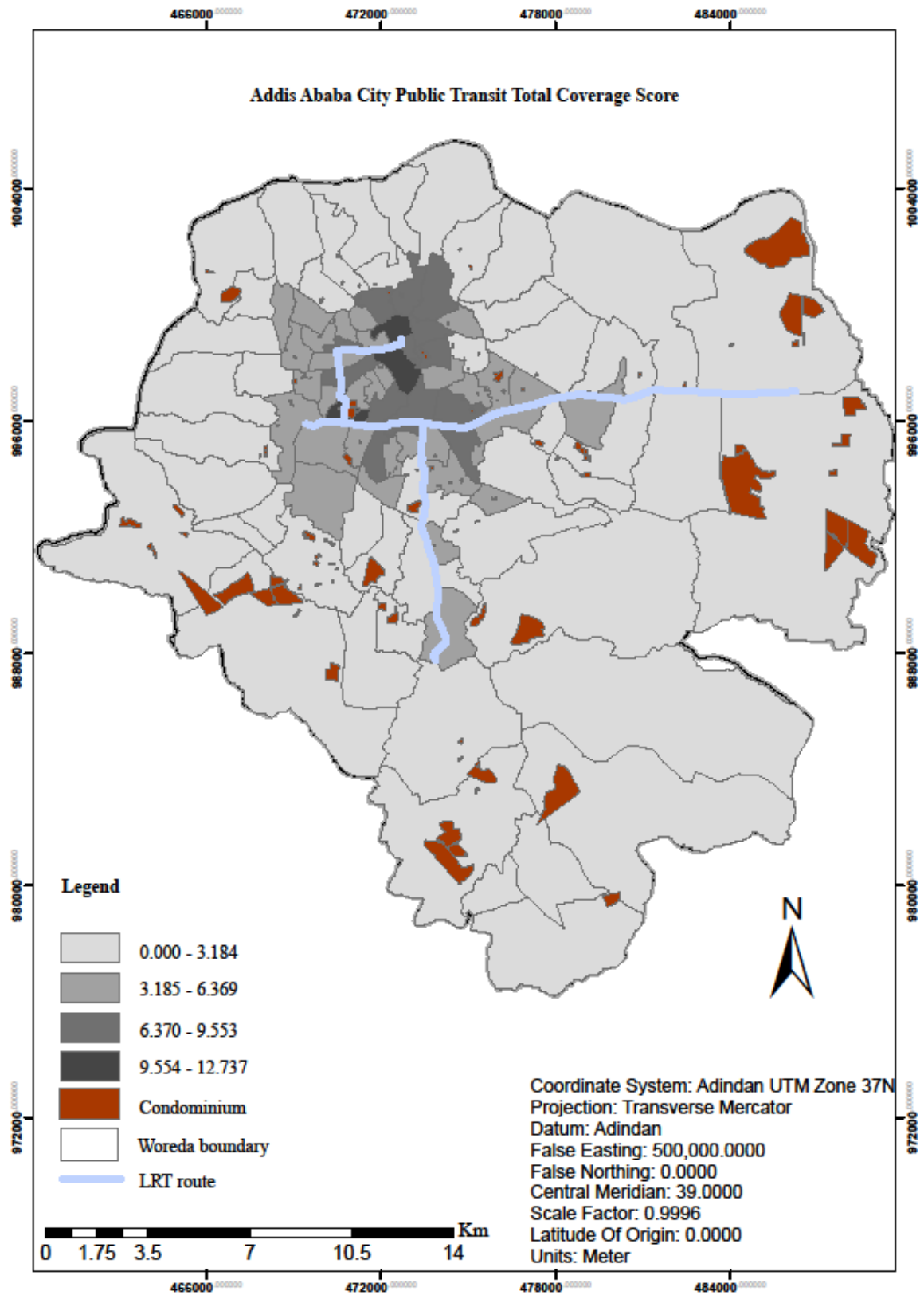


Figure 40: Public transit total coverage score distribution in Addis Ababa city Woredas

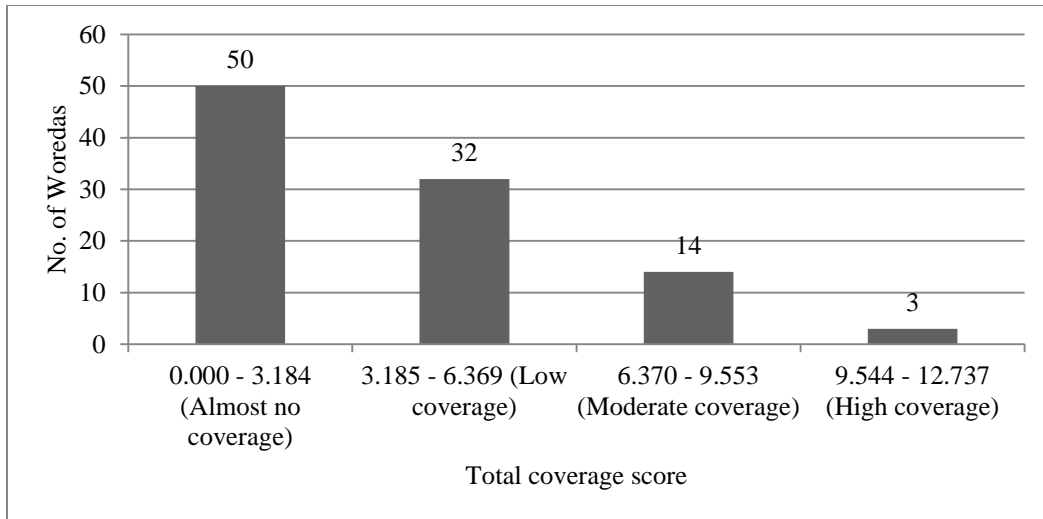


Figure 41: Public transit total coverage score distribution in Addis Ababa city Woredas

The total coverage score of the city Woredas are shown in the map (figure 40) and the bar graph (figure 41). According to the bar graph 50 Woredas capacity score distribution lay in very low or almost no coverage, 32 Woredas have low coverage score, 14 Woredas have moderate coverage and three Woredas have high capacity score. Based on the map high to low transit coverage score is shown in inner city Woredas. Periphery woredas transit coverage score is very low or almost no coverage.

The periphery Woredas with condominium residential neighborhood lies in very low or almost no coverage score.

The result of total transit coverage score shows that in the inner city Woredas; there is well coverage in number of transit stops in relative with the periphery Woredas transit coverage. The periphery Woredas boundary size and distribution of transit stops are not balanced. As a result, low transit coverage score shown in the map.

5.3.5. Standardized overall public transit availability index of Addis Ababa city

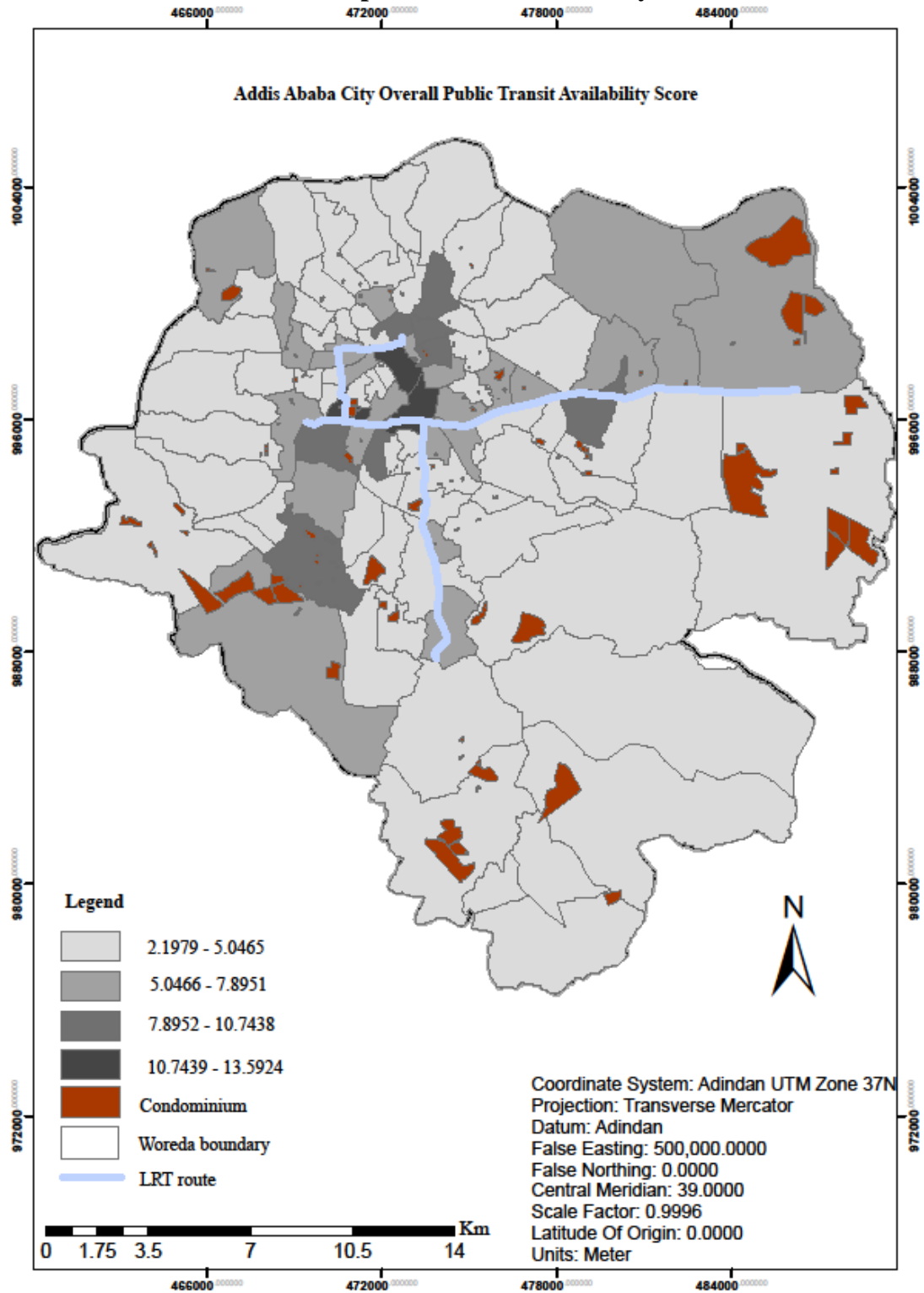


Figure 42: standardized overall transit availability index of Addis Ababa city Woredas

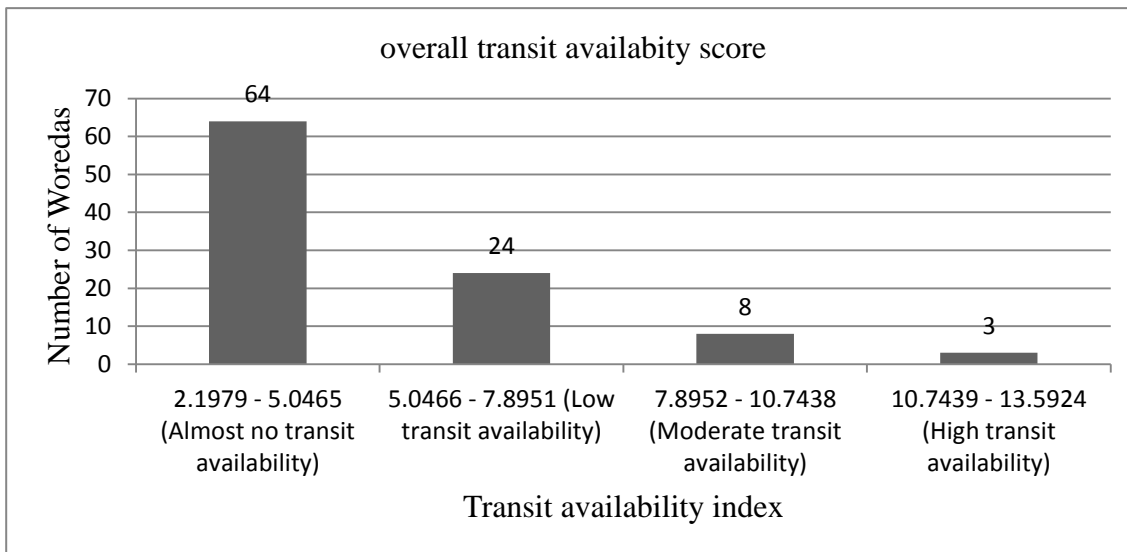


Figure 43: Standardized overall public transit availability score of Addis Ababa city Woredas

The standardized public transit availability score of the city Woredas is the final sum output of each public transit standardized frequency, capacity and coverage score of the transit services. As it is presented on the graph (figure 43) 64 Woredas of the city lies in almost no transit availability range, 24 Woredas have low transit availability, 8 Woredas have moderate transit availability and three Woredas have high transit availability. The map (figure 42) shows that Woredas with high transit availability is displayed in inner part of the city around Stadium, Legehar, Bherawi, Piassa and Awtobs Tera. Moderate transit availability is displayed around Megenagna, Torhayloch, Arat killo and Mekanisa. Low transit availability is shown in the North part of the city around Mikilily land condominium, North – East around Yeka Abado and South – West around Jemo. The remaining low transit availability index is shown on the map in inner part of the city Woredas. However, most part of the city Woredas lies in very low or almost no transit availability index.

The result indicates that public transit availability is low or almost not available in all periphery Woredas with condominium residential neighborhoods whereas relatively inner part of the city Woredas have low to high transit availability.

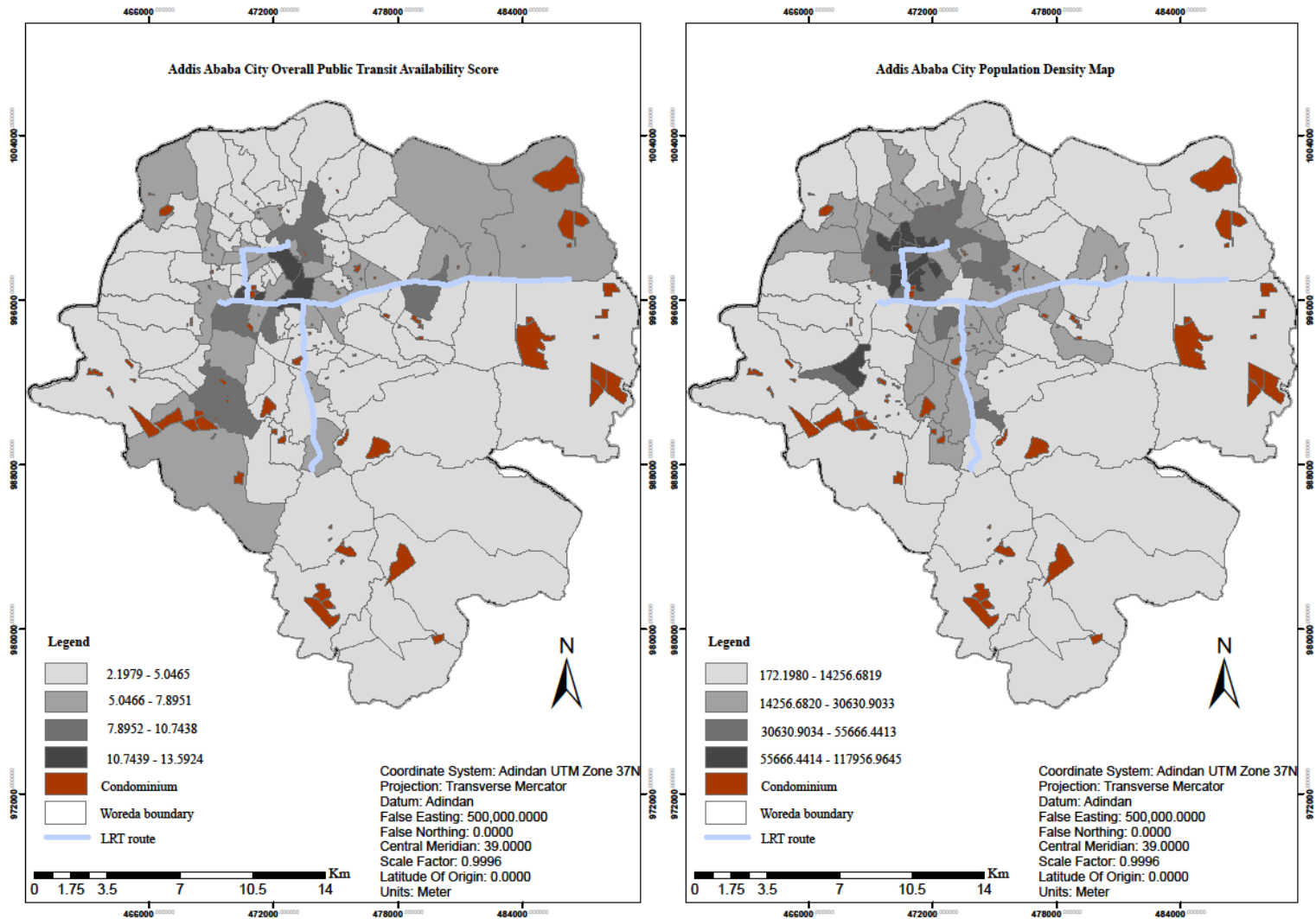


Figure 44: comparison between population density and public transit availability index

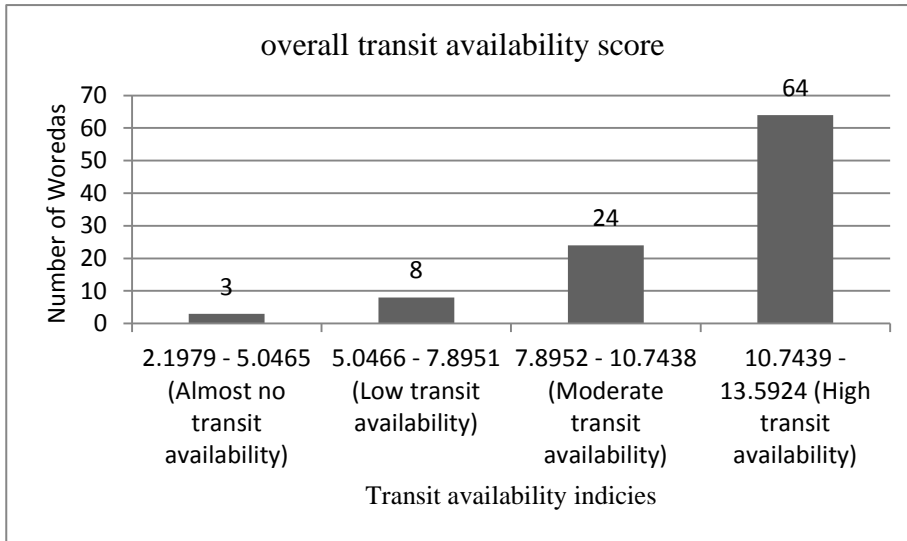


Figure 45: Intensity of public transit availability in Woredas

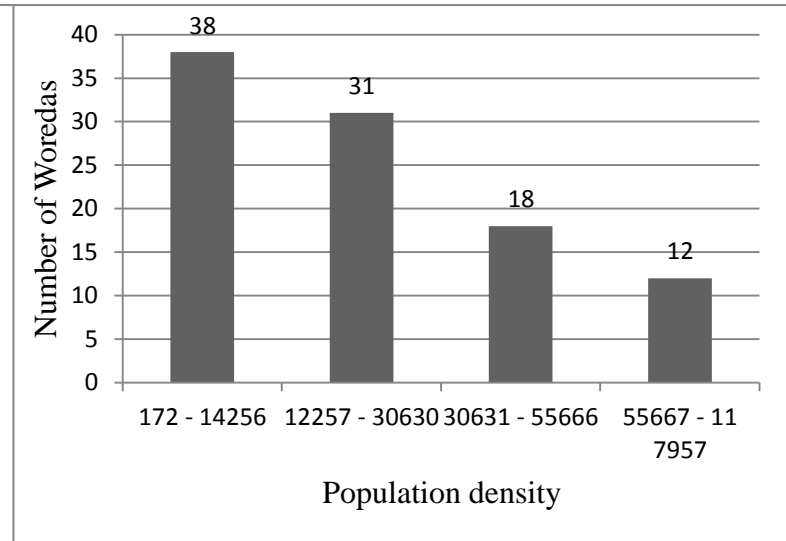


Figure 46 Population density in Woredas

Based on four equal interval population density ranges, Woredas with very low population density are 38 and Woredas with high population density are 12 (figure 46). The population density distribution is mapped as shown in figure 44. Based on the map low to high population density is displayed in the inner part of the city Woredas whereas the rest part of the city Woredas lies in very low population category. When the population density is compared with transit availability index as shown on the map (figure 44); inner part of the city Woredas as well as South –East and North – East part of the city Woredas have low to high public transit service. The remaining Woredas including the peripheries have almost no transit service and very low population density. Low population and low transit service shows that there is no or limited number of public transport service provision for less number of population at the periphery and other part of the city Woredas.

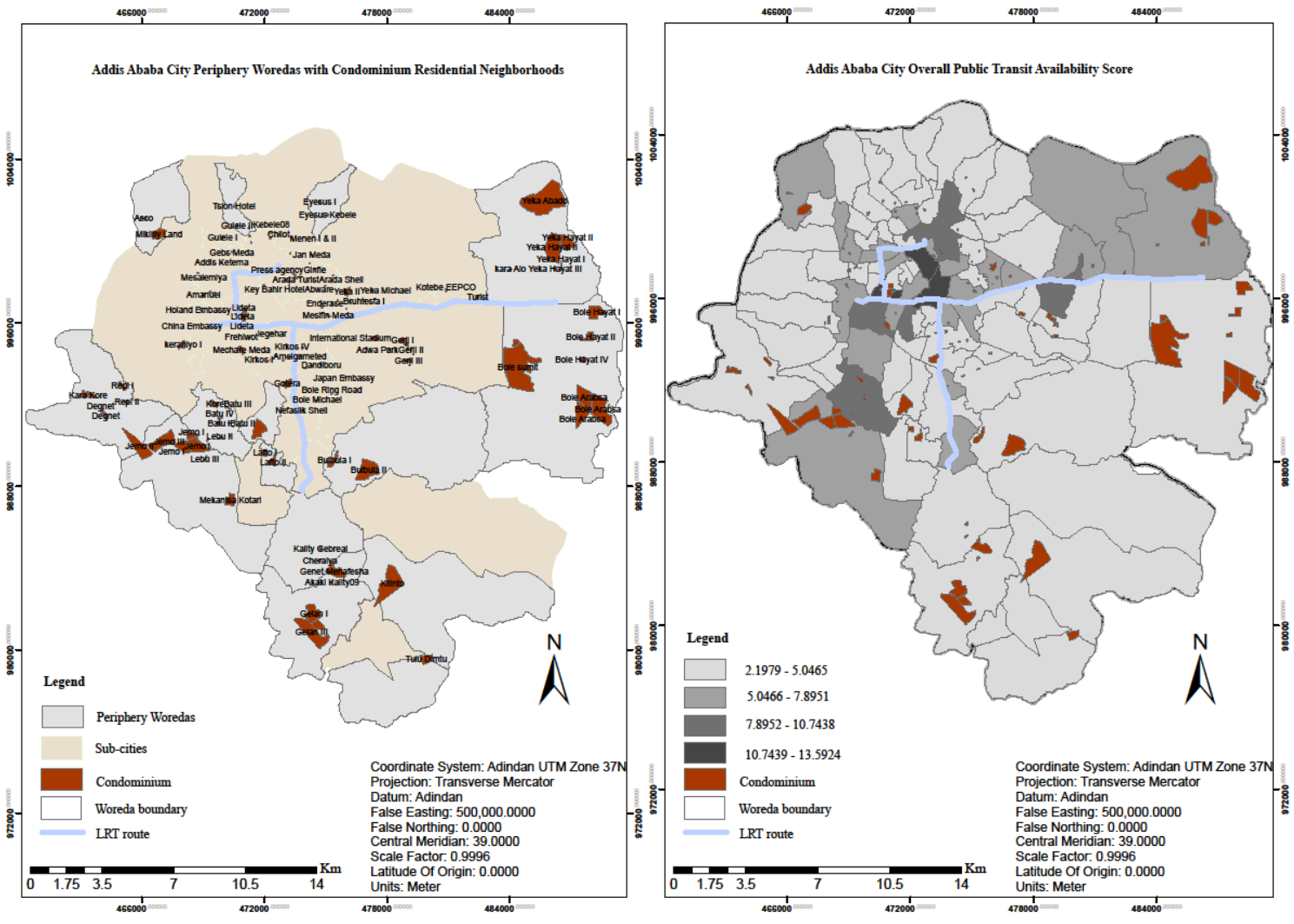


Figure 47: Periphery woredas condominium residential neighborhoods in comparison with public transit availability index

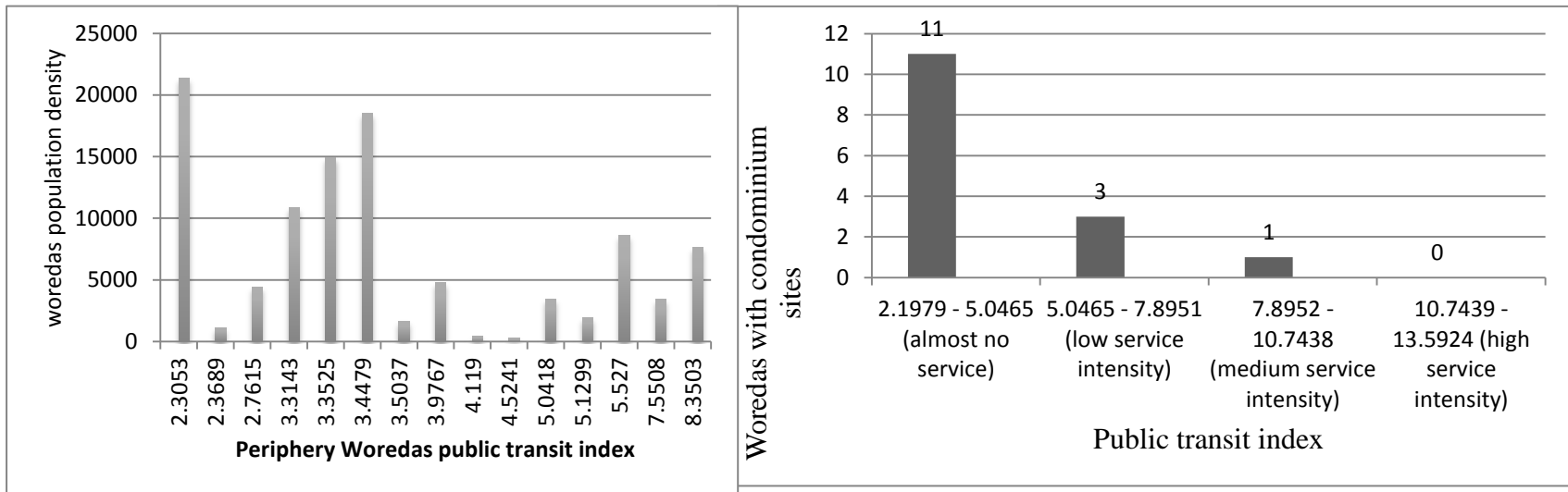


Figure 48: periphery Woredas with condominium residential neighborhood

The map (figure 47) and the graph (figure 48) show that 11 periphery woredas with condominium residential neighborhoods such as Bole Ayat, Bole Arabse, kilinto, etc. lies in almost no transit availability index, three Woredas with Yeka Abado, Yeka Ayat, and Jemo condominiums have low transit service intensity and one Woreda around Mekanisa has moderate service intensity. According to the Woreda population and public transit index graph, Woredas with high and low population density lies in almost no service intensity but Woredas with high service intensity have average population density.

Therefore, the result indicates that periphery condominium residential neighborhoods have low transit coverage.

5.3.6. Public transit index and Socio – economic characteristics of periphery Woredas

Periphery woredas with condominium residential neighborhoods socio-economic and demographic variables are compared with public transit availability index as dependent variables whereas transit availability is independent variable in the result and discussion below.

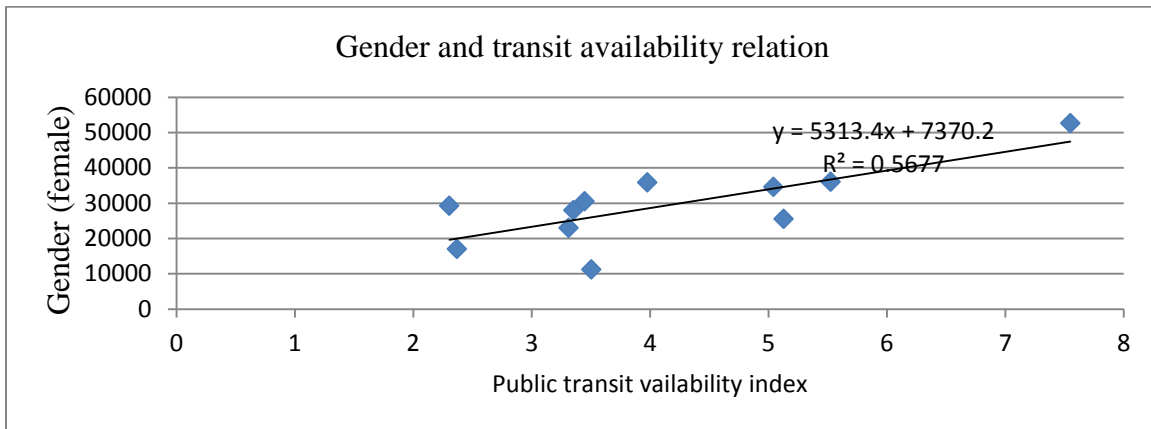


Figure 49: Transit availability index and gender relationship in periphery Woredas with condominium

The figure 49 shows that the relation between female and public transit index is positive. Based on the figure gender distribution is affected in the change that occurs in public transit availability by 56% as R square shows.

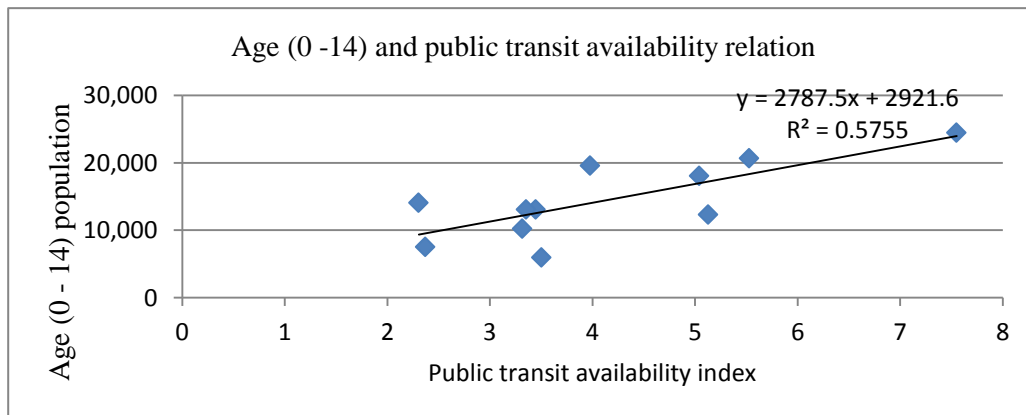


Figure 50: Age (0 - 14) and public transit availability index relation

The result shows Age (0 – 14) is affected in public transit availability by 57%.

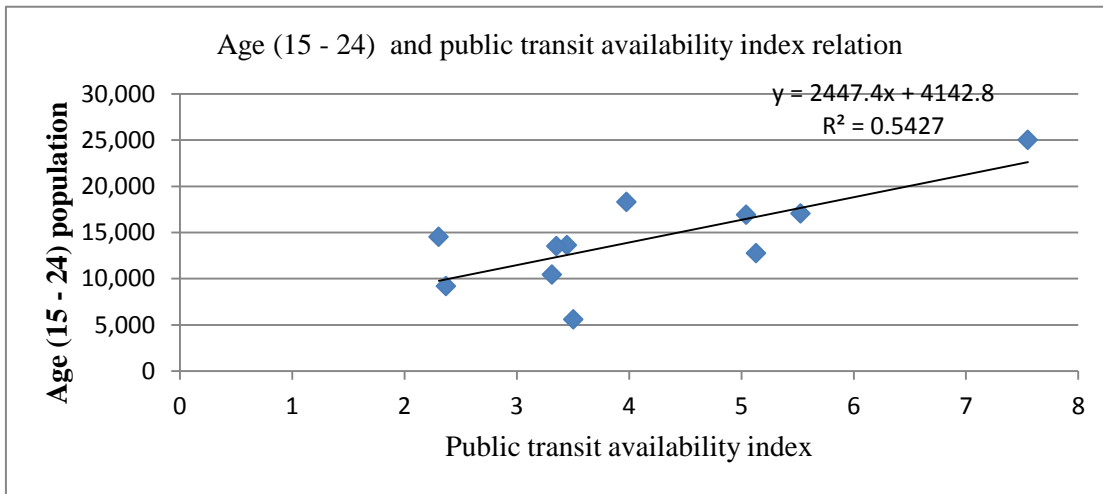


Figure 51: Age (15 - 24) and public transit availability index relation

The result (figure 51) shows that age (15 -24) is affected by transit availability index in 54 percent. This age category is active working age which demands transit service to get and to actively engage in their jobs.

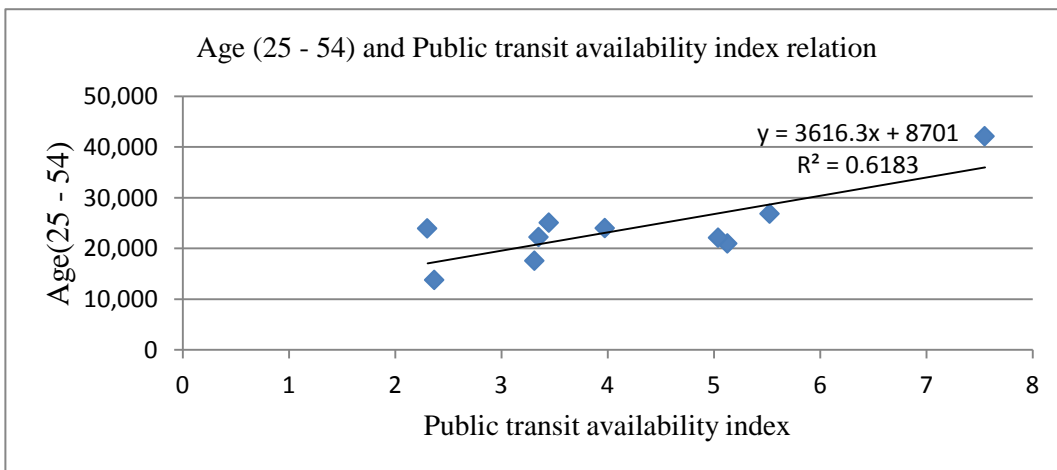


Figure 52: Age (25 -24) and public transit index relation

The age (25 – 54) has positive relation with transit availability index. The transit availability affects the age group by 61 percent. It also shows there is a likelihood of this working age to exist around public transit serviced area. This age group according to CSA (2016) categorized as matured working age. As a result, to engage in their job they demand high transit availability.

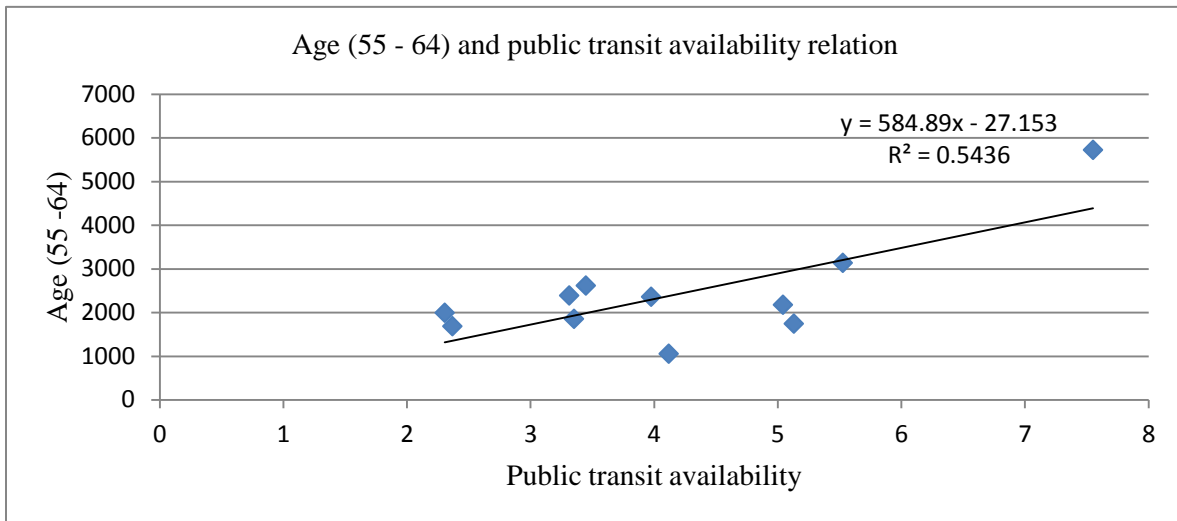


Figure 53 : Age (55 - 64) and public transit availability relation

This age group has positive relation with the public transit availability index. It is also shows that there is a likelihood of existing age 55 to 64 around public transit serviced area.

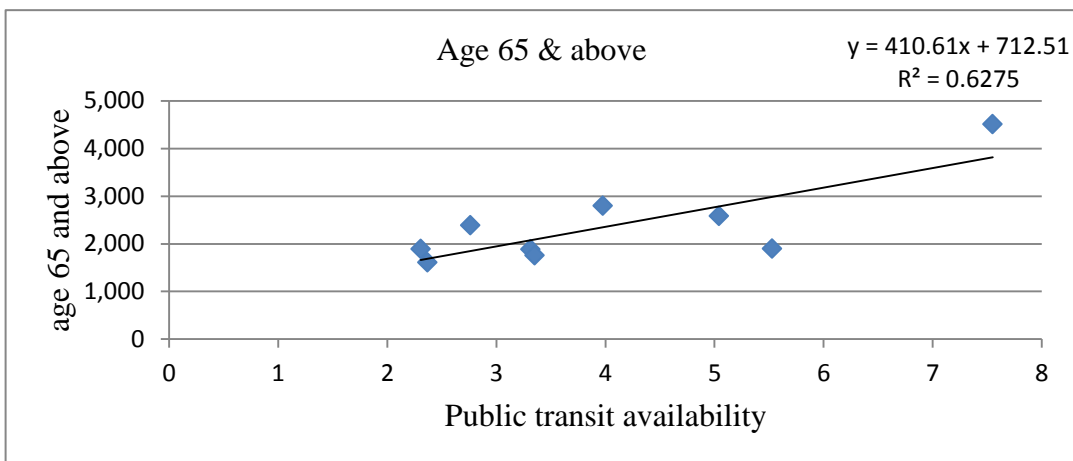


Figure 54 : Age 65 and public transit availability relation

The figure shows that the age 65 and above has positive relation with public transit availability.

As the figure shows the change in public transit availability has 62 percent positive impact on age 65 and above.

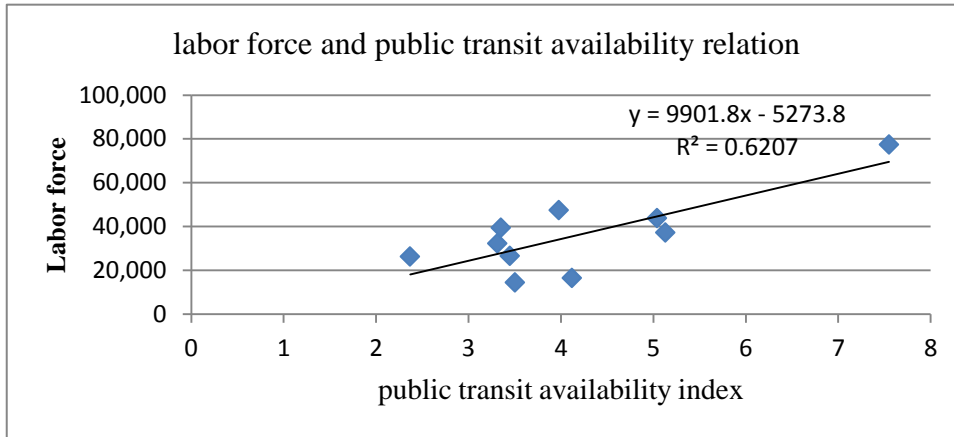


Figure 55: Labor force and public transit index relation

The labor force variable has positive relation with public transit index. As a result, the increase in public transit service in one unit will change the labor force in 62 percent.

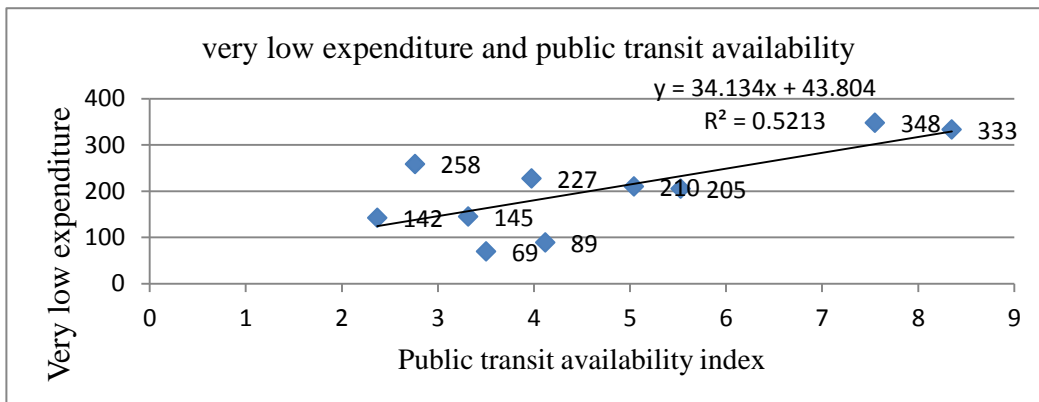


Figure 56: Very low expenditure and public transit availability index

Based on CSA 2016 socio-economic data document, income data is replaced by expenditure. CSA categorized the community based on annual expenditure into five. Very poor (≤ 5379.48 birr), poor (5379.81 birr – 7688.06 birr), medium income (7688.11 – 10121.95), high income (10123.36 – 15109.21), very high income (≥ 15110.22). According to figure 56, very low expenditure has positive relationship with public transit availability. Therefore, expenditure is 52 percent positively affected by the change in public transit availability.

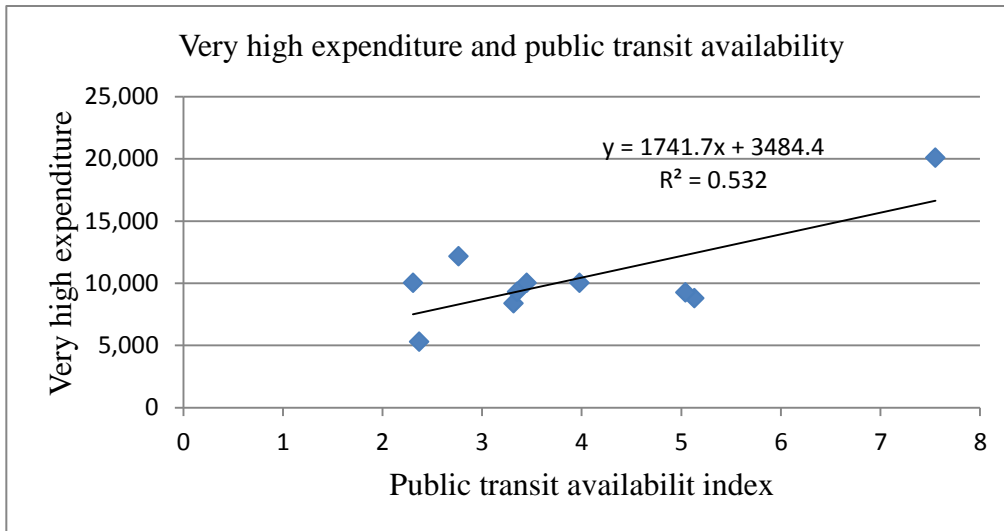


Figure 57: very high expenditure and public transit relation

Very high expenditure has positive relation with public transit availability. The public transit availability affects high expenditure by 53 percent.

5.4. Discussion

The findings from this study suggest that socio-economic characteristics of periphery Woredas condominium residential neighborhoods are influenced by the intensity of public transit availability.

The result indicates that public transit availability is low or almost not available in all periphery Woredas with condominium residential neighborhoods whereas relatively inner part of the city Woredas have low to high transit availability. As McKenzie (2013) study shows compared to compact urban centers or inner cities, transit availability in suburb communities is relatively poor in most metropolitan areas. The reason behind is that peripheries condominium residential developments are not well integrated by public transportation with inner cities in terms of availability of adequate public transit route , number of stops and number of transit service. The other reason for low intensity of transit availability is that a number of transit

services are using the same route and this affects the spatial distribution of the service in terms of transit stops and route coverage through the Woredas. Which means communities who are far away from the transit route cannot access the service in walking distance. According to Abreha (2007) study, the higher the spatial coverage of the service the shorter will be the walking distance to the service. The unbalanced periphery Woredas boundary and population size with the distribution of transit stops route coverage and number of transit can also contribute for low coverage of transit at the periphery residential neighborhoods. But in the other way condominium residential neighborhoods are dense settlements which are easy to provide transport infrastructures from the perspective of getting riders in a specific point.

The result of total transit coverage score shows that the inner city Woredas has well coverage of transit availability. This is because of adequate number of transit stops, route and number of bus availability in relative with the periphery Woredas transit coverage. According to Scott (2014) spatial mismatch research has found that transportation access has a positive relationship with employment outcomes whereas housing and employment discrimination have a negative relationship with the spatial mismatch of jobs and housing. This literature proves the result of transit availability and socio-economic characteristics of the periphery woredas with condominium residential neighborhoods correlation. As the results show socio-economic and public transit availability have strong positive relationships. This result is analyzed and presented by simple regression analysis and the strength of the relation is presented using R^2 . According to Etenesh (2007) study in periphery condominium areas female headed households compared to their male counterparts prone to economic challenges.

Therefore, less transit availability has negative impact on the residents of periphery condominiums. Based on Woldeamanuel and Covington (2014) study a portion of Americans

relies on various modes of public transit for commuting. As they discussed great portion of members in low-income, elderly and minority households are depend on public transit. As a result, the intensity (high and low) of transit availability in periphery area has positive or negative impact on the socio-economic characteristics of the neighborhoods.

CHAPTER SIX: CONCLUSION AND RECOMMENDATION

6.1. Conclusion

The research condominium boom in Addis Ababa and public transit mismatch evaluation is done based on the problems that are observed in the city. It is more of emphasized on its periphery condominium residential neighborhoods socio – economic and demographic characteristics in relation with public transit availability.

For the problems identified in the research problem statement three objectives and research questions were formulated. Then after, the methodology is designed to achieve objectives and to answer research questions. The analysis method developed to answer research questions one and two was ABLSI (Addis Ababa bus and LRT service index) whereas objective three was answered using simple regression method.

ABLSI was developed by calculating the capacity, frequency and coverage of Anbessa , Sheger and LRT public transit services within 99 traffic analysis zones (Woredas).The calculated and standardized result of each transit service capacity, frequency and coverage were added to give overall transit availability index of the city Woredas. Then after the overall transit availability index were joined in GIS to produce the result of the first two objectives in the form of spatial analysis or maps.

The result of transit service availability in the periphery suburban condominium residential neighborhoods is low. This result is shown in Anbessa , Sheger and LRT public transit services capacity , frequency and coverage score. It is also shown in the total score of three transit services capacity, frequency and coverage scores. Finally low availability of public transit service is shown in the standardized sum of three transit services availability scores.

According to the overall transit availability index (figure 42) the result shows that there is a difference in the intensity of public transit service availability between the city center and periphery Woredas with condominium residential neighborhoods. Periphery woredas with condominium residential neighborhoods lies between low and almost no transit availability scores whereas the inner part of the city Woredas lies in between low and high transit availability index.

Simple regression analysis method is used to answer the third research question of the study. In the simple regression analysis method scatter plot graph type and trend line is used to identify the relationship between the socio-economic and demographic impact of public transit availability at the periphery condominium residential areas. The result of simple regression analysis interpreted based on R^2 value which lies between 0 - 1 and the independent variable coefficient. If the independent variable coefficient is negative then the two variables have negative relationship. This is to mean when independent variable increase, the dependent variable decrease and the reverse is true. The R^2 value has to be greater than or equal to 0.5 in order to have the two variables positive relationship. Therefore, the result of the study regression analysis R^2 shows that public transit availability and periphery Woredas socio-economic and demographic characteristics have positive relationship. Periphery Woredas socio-economic and demographic characteristics that are compared with public transit index are gender, age, labor force and expenditure. Each of these periphery Woredas characteristics has R^2 greater than 0.5 values which indicates positive relationship between variables in the study.

6.2. Recommendation

In this study, analysis and discussions have been carried out to evaluate transit availability in the periphery Woredas condominium residential neighborhoods. As seen from the evaluation, it is clearly identified the neighborhoods low intensity of public transit service availability. Based on the evaluation carried out in the previous chapter, recommendations are proposed to improve the public transit availability in periphery residential condominium neighborhoods of Addis Ababa city.

There should be possible solutions by state/municipal government in to improve the availability of public transit service. According to the public transit availability in the peripheral condominium residential neighborhoods, the study area needs the following recommendations which were outlined based on the evaluated findings.

1. Providing additional and extending the existing public transit routes

Based on the result Woredas with low and almost no transit service availability are because of limited or overlapped number of public transit routes. The presence of limited or overlapped routes influences the transit service provision in the negative way. The reason behind is that it limits the service availability across woredas or the riders cannot access the service easily in proximity with their residence. Therefore, in order to get the service they have to walk long distance. As a result, the route has to be provided with walking distance of the riders to increase the transit availability in the area. The increase in transit service availability of periphery Woredas would benefit the socio-economic and demographic characteristics. The route helps to connect woredas community with inner part of the city in terms of social, economic and recreational purpose.

2. Increasing density or number of stops in the provided public transit routes

Stops density is one factor for the result of low or no transit service availability in periphery Woredas with condominium residential neighborhoods. When the number of stops in an area exists in walking distance then riders have the chance to get the transit service frequently.

3. Increasing the number of Anbessa bus, Sheger bus and LRT trams in the route.

According to the result discussed in chapter five the numbers of bus and LRT transit services are the leading factor that affect the transit availability of Woredas. As the result shows the number of transit availability and Woredas population density is not balanced. The current transit service even is not available in low population density as it is shown in the result and discussion part of the study. Therefore, the number of transit services should be provided by considering the number of population, the standard carrying capacity and headway or frequency of buses and LRT transit services.

Future studies related with spatial analysis of public transit availability for cities should include primary socio-economic data in addition to secondary data to triangulate the result of relation between intensity of transit availability and socio-economic characteristics.

Further studies are recommended for Woredas that have low and almost no public transit availability index route design in order to alleviate the spatial distribution and proximity of the transit service by considering primary socio-economic data.

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Appendix 1: Anbessa Bus Route Information

route No.	Origin-Destination	No. of buses	Frequency per bus	Total daily bus frequency within route	Total daily bus seats	Trip Time (Min.)	km
1	Megenagna - Karalo	4	5	20	1400	33	7.7
2	Kore Mekanissa - Addis Ketema	3	6	18	1260	54	11.1
3	Ayer Tena - Menelik Squar	8	5	40	2800	60	10.8
4	Kaliti - Addis Ketema	4	3	12	840	80	19.4
5	Kore Mekanissa - Menelik Squar	2	2	4	280	53	12.7
6	Kera - Semen Gebeya Squar	8	5	40	2800	52	9.9
7	Megenagna - Aleltu	3	7	21	1470	100	49
8	Kechene - Addis Ketema	2	8	16	1120	38	9.4
9	Bole Brass Clinic - Piassa	2	2	4	280	49	10.5
10	Kotebe College - Piassa	5	14	70	4900	53	12.7
11	Kolfe Efoyeta - Menelik Hospital	2	4	8	560	49	10
12	Gurara Ferensay Kela - Addis Ketema	6	7	42	2940	44	9.9
13	Italy Embassy - Addis Ketema	3	2	6	420	48	9.9
14	Saris Abo - Menelik Squar	3	3	9	630	60	12.3
15	Megenagna - Addis Ketema	4	5	20	1400	53	10.4
16	Kidanimihret - Addis Ketema	6	3	18	1260	42	7.9
17	Kusqum - Addis Ketema	4	4	16	1120	49	9.1
18	Keraniyo - Addis Ketema	6	9	54	3780	48	7.3
19	Sansusi - Piassa	5	9	45	3150	48	12.8
20	Dil Ber - Addis Ketema	2	6	12	840	41	8.6
21	Felidoro - Addis Ketema	6	3	18	1260	52	8.6
22	Summit - Legehar	6	4	24	1680	58	14.3
23	Lamberet - Addis Ketema	5	6	30	2100	53	12

24	Dire Sololiya -Addis Ketema	4	5	20	1400	70	15.9
25	Legehar - Akaki	3	4	12	840	80	19
26	Addis Ketema - Sebeta	4	9	36	2520	74	25.5
27	Legehar - Kaliti	3	2	6	420	65	14.9
28	Asko Sansuzi -Addis Ketema	3	7	21	1470	51	11.1
29	Saris Addisu Sefer - Addis Ketema	4	5	20	1400	58	12.7
30	Sululta -Addis Ketema	2	10	20	1400	70	25.8
31	Legehar -Shiro Meda	5	10	50	3500	35	7.4
32	Hana Mariam -Legehar	6	2	12	840	51	10.6
33	Kotebe Gebriel - Arat Kilo	5	6	30	2100	40	11.4
34	German Squar - Addis Ketema	2	4	8	560	52	9.8
35	Lebu Muziqa Sefer- Addis Ketema	2	2	4	280	60	15
36	Kara Kore - Legehar	3	5	15	1050	55	11.7
37	Keraniyo - Menelik Squar	3	3	9	630	60	12
38	German Squar - Sidist Kilo	3	3	9	630	60	11
39	Bole School - Addis Ketema	3	2	6	420	52	9.6
40	Karalo - Addis Ketema	4	2	8	560	70	17.9
41	Eyesus - Addis Ketema	4	2	8	560	46	8.5
42	Megenagna - Legehar	2	2	4	280	50	9.8
43	Menagesha - Addis Ketema	2	4	8	560	85	30.2
44	Legedadi - Addis Ketema	2	16	32	2240	91	30.4
45	Legehar - Dil Ber	4	4	16	1120	46	8.6
46	Gerji - Arat Kilo	4	2	8	560	55	11.2
47	Yenegew Fire School - Addis Ketema	2	5	10	700	41	6
48	Bole Michael - Menelik Sq;	3	3	9	630	49	10.9
49	Chefe Ayate; - Megenagna	4	10	40	2800	40	11
50	Ayer Tena - Megenagna	3	20	60	4200	62	14.9
51	Bethel Hospital - Addis Ketema	2	3	6	420	51	10.9
52	Gerji - Addis Ketema	3	3	9	630	70	14.1
53	Bole Michael - Shiro Meda	4	3	12	840	52	11.5

54	Lafto - Legehar	2	3	6	420	57	9.5
55	Legehar - Gurara Ferensay Kella	4	6	24	1680	45	9.5
56	Saris Abo - Shiro Meda	4	2	8	560	51	14.2
57	Kara - Legehar	4	3	12	840	60	14.4
58	Legehar - Alem Bank	4	3	12	840	52	12
59	Bethel Hospital - Menelik Squar	5	5	25	1750	54	11.5
60	Debr Zeit - Legehar	4	7	28	1960	100	47.2
61	Chefe Ayate - Legehar	4	6	24	1680	65	18
62	Sebeta - Legehar	3	7	21	1470	80	23.8
63	Addis Ketema - Mikililand	5	3	15	1050	47	9.1
64	Sidist Kilo - Megenagna Gorf Aswegaj	2	19	38	2660	46	9.5
65	Addis Ketema - Alem Bank	4	3	12	840	48	11
66	Addis Ketema - Kara Qorre	4	3	12	840	50	10.5
67	Legehar - Jemmo Mekanissa	6	7	42	2940	48	10.6
68	Menelik Hospital - Tore Hailoch	2	5	10	700	46	10.2
69	Lome Meda - Merkato	4	1	4	280	41	5.9
70	Aware Square - Ayer Tena	3	3	9	630	52	12
71	Gerji - Balcha Hospital	3	8	24	1680	60	10.9
72	Hana Mariam - Sari Abo	4	4	16	1120	24	4.9
73	Legehar - Ring Road Vis Winget	4	6	24	1680	60	10.2
74	Cmc Square - Addis Ketema	4	2	8	560	60	14.2
75	Sidist Kilo - Qera	2	3	6	420	47	10.4
76	Megenagna - Kaliti	3	4	12	840	70	18.2
77	Ayer Tena - Kera	3	12	36	2520	35	5
78	Megenagna - Gofa Condominium	4	2	8	560	60	12.4
79	Arat Kilo - Semit Condominium	4	5	20	1400	53	14.7
80	Semen Gebeya Squar - Megenagna	3	2	6	420	59	12.4
81	Sidist Kilo - Sansusi	2	5	10	700	54	11.1
82	Goro Adebabay - Balcha Hospital	3	4	12	840	59	14.6
83	Chefe Ayate - Sidist Kilo	2	13	26	1820	60	18

84	Kolfe Efoyta - Legehar	2	1	2	140	54	9.5
85	Addis Ketema - Holeta	3	2	6	420	90	45
86	Ayer Tena - Korki	3	4	12	840	55	12.3
87	Winget Vis Ring Road- Ayer Tena	2	20	40	2800	42	10.5
88	Addis Ketema -Chancho	4	5	20	1400	90	40
89	Addis Ketema -Sendafa	5	3	15	1050	110	44
90	Betel Hospital - Legehar	4	4	16	1120	55	10
91	Addis Ketema - Teji	2	4	8	560	125	52
92	Hana Mariam Ring Road- Balcha	3	7	21	1470	41	9.6
93	Bole Bulbula - Megenanga	3	3	9	630	55	15.2
94	Piassa - Mikililand	6	5	30	2100	44	9.9
95	Addis Ketema - Addis Alem	3	3	9	630	100	47
96	Megenagna - Goro Sefera	2	2	4	280	31	9.2
97	Megenagna - Legetafo Mission	3	7	21	1470	58	15.8
98	Dukem - Saris Abo	4	6	24	1680	70	26.3
99	Ayer Tena - Alem Gena Michael	2	8	16	1120	36	9.4
100	Addis Ketema - Jemo	4	5	20	1400	51	14.5
101	Megenagna - Aba Kirros Sq.	3	13	39	2730	43	12
102	Kara - Legehar	4	3	12	840	52	13.7
103	Jemo - Piassa	5	6	30	2100	59	12.2
104	Werku Sefer - Kera	2	5	10	700	35	8.3
105	Anfo Meda - Legehar	4	4	16	1120	55	12
106	Goro Adebabay - Sammit Megenagna	3	20	60	4200	50	10.8
107	Saris Abo - Akaki Qorqoro	3	7	21	1470	50	11.4
108	Asko Addisu Sefer - 18 Sq . Menelik Sq.	4	2	8	560	50	9.3
109	Saris Abo - Tulu Dimetu Square	4	6	24	1680	45	12
110	Sidist Kilo -Tulu Dimetu Square	4	3	12	840	85	24.9
111	Dire Sololiya - Piassa	6	8	48	3360	72	16.6
112	Circular Route With In Ring Road 4 Turning Points	6	14	84	5880	161	9.4

113	Kaliti Total - Feche Koye	2	3	6	420	45	8.1
114	Gelan Condominium - Saris Abo	5	7	35	2450	35	7.9
115	Lebu Muziqa Bet - Mexico Square	2	1	2	140	45	9.4
116	Mekanissa Michael Sq - Jemo No_2	3	10	30	2100	25	5.6
117	Kotari Condominium - Mexico Square	3	3	9	630	35	9.2
118	Merkato - Tateq Kella	2	9	18	1260	70	18
119	Megenagna - Summit Condominium	4	7	28	1960	35	9.2
120	Burayu Keta - Tore Hiloch	2	11	22	1540	45	12.1
121	Jemo Qedus Gebreal - Mexico Square	4	5	20	1400	45	10
122	Arat Kilo -Entoto Mariam	3	7	21	1470	31	16.6
123	Megenagna - Yeka Abado	4	4	16	1120		
124	Megenagna - Tulu Dimtu	4	4	16	1120		
	Total	443	687				

Appendix2: Sheger Bus Route Information

route No.	Origin - Destination	No. of buses	Frequency per bus	Total daily bus frequency within the route	Total daily bus seats (70)
1	Addisu Gebeya -- Bole	1	6	6	420
2	Adissu Gebeya -- Kera	1	6	6	420
3	Piassa -- Addisu Gebeya	4	9	36	2520
4	Piassa -- Bole	5	6	30	2100
5	Piassa -- Asko/wingate	12	9	108	7560
6	Piassa -- Kera Mebrathail	8	7	56	3920
7	Piassa -- Saris	11	6	66	4620
8	Piassa -- Betel	4	5	20	1400
9	Piassa -- Megenagna	2	6	12	840
10	Piassa -- Jemo2	6	6	36	2520
11	Piassa -- Ferensay	5	9	45	3150

12	Awtobs Tera --Alembank	6	7	42	2940
13	Awtobs Tera --Asko	3	8	24	1680
14	Awtobs Tera -- Saris Abo	2	6	12	840
15	Awtobs Tera - Jemo 1	2	6	12	840
16	Awtobs Tera -- Ashewa Meda	3	6	18	1260
17	Awtobs Tera -- Karakore	3	6	18	1260
18	Awtobs Tera -- Spain Embassy	1	9	9	630
19	Awtobs Tera -- Ayer Tena	6	8	48	3360
20	Awtobs Tera -- Kela	3	5	15	1050
21	Mrab Hotel -- Alem Bank	2	7	14	980
22	Ayer Tena -- Stadium	2	7	14	980
23	Ayer Tena -- Saris ABO	2	6	12	840
24	Ayer Tena -- Mexico	3	9	27	1890
25	Mexico -- Jemo2	27	7	189	13230
26	Mexico -- Haile Garment	6	9	54	3780
27	Mexico -- Hanna Mariyam	2	7	14	980
28	Mexico -- Sefera	3	7	21	1470
29	Mexico -- Alem Bank	3	7	21	1470
30	Mexico -- Gelan	3	9	27	1890
31	Mexico -- Tulu Dimtu	4	4	16	1120
32	Mexico -- Shiromeda	12	8	96	6720
33	Mexico -- Lafto	3	8	24	1680
34	4Killo -- Bole	3	6	18	1260
35	4Killo -- Ferensay	2	9	18	1260
36	6Killo -- Ksanchis	1	9	9	630
37	Shiromeda -- Saris	2	5	10	700
38	Shiromeda -- Bole	3	5	15	1050
39	Megenagna -- Yekabado	24	7	168	11760
40	Megenagna -- Semmit	3	6	18	1260
41	Megenagna -- Goro	3	8	24	1680

42	Megenagna -- Koye Fiche	1	5	5	350
43	Megenagna -- Tulu Dimtu	7	5	35	2450
44	Megenagna -- Saris	4	8	32	2240
45	Megenagna -- Tafo	4	5	20	1400
46	Megenagna -- Shiromeda	2	8	16	1120
47	Megenagna -- Pissa	4	5	20	1400
48	Megenagna -- Mexico	2	9	18	1260
49	Megenagna -- Bole Arabsa	8	5	40	2800
50	Goro -- Tulu Dimtu	3	6	18	1260
51	Yekabado -- Piassa	4	5	20	1400

Appendix 3: Woreda Labor force and population density distribution

Subcity	woreda	Woreda ID	Both gender	Labor force	Area (sq.km)	Density
Gulele-Sub City	KEBELE 13/14	1	37,120	26,464	5.26	7,057
Gulele-Sub City	KEBELE 16/17	2	38,322	27,320	4.42	8,670
Gulele-Sub City	KEBELE 18	3	40,869	29,136	3.23	12,653
Gulele-Sub City	KEBELE 19/20/21	4	45,737	32,607	7.94	5,760
Gulele-Sub City	KEBELE 01/02	5	32,748	23,346	2.2	14,885
Gulele-Sub City	KEBELE 03/04/05	6	43,999	31,368	1.37	32,116
Gulele-Sub City	KEBELE 09/15	7	49,991	35,640	1.66	30,115
Gulele-Sub City	KEBELE 07/08	8	57,989	41,341	3.13	18,527
Gulele-Sub City	KEBELE 10/11/12	9	51,165	36,476	1.95	26,238
Arada-Sub City	KEBELE 07/08	10	39,586	31,165	1.13	35,032
Arada-Sub City	KEBELE 06	11	21,385	16,836	0.63	33,944
Arada-Sub City	KEBELE 03/09	12	38,682	30,453	0.95	40,717
Arada-Sub City	KEBELE 04/05	13	34,434	27,109	0.56	61,489

Arada-Sub City	KEBELE 11/12	14	31,072	24,462	0.92	33,774
Arada-Sub City	KEBELE 10	15	21,153	16,653	0.38	55,666
Arada-Sub City	KEBELE 17	16	28,461	22,406	1	28,461
Arada-Sub City	KEBELE 15/16	17	38,528	30,332	1.08	35,674
Arada-Sub City	KEBELE 13/14	18	44,051	34,680	1.35	32,630
Arada-Sub City	KEBELE 01/02	19	33,536	26,402	1.47	22,814
Yeka-Sub City	KEBELE 01/02	20	42,496	32,282	3.92	10,841
Yeka-Sub City	KEBELE 03/04	21	50,604	38,442	6.27	8,071
Yeka-Sub City	KEBELE 05	22	21,429	16,278	1.02	21,008
Yeka-Sub City	KEBELE 06/07	23	29,479	22,394	3.58	8,234
Yeka-Sub City	KEBELE 18/19	24	49,835	37,857	21.36	2,333
Yeka-Sub City	KEBELE 20/21	25	101,889	77,401	29.79	3,420
Yeka-Sub City	KEBELE 15/17	26	86,101	65,407	4.9	17,572
Yeka-Sub City	KEBELE 08/15	27	47,594	36,155	6.78	7,020
Yeka-Sub City	KEBELE 11/12	28	33,311	25,305	1.72	19,367
Yeka-Sub City	KEBELE 13/14	29	37,328	28,357	1.5	24,886
Yeka-Sub City	KEBELE 09/10	30	42,280	32,118	0.98	43,143
Addis Ketema-Sub City	KEBELE 19/20	31	30,977	24,648	1.23	25,184
Addis Ketema-Sub City	KEBELE 14/21	32	44,805	35,651	0.62	72,266
Addis Ketema-Sub City	KEBELE 16/17	33	44,653	35,530	0.77	57,991
Addis Ketema-Sub City	KEBELE 10/11/12	34	51,089	40,652	1.19	42,932
Addis Ketema-Sub City	KEBELE 08/09/18	35	51,747	41,174	0.98	52,803
Addis ketema	KEBELE 13/15	36	36,294	28,879	0.48	75,613

Addis Ketema-Sub City	KEBELE 01/02/03	37	52,033	41,402	0.79	65,864
Addis Ketema-Sub City	KEBELE 04/05	38	42,465	33,789	0.36	117,957
Addis Ketema-Sub City	KEBELE 06/07	39	45,460	36,173	0.89	51,079
Kolfe Keraniyo-Sub City	KEBELE 13/14	40	59,391	103,069	2.12	28,014
Kolfe Keraniyo-Sub City	KEBELE 15/16	41	68,835	119,460	7.97	8,637
Kolfe Keraniyo-Sub City	KEBELE 12	42	20,391	35,388	1.27	16,056
Kolfe Keraniyo-Sub City	KEBELE 10/11	43	80,567	139,820	4.87	16,544
Kolfe Keraniyo-Sub City	KEBELE 07	44	55,728	96,713	7.77	7,172
Kolfe Keraniyo-Sub City	KEBELE 08/09	45	63,696	110,541	2.51	25,377
Kolfe Keraniyo-Sub City	KEBELE 06	46	65,318	113,356	6.29	10,384
Kolfe Keraniyo-Sub City	KEBELE 05	47	20,751	36,012	6.86	3,025
Kolfe Keraniyo-Sub City	KEBELE 01/02	48	119,019	206,550	1.88	63,308
Kolfe Keraniyo-Sub City	KEBELE 03	49	51,418	89,233	1.46	35,218
Kolfe Keraniyo-Sub City	KEBELE 04	50	86,631	150,343	19.52	4,438
Lideta-Sub City	KEBELE 02/03	51	38,450	30,792	2.92	13,168
Lideta-Sub City	KEBELE 04/06	52	41,944	33,590	0.58	72,316
Lideta-Sub City	KEBELE 05/07	53	44,065	35,288	1.03	42,782
Lideta-Sub City	KEBELE 08/10	54	45,637	36,548	0.64	71,308

Lideta-Sub City	KEBELE 09/11	55	20,909	16,745	0.5	41,818
Lideta-Sub City	KEBELE 12	56	27,308	21,869	0.37	73,805
Lideta-Sub City	KEBELE 13/14	57	41,282	33,060	1.14	36,212
Lideta-Sub City	KEBELE 15/16/17	58	22,458	17,985	1.01	22,236
Lideta-Sub City	KEBELE 01/18	59	33,522	26,845	2.72	12,324
Kirkos-Sub City	KEBELE 17/18	60	33,646	27,149	1.69	19,909
Kirkos-Sub City	KEBELE 15/16	61	26,803	21,627	1.88	14,257
Kirkos-Sub City	KEBELE 01/19	62	28,530	23,021	1.43	19,951
Kirkos-Sub City	KEBELE 20/21	63	32,162	25,952	1.05	30,631
Kirkos-Sub City	KEBELE 02/03	64	39,107	31,556	1.91	20,475
Kirkos-Sub City	KEBELE 04	65	20,013	16,149	1.35	14,824
Kirkos-Sub City	KEBELE 05/06/07	66	44,536	35,936	1.6	27,835
Kirkos-Sub City	KEBELE 13/14	67	35,504	28,649	0.68	52,212
Kirkos-Sub City	KEBELE 11/12	68	35,780	28,871	0.71	50,394
Kirkos-Sub City	KEBELE 08/09	69	32,752	26,428	1.19	27,523
Kirkos-Sub City	KEBELE 10	70	17,283	13,946	1.14	15,160
Bole-Sub City	KEBELE 02	71	12,758	9,922	1.15	11,094
Bole-Sub City	KEBELE 04/06/07	72	45,415	35,318	1.89	24,029
Bole-Sub City	KEBELE 08/09	73	31,646	24,610	1.55	20,417
Bole-Sub City	KEBELE 03/05	74	49,683	38,637	5.32	9,339
Bole-Sub City	KEBELE 12/13	75	38,112	29,639	3.19	11,947
Bole-Sub City	KEBELE 11/14	76	28,850	22,436	5.35	5,393
Bole-Sub City	KEBELE 10	77	50,473	39,252	2.92	17,285
Bole-Sub City	KEBELE 15	78	127,356	99,042	11.63	10,951
Bole-Sub City	KEBELE 16/18/21/22	79	21,169	16,463	47.87	442
Bole-Sub City	KEBELE 01	80	44,123	34,313	8.15	5,414
Bole-Sub City	KEBELE 17/19/20	81	33,829	26,308	29.53	1,146
Nefas Silk-	KEBELE 12/13	82	43,841	32,921	1.2	36,534
Lafto-Sub	KEBELE 11	83	25,047	18,808	1.06	23,629

Nefas Silk-Lafto-Sub City	KEBELE 10/18	84	64,611	48,517	3.65	17,702
Nefas Silk-Lafto-Sub City	KEBELE 09/14	85	52,455	39,389	3.52	14,902
Nefas Silk-Lafto-Sub City	KEBELE 03/04/05	86	54,516	40,936	4.3	12,678
Nefas Silk-Lafto-Sub City	KEBELE 06/07/08	87	63,148	47,418	2.72	23,216
Nefas Silk-Lafto-Sub City	KEBELE 02	88	50,414	37,856	6.58	7,662
Nefas Silk-Lafto-Sub City	KEBELE 01(HANA,LEBU,DERTU)	89	49,480	37,155	25.68	1,927
Nefas Silk-Lafto-Sub City	KEBELE 16/17	90	56,448	42,387	2.64	21,382
Nefas Silk-Lafto-Sub City	KEBELE 15	91	34,856	26,174	6.59	5,289
Akaki Kality-Sub City	KEBELE 12/13	92	42,369	28,047	3.62	11,704
Akaki Kality-Sub City	GELANGORA	93	6,106	4,042	35.46	172
Akaki Kality-Sub City	KEBELE 10/11	94	71,701	47,464	15.03	4,771
Akaki Kality-Sub City	KEBELE 07/08/09	95	66,194	43,818	19.16	3,455
Akaki Kality-Sub	KEBELE 05/06	96	27,503	18,206	2.49	11,046
Akaki Kality-Sub City	KEBELE 01/03	97	39,844	26,375	6.11	6,521
Akaki Kality-Sub City	KEBELE 02/04	98	21,860	14,471	13.47	1,623
Akaki Kality-Sub City	KILINITO,FECHE KOYE(17/18/19)	99	8,013	5,304	29.09	275

Appendix 4: Population data

Woreda ID	2007 CSA Population			Projected population(2019)		
	Both genders	Male	Female	Both genders	Male	Female
1	23,727	11,335	12,392	37,120.27	17,733.31	19,386.96
2	24,495	12,208	12,287	38,321.78	19,099.09	19,222.69
3	26,123	14,131	11,992	40,868.74	22,107.58	18,761.17
4	29,235	14,045	15,190	45,737.39	21,973.03	23,764.35
5	20,932	10,361	10,571	32,747.56	16,209.51	16,538.05
6	28,124	13,247	14,877	43,999.26	20,724.58	23,274.67
7	31,954	14,877	17,077	49,991.19	23,274.67	26,716.52
8	37,066	17,605	19,461	57,988.78	27,542.56	30,446.22
9	32,704	15,481	17,223	51,164.54	24,219.62	26,944.93
10	25,303	11,524	13,779	39,585.88	18,028.99	21,556.88
11	13,669	6,373	7,296	21,384.79	9,970.39	11,414.40
12	24,725	11,571	13,154	38,681.61	18,102.52	20,579.09
13	22,010	10,709	11,301	34,434.06	16,753.95	17,680.12
14	19,861	9,238	10,623	31,072.01	14,452.61	16,619.40
15	13,521	6,337	7,184	21,153.25	9,914.07	11,239.18
16	18,192	8,671	9,521	28,460.90	13,565.55	14,895.35
17	24,627	11,601	13,026	38,528.29	18,149.46	20,378.83
18	28,157	12,852	15,305	44,050.88	20,106.61	23,944.27
19	21,436	10,289	11,147	33,536.06	16,096.87	17,439.19
20	27,163	12,519	14,644	42,495.80	19,585.65	22,910.15
21	32,346	15,110	17,236	50,604.46	23,639.20	26,965.27
22	13,697	6,025	7,672	21,428.60	9,425.95	12,002.64
23	18,843	8,542	10,301	29,479.38	13,363.73	16,115.64
24	31,854	14,864	16,990	49,834.74	23,254.34	26,580.41
25	65,127	31,515	33,612	101,889.47	49,304.39	52,585.09
26	55,035	26,241	28,794	86,100.81	41,053.35	45,047.45
27	30,422	14,247	16,175	47,594.42	22,289.06	25,305.36
28	21,292	9,582	11,710	33,310.77	14,990.79	18,319.99
29	23,860	10,837	13,023	37,328.34	16,954.20	20,374.14
30	27,025	12,110	14,915	42,279.90	18,945.78	23,334.12
31	19,800	9,541	10,259	30,976.58	14,926.64	16,049.93

32	28,639	14,039	14,600	44,804.96	21,963.65	22,841.31
33	28,542	13,524	15,018	44,653.21	21,157.94	23,495.26
34	32,656	15,742	16,914	51,089.45	24,627.94	26,461.51
35	33,076	16,834	16,242	51,746.53	26,336.35	25,410.18
36	23,199	11,062	12,137	36,294.22	17,306.21	18,988.02
37	33,259	16,574	16,685	52,032.83	25,929.59	26,103.24
38	27,143	13,047	14,096	42,464.51	20,411.69	22,052.82
39	29,058	14,535	14,523	45,460.47	22,739.62	22,720.85
40	37,962	18,557	19,405	59,390.55	29,031.94	30,358.61
41	43,999	20,983	23,016	68,835.27	32,827.35	36,007.92
42	13,034	6,497	6,537	20,391.35	10,164.39	10,226.96
43	51,498	26,246	25,252	80,567.26	41,061.17	39,506.09
44	35,621	17,844	17,777	55,728.11	27,916.47	27,811.65
45	40,714	20,752	19,962	63,695.98	32,465.96	31,230.02
46	41,751	19,000	22,751	65,318.34	29,725.00	35,593.34
47	13,264	6,106	7,158	20,751.18	9,552.68	11,198.50
48	76,076	35,088	40,988	119,018.89	54,894.25	64,124.64
49	32,866	15,731	17,135	51,417.99	24,610.73	26,807.26
50	55,374	26,943	28,431	86,631.16	42,151.61	44,479.55
51	24,577	11,760	12,817	38,450.07	18,398.21	20,051.86
52	26,810	13,088	13,722	41,943.54	20,475.83	21,467.71
53	28,166	13,315	14,851	44,064.96	20,830.97	23,234.00
54	29,171	14,283	14,888	45,637.26	22,345.38	23,291.88
55	13,365	6,364	7,001	20,909.19	9,956.31	10,952.88
56	17,455	8,234	9,221	27,307.89	12,881.88	14,426.01
57	26,387	12,465	13,922	41,281.77	19,501.16	21,780.60
58	14,355	6,794	7,561	22,458.02	10,629.03	11,828.98
59	21,427	9,969	11,458	33,521.98	15,596.24	17,925.74
60	21,506	9,762	11,744	33,645.57	15,272.39	18,373.18
61	17,132	8,498	8,634	26,802.56	13,294.90	13,507.67
62	18,236	8,495	9,741	28,529.74	13,290.20	15,239.54
63	20,558	9,462	11,096	32,162.45	14,803.05	17,359.40
64	24,997	11,478	13,519	39,107.15	17,957.03	21,150.12

65	12,792	6,269	6,523	20,012.75	9,807.69	10,205.06
66	28,467	13,065	15,402	44,535.87	20,439.85	24,096.02
67	22,694	10,745	11,949	35,504.16	16,810.27	18,693.90
68	22,870	10,636	12,234	35,779.51	16,639.74	19,139.77
69	20,935	9,873	11,062	32,752.26	15,446.05	17,306.21
70	11,047	5,217	5,830	17,282.74	8,161.86	9,120.88
71	8,155	3,699	4,456	12,758.28	5,786.99	6,971.29
72	29,029	13,339	15,690	45,415.10	20,868.51	24,546.59
73	20,228	9,645	10,583	31,646.17	15,089.35	16,556.82
74	31,757	14,849	16,908	49,682.99	23,230.87	26,452.12
75	24,361	11,129	13,232	38,112.14	17,411.03	20,701.11
76	18,441	7,959	10,482	28,850.46	12,451.65	16,398.81
77	32,262	14,822	17,440	50,473.05	23,188.63	27,284.42
78	81,405	39,025	42,380	127,355.97	61,053.58	66,302.39
79	13,531	6,846	6,685	21,168.89	10,710.39	10,458.51
80	28,203	13,120	15,083	44,122.85	20,525.89	23,596.96
81	21,623	10,792	10,831	33,828.61	16,883.80	16,944.81
82	28,023	12,806	15,217	43,841.24	20,034.65	23,806.59
83	16,010	7,722	8,288	25,047.22	12,080.87	12,966.36
84	41,299	19,560	21,739	64,611.20	30,601.10	34,010.09
85	33,529	15,698	17,831	52,455.24	24,559.11	27,896.13
86	34,846	16,089	18,757	54,515.65	25,170.82	29,344.83
87	40,364	19,140	21,224	63,148.41	29,944.02	33,204.39
88	32,224	15,096	17,128	50,413.60	23,617.29	26,796.30
89	31,627	15,323	16,304	49,479.61	23,972.43	25,507.18
90	36,081	17,447	18,634	56,447.77	27,295.37	29,152.40
91	22,280	10,103	12,177	34,856.47	15,805.88	19,050.60
92	27,082	13,027	14,055	42,369.07	20,380.40	21,988.68
93	3,903	2,109	1,794	6,106.14	3,299.47	2,806.67
94	45,831	22,931	22,900	71,701.39	35,874.94	35,826.45
95	42,311	20,263	22,048	66,194.44	31,700.93	34,493.51
96	17,580	8,376	9,204	27,503.45	13,104.03	14,399.42
97	25,468	12,555	12,913	39,844.01	19,641.97	20,202.05
98	13,973	6,838	7,135	21,860.39	10,697.87	11,162.52
99	5,122	2,615	2,507	8,013.23	4,091.10	3,922.14

Appendix 5: Age distribution in all Woredas

Woreda ID	age(0 - 14)	age(15 - 24)	age(25 - 54)	age(55 - 64)	age(65 & above)
1	8,377	8,734	16,055	1,674	2,277
2	8,648	9,017	16,575	1,729	2,351
3	9,223	9,616	17,676	1,844	2,507
4	10,321	10,762	19,782	2,063	2,805
5	7,390	7,706	14,164	1,477	2,009
6	9,929	10,353	19,030	1,985	2,699
7	11,281	11,763	21,622	2,255	3,066
8	13,086	13,645	25,081	2,616	3,557
9	11,546	12,039	22,129	2,308	3,138
10	8,420	9,566	17,039	2,378	2,182
11	4,549	5,168	9,205	1,285	1,179
12	8,228	9,347	16,650	2,324	2,132
13	7,324	8,321	14,821	2,069	1,898
14	6,609	7,509	13,374	1,867	1,712
15	4,499	5,112	9,105	1,271	1,166
16	6,054	6,878	12,250	1,710	1,568
17	8,195	9,310	16,584	2,315	2,123
18	9,370	10,645	18,961	2,647	2,428
19	7,133	8,104	14,435	2,015	1,848
20	10,213	10,432	17,587	2,384	1,879
21	12,162	12,422	20,943	2,839	2,238
22	5,150	5,260	8,868	1,202	948
23	7,085	7,236	12,200	1,654	1,303
24	11,977	12,233	20,624	2,796	2,204
25	24,488	25,011	42,167	5,717	4,505
26	20,694	21,136	35,633	4,831	3,807
27	11,439	11,683	19,697	2,670	2,104
28	8,006	8,177	13,786	1,869	1,473
29	8,972	9,163	15,449	2,094	1,651
30	10,162	10,379	17,498	2,372	1,869
31	6,329	8,565	12,652	1,487	1,943
32	9,154	12,389	18,300	2,151	2,810
33	9,123	12,347	18,238	2,144	2,801
34	10,438	14,127	20,867	2,453	3,204
35	10,572	14,308	21,136	2,485	3,246
36	7,415	10,036	14,824	1,743	2,276

37	10,631	14,388	21,253	2,498	3,264
38	8,676	11,742	17,345	2,039	2,663
39	9,288	12,570	18,568	2,183	2,851
40	17,826	14,717	23,201	2,702	1,635
41	20,660	17,057	26,890	3,132	1,896
42	6,120	5,053	7,966	928	562
43	24,182	19,964	31,473	3,666	2,219
44	16,726	13,809	21,770	2,535	1,535
45	19,118	15,784	24,882	2,898	1,754
46	19,605	16,186	25,516	2,972	1,799
47	6,228	5,142	8,106	944	571
48	35,723	29,492	46,494	5,415	3,277
49	15,433	12,741	20,086	2,339	1,416
50	26,002	21,467	33,842	3,941	2,386
51	7,657	9,381	16,022	2,525	2,863
52	8,353	10,234	17,478	2,755	3,123
53	8,776	10,751	18,362	2,894	3,281
54	9,089	11,135	19,017	2,997	3,398
55	4,164	5,101	8,713	1,373	1,557
56	5,438	6,663	11,379	1,793	2,033
57	8,221	10,072	17,202	2,711	3,074
58	4,473	5,479	9,358	1,475	1,672
59	6,676	8,179	13,969	2,202	2,496
60	6,493	6,493	14,437	2,065	2,315
61	5,172	5,172	11,501	1,645	1,844
62	5,506	5,506	12,242	1,751	1,963
63	6,207	6,207	13,801	1,974	2,213
64	7,547	7,547	16,781	2,400	2,691
65	3,862	3,862	8,587	1,228	1,377
66	8,594	8,594	19,110	2,734	3,065
67	6,851	6,851	15,235	2,179	2,443
68	6,905	6,905	15,353	2,196	2,462
69	6,320	6,320	14,054	2,010	2,254
70	3,335	3,335	7,416	1,061	1,189
71	2,837	3,471	5,211	634	606
72	10,098	12,356	18,549	2,256	2,157
73	7,037	8,610	12,926	1,572	1,503
74	11,047	13,518	20,293	2,468	2,360
75	8,475	10,369	15,567	1,893	1,810
76	6,415	7,850	11,784	1,433	1,370

77	11,223	13,733	20,615	2,507	2,397
78	28,319	34,651	52,017	6,325	6,049
79	4,707	5,760	8,646	1,051	1,005
80	9,811	12,005	18,022	2,191	2,096
81	7,522	9,204	13,817	1,680	1,607
82	10,922	11,299	18,612	1,544	1,465
83	6,240	6,456	10,633	882	837
84	16,096	16,653	27,429	2,276	2,159
85	13,068	13,520	22,269	1,848	1,753
86	13,581	14,051	23,144	1,920	1,821
87	15,732	16,276	26,808	2,225	2,110
88	12,559	12,993	21,402	1,776	1,684
89	12,326	12,753	21,006	1,743	1,653
90	14,062	14,549	23,964	1,988	1,886
91	8,683	8,984	14,798	1,228	1,165
92	11,562	10,822	14,186	1,390	1,648
93	1,666	1,560	2,044	200	238
94	19,566	18,314	24,006	2,353	2,790
95	18,063	16,908	22,163	2,172	2,575
96	7,505	7,025	9,208	903	1,070
97	10,873	10,177	13,340	1,308	1,550
98	5,965	5,584	7,319	717	851
99	2,187	2,047	2,683	263	312

Appendix 6: Expenditure distribution in all Woredas

expenditure(1)	expenditure(2)	expenditure(3)	expenditure(4)	expenditure(5)
253	518	660	2,378	6,406
262	535	681	2,455	6,613
279	571	726	2,618	7,053
312	639	813	2,929	7,893
224	457	582	2,097	5,651
300	614	782	2,818	7,593
341	698	888	3,202	8,627
396	810	1,030	3,714	10,007
349	714	909	3,277	8,829
108	550	973	2,143	6,183
58	297	526	1,158	3,340
105	537	951	2,094	6,042

94	478	846	1,864	5,378
84	431	764	1,682	4,853
57	294	520	1,145	3,304
77	395	700	1,541	4,445
105	535	947	2,086	6,018
120	612	1,083	2,385	6,880
91	466	824	1,816	5,238
145	218	789	1,932	8,367
173	260	940	2,301	9,963
73	110	398	974	4,219
101	152	547	1,340	5,804
170	256	925	2,266	9,812
348	524	1,892	4,632	20,061
294	443	1,599	3,914	16,952
162	245	884	2,164	9,371
114	171	618	1,514	6,558
127	192	693	1,697	7,349
144	217	785	1,922	8,324
95	603	876	1,241	3,689
138	872	1,267	1,796	5,336
138	869	1,263	1,789	5,318
157	994	1,445	2,047	6,084
159	1,007	1,464	2,074	6,162
112	706	1,027	1,455	4,322
160	1,013	1,472	2,085	6,197
131	827	1,201	1,702	5,057
140	885	1,286	1,822	5,414
177	1,663	1,122	2,225	8,324
205	1,928	1,300	2,579	9,648
61	571	385	764	2,858
240	2,257	1,522	3,019	11,292
166	1,561	1,053	2,088	7,811
190	1,784	1,203	2,386	8,928
195	1,829	1,234	2,447	9,155
62	581	392	777	2,908
355	3,334	2,248	4,459	16,682
153	1,440	971	1,926	7,207
258	2,426	1,636	3,246	12,142
581	2,361	1,592	3,158	11,813
633	2,575	1,737	3,445	12,886

665	2,705	1,824	3,619	13,538
689	2,802	1,890	3,748	14,021
316	1,284	866	1,717	6,424
412	1,677	1,131	2,243	8,390
623	2,535	1,709	3,390	12,683
339	1,379	930	1,844	6,900
506	2,058	1,388	2,753	10,299
204	340	703	1,725	5,744
163	271	560	1,374	4,576
173	289	596	1,463	4,870
195	325	672	1,649	5,491
237	396	818	2,005	6,676
121	202	418	1,026	3,416
270	450	931	2,284	7,603
216	359	742	1,821	6,061
217	362	748	1,835	6,108
199	331	685	1,679	5,591
105	175	361	886	2,950
53	197	366	84	1,997
190	702	1,303	300	7,108
133	489	908	209	4,953
208	768	1,426	328	7,776
160	589	1,094	252	5,965
121	446	828	191	4,515
211	780	1,448	334	7,900
533	1,969	3,654	842	19,932
89	327	607	140	3,313
185	682	1,266	292	6,906
142	523	971	224	5,294
290	459	489	3,068	7,773
165	262	280	1,753	4,441
427	677	721	4,522	11,455
347	549	585	3,671	9,300
360	571	608	3,816	9,666
417	661	705	4,420	11,196
333	528	563	3,528	8,938
327	518	552	3,463	8,773
373	591	630	3,951	10,008
230	365	389	2,440	6,180
134	682	1,423	3,414	5,916

19	98	205	492	853
227	1,155	2,409	5,777	10,011
210	1,066	2,224	5,334	9,243
87	443	924	2,216	3,840
126	642	1,339	3,211	5,563
69	352	734	1,761	3,052
25	129	269	646	1,119

Appendix 7: Anbessa bus capacity, frequency and coverage score

Woreda ID	Route length	No. of Stops	Total daily bus frequency	Total daily seats	Capacity score	Coverage score
1	2.62	5.75	99.5	6965	0.492	1.093
2	2.76	3.5	48.5	3395	0.245	0.792
3	0	0	0	0	0.000	0.000
4	4.06	3.5	16	1120	0.099	0.441
5	5.69	8.35	245.5	17185	2.986	3.795
6	2.27	6.6	16	1120	0.058	4.818
7	1.19	3	71.5	5005	0.119	1.807
8	4.17	6.5	50.5	3535	0.254	2.077
9	1.7	3.6	123	8610	0.286	1.846
10	2.16	4.6	223.5	15645	0.854	4.071
11	1.34	1.8	85.5	5985	0.375	2.857
12	3.53	7.1	265.5	18585	1.696	7.474
13	1.21	2	127.5	8925	0.314	3.571
14	3.14	4.1	501.5	35105	3.548	4.457
15	1.09	1.5	362	25340	1.306	3.947
16	2.53	5	487	34090	3.030	5.000
17	2.76	4	202	14140	1.013	3.704
18	2.52	1.8	230	16100	0.921	1.333
19	4.1	9.3	751.5	52605	6.431	6.327
20	1.65	4.3	96	6720	0.261	1.097
21	2.64	5	66	4620	0.241	0.797
22	1.23	2.05	56	3920	0.225	2.010
23	1.42	1.25	9	630	0.030	0.349
24	1.52	6	260	18200	0.555	0.281
25	14.69	14.3	255	17850	2.574	0.480
26	2.89	6	383	26810	0.900	1.224
27	1.66	2	115	8050	0.281	0.295
28	3.3	6	342	23940	2.372	3.488
29	3.65	4	282	19740	1.930	2.667

30	2.01	5	136	9520	0.453	5.102
31	2.04	4.6	164	11480	0.756	3.740
32	1.81	3.3	57	3990	0.161	5.323
33	1.02	2.6	135.5	9485	0.217	3.377
34	2.99	3.8	236	16520	0.967	3.193
35	2.88	2.6	204	14280	0.795	2.653
36	1.69	2.1	238	16660	0.776	4.375
37	2.78	2.8	250.5	17535	0.937	3.544
38	0.32	1.3	60	4200	0.032	3.611
39	1.52	4	2	140	0.005	4.494
40	1.51	3.5	132	9240	0.235	1.651
41	3.5	10	258	18060	0.918	1.255
42	2.13	4.5	148	10360	1.082	3.543
43	1.5	4	54.5	3815	0.071	0.821
44	9.82	8	56.5	3955	0.697	1.030
45	1.9	5	199.5	13965	0.417	1.992
46	3.55	4	41	2870	0.156	0.636
47	4.7	7	65.5	4585	1.038	1.020
48	1.07	2.55	95	6650	0.060	1.356
49	2.8	1.5	6	420	0.023	1.027
50	3.46	4.25	60	4200	0.168	0.218
51	4.66	8.3	235.5	16485	1.998	2.842
52	1.12	1.3	65.5	4585	0.122	2.241
53	3.4	5.3	203.5	14245	1.099	5.146
54	1.3	2	30.5	2135	0.061	3.125
55	1.49	1.3	35	2450	0.175	2.600
56	0.66	1.3	41	2870	0.069	3.514
57	5.03	6.4	194.5	13615	1.659	5.614
58	1.18	2.5	198.5	13895	0.730	2.475
59	2.34	4.5	180	12600	0.880	1.654
60	5.05	6.6	194.5	13615	2.044	3.905
61	4.1	6.1	298.5	20895	3.196	3.245
62	2.69	5.3	97	6790	0.640	3.706
63	1.82	2.5	101.5	7105	0.402	2.381
64	3.59	4.5	141.5	9905	0.909	2.356
65	2.58	3	92.5	6475	0.835	2.222
66	1.76	1.5	74	5180	0.205	0.938
67	0.39	1.5	78	5460	0.060	2.206
68	1.23	2	40.5	2835	0.097	2.817
69	1.58	3	123.5	8645	0.417	2.521
70	2.72	4.3	96	6720	1.058	3.772

71	2.74	3.3	35.5	2485	0.534	2.870
72	3.29	5.3	133	9310	0.674	2.804
73	2.26	1.8	71	4970	0.355	1.161
74	7.69	8.8	92.5	6475	1.002	1.654
75	3.54	5.8	302	21140	1.964	1.818
76	2.89	7.5	39	2730	0.273	1.402
77	1.13	2	8.5	595	0.013	0.685
78	1.18	5.1	113	7910	0.073	0.439
79	0.47	7.6	109	7630	0.169	0.159
80	2.57	1.8	27	1890	0.110	0.221
81	7.92	2.8	11	770	0.180	0.095
82	1.23	1.6	124.5	8715	0.245	1.333
83	1.81	3	130.5	9135	0.660	2.830
84	3.84	7.6	121.5	8505	0.505	2.082
85	3.04	3	23	1610	0.093	0.852
86	5.13	9.3	162	11340	1.067	2.163
87	1.41	2.3	82	5740	0.128	0.846
88	8.86	7.8	131	9170	1.612	1.185
89	5.8	7	101	7070	0.829	0.273
90	0	0	0	0	0.000	0.000
91	4.32	2.5	27	1890	0.234	0.379
92	4.26	6.5	212	14840	1.492	1.796
93	3.55	0	0	0	0.000	0.000
94	4.65	7	159	11130	0.722	0.466
95	3.23	7.5	352	24640	1.202	0.391
96	0.86	1.5	16.5	1155	0.036	0.602
97	6.1	6.3	102.5	7175	1.098	1.031
98	3.08	2.3	104	7280	1.026	0.171
99	3.18	2	24	1680	0.667	0.069

Appendix 8: Sheger bus capacity, frequency and coverage score

Woreda ID	Route Length	No. of Stops	Total daily bus frequency	Total daily seat	capacity score	coverage score
1	0.62	1.3	66	4620	0.077	0.247
2	0.34	1.5	19.5	1365	0.012	0.339
3	0	0	0	0	0.000	0.000
4	0.19	0.5	73	5110	0.021	0.063
5	4.09	9	173	12110	1.512	4.091
6	0.95	2.33	4.5	315	0.007	1.701
7	0.42	1.5	39	2730	0.023	0.904

8	0.77	3	39	2730	0.036	0.958
9	1.15	2.33	54	3780	0.085	1.195
10	1.97	5.5	132	9240	0.460	4.867
11	0.76	1.5	54	3780	0.134	2.381
12	2.42	5	320	22400	1.401	5.263
13	0.33	0.5	4.5	315	0.003	0.893
14	1.88	2.16	204.5	14315	0.866	2.348
15	0.61	1	187	13090	0.377	2.632
16	2.08	4.5	200	14000	1.023	4.500
17	1.41	2	100	7000	0.256	1.852
18	1.87	1	56	3920	0.166	0.741
19	2.91	7.5	164.5	11515	0.999	5.102
20	0.71	1.5	31.5	2205	0.037	0.383
21	2.05	3.5	94.5	6615	0.268	0.558
22	1.23	2.33	39.5	2765	0.159	2.284
23	0.06	0	0	0	0.000	0.000
24	2.31	3.5	227	15890	0.737	0.164
25	12.3	13.16	228	15960	1.927	0.442
26	2.68	3.5	282	19740	0.614	0.714
27	1.69	2	112	7840	0.278	0.295
28	1.2	1.5	43	3010	0.108	0.872
29	1.91	2.5	82	5740	0.294	1.667
30	0	0	0	0	0.000	0.000
31	0.77	1.66	54	3780	0.094	1.350
32	0.22	0.33	54	3780	0.019	0.532
33	0.2	0.33	28.5	1995	0.009	0.429
34	0.98	1	57	3990	0.077	0.840
35	1.73	1.66	179	12530	0.419	1.694
36	0.73	1.33	33	2310	0.046	2.771
37	1.27	3.33	99.5	6965	0.170	4.215
38	0.32	0.83	89.5	6265	0.047	2.306
39	0	0	0	0	0.000	0.000
40	1.5	3	66	4620	0.117	1.415
41	1.41	4.5	198	13860	0.284	0.565
42	1.87	3.5	66	4620	0.424	2.756
43	3.3	3.33	28.5	1995	0.082	0.684
44	3.8	2.83	54.5	3815	0.260	0.364
45	0.67	1	16.5	1155	0.012	0.398
46	3.14	2	56	3920	0.188	0.318
47	4.92	7.33	59.5	4165	0.988	1.069
48	1.03	1.5	64.5	4515	0.039	0.798

49	2.91	2.16	15	1050	0.059	1.479
50	1.24	2.25	18	1260	0.018	0.115
51	2.56	3.5	98.5	6895	0.459	1.199
52	0.71	1.3	83	5810	0.098	2.241
53	2.64	4.8	122.5	8575	0.514	4.660
54	0.38	0.5	10	700	0.006	0.781
55	0.18	0.5	10	700	0.006	1.000
56	0.16	0.5	10	700	0.004	1.351
57	1.61	3.5	82.5	5775	0.225	3.070
58	1.19	2	217	15190	0.805	1.980
59	3.28	5.5	256	17920	1.753	2.022
60	3.26	3.5	21	1470	0.142	2.071
61	2.95	4.8	219	15330	1.687	2.553
62	2.81	3.5	43.5	3045	0.300	2.448
63	1.44	2	42.5	2975	0.133	1.905
64	1.48	2	42.5	2975	0.113	1.047
65	0.48	0.5	8	560	0.013	0.370
66	1.75	1.5	14	980	0.039	0.938
67	0.24	0.5	8	560	0.004	0.735
68	0.1	1	24.5	1715	0.005	1.408
69	1.27	2.5	49	3430	0.133	2.101
70	2.67	4.8	203	14210	2.195	4.211
71	1.58	1.3	53.5	3745	0.464	1.130
72	1.3	1.8	15	1050	0.030	0.952
73	1.32	0.5	63	4410	0.184	0.323
74	2.49	1.3	50.5	3535	0.177	0.244
75	5	5.3	204	14280	1.873	1.661
76	3.08	3.5	103	7210	0.770	0.654
77	0.4	0	0	0	0.000	0.000
78	4.78	5.1	121	8470	0.318	0.439
79	8.9	6.8	59	4130	1.736	0.142
80	2.58	2.3	66.5	4655	0.272	0.282
81	6	0	0	0	0.000	0.000
82	1.2	2	46	3220	0.088	1.667
83	1.66	2	46	3220	0.213	1.887
84	2	2.5	30	2100	0.065	0.685
85	3.17	3	86	6020	0.364	0.852
86	3.69	4.8	227.5	15925	1.078	1.116
87	1.29	1.8	151.5	10605	0.217	0.662
88	7.86	8.1	381	26670	4.158	1.231
89	2.99	2.5	261	18270	1.104	0.097

90	0.82	0.5	12	840	0.012	0.189
91	4.44	2.5	84	5880	0.749	0.379
92	3.34	3.3	42	2940	0.232	0.912
93	3.55	0	0	0	0.000	0.000
94	5.82	7	49	3430	0.278	0.466
95	3.18	4.5	43	3010	0.145	0.235
96	0.9	0	0	0	0.000	0.000
97	4.67	3.5	69	4830	0.566	0.573
98	0.32	0.5	34.5	2415	0.035	0.037
99	5.66	4	58	4060	2.868	0.138

Appendix 9: LRT capacity, frequency and coverage score

Woreda ID	Route Length	No. of Stops	Total daily tram car frequency	Total daily seat	capacity score	coverage score
1	0	0	0	0	0.000	0.000
2	0	0	0	0	0.000	0.000
3	0	0	0	0	0.000	0.000
4	0	0	0	0	0.000	0.000
5	0	0	0	0	0.000	0.000
6	0	0	0	0	0.000	0.000
7	0	0	0	0	0.000	0.000
8	0	0	0	0	0.000	0.000
9	0	0	0	0	0.000	0.000
10	0	0	0	0	0.000	0.000
11	0	0	0	0	0.000	0.000
12	0	0	0	0	0.000	0.000
13	0.32	0.5	32	18304	0.170	0.893
14	0	0	0	0	0.000	0.000
15	0.1	0.5	32	18304	0.087	1.316
16	0	0	0	0	0.000	0.000
17	0	0	0	0	0.000	0.000
18	0	0	0	0	0.000	0.000
19	0.5	0.5	32	18304	0.273	0.340
20	0	0	0	0	0.000	0.000
21	0	0	0	0	0.000	0.000
22	0	0	0	0	0.000	0.000
23	0	0	0	0	0.000	0.000
24	0.72	1	32	18304	0.264	0.047
25	1.71	1.5	32	18304	0.307	0.050
26	0.59	0.5	32	18304	0.125	0.102

27	0.07	0.3	32	18304	0.027	0.044
28	0.47	0.5	32	18304	0.258	0.291
29	0.92	1.3	32	18304	0.451	0.867
30	0	0	0	0	0.000	0.000
31	0	0	0	0	0.000	0.000
32	0	0	0	0	0.000	0.000
33	0	0	0	0	0.000	0.000
34	0	0	0	0	0.000	0.000
35	1.1	1.3	32	18304	0.389	1.327
36	0.51	1	32	18304	0.257	2.083
37	0.32	0.3	32	18304	0.113	0.380
38	0.32	0.3	32	18304	0.138	0.833
39	0	0	0	0	0.000	0.000
40	0	0	0	0	0.000	0.000
41	0	0	0	0	0.000	0.000
42	0	0	0	0	0.000	0.000
43	0	0	0	0	0.000	0.000
44	0	0	0	0	0.000	0.000
45	0	0	0	0	0.000	0.000
46	0	0	0	0	0.000	0.000
47	0	0	0	0	0.000	0.000
48	0	0	0	0	0.000	0.000
49	0	0	0	0	0.000	0.000
50	0	0	0	0	0.000	0.000
51	0.07	0.5	32	18304	0.033	0.171
52	0.26	0.8	32	18304	0.113	1.379
53	1.74	2.1	223.5	127842	5.048	2.039
54	0.04	0	0	0	0.000	0.000
55	0	0	0	0	0.000	0.000
56	0	0	0	0	0.000	0.000
57	0.29	0.5	127.5	72930	0.512	0.439
58	0.47	0.8	127.5	72930	1.526	0.792
59	1.04	1.1	159.5	91234	2.830	0.404
60	0.68	0.8	32	18304	0.370	0.473
61	1.18	2.5	255	145860	6.422	1.330
62	0.69	1.3	32	18304	0.443	0.909
63	1.01	1.3	127.5	72930	2.290	1.238
64	0.64	1.1	32	18304	0.300	0.576
65	0.49	0.3	32	18304	0.448	0.222
66	1.24	1.1	32	18304	0.510	0.688
67	0.24	0.5	32	18304	0.124	0.735

68	0	0	0	0	0.000	0.000
69	0	0	0	0	0.000	0.000
70	0.55	0.5	127.5	72930	2.321	0.439
71	0	0	0	0	0.000	0.000
72	1.28	1.6	32	18304	0.516	0.847
73	0.25	0	0	0	0.000	0.000
74	0	0	0	0	0.000	0.000
75	1.92	1.8	32	18304	0.922	0.564
76	0.64	1	32	18304	0.406	0.187
77	0	0	0	0	0.000	0.000
78	1.18	1.5	32	18304	0.170	0.129
79	0	0	0	0	0.000	0.000
80	0	0	0	0	0.000	0.000
81	0	0	0	0	0.000	0.000
82	0	0	0	0	0.000	0.000
83	0.77	0.5	32	18304	0.563	0.472
84	1.58	1.5	32	18304	0.448	0.411
85	0	0	0	0	0.000	0.000
86	0	0	0	0	0.000	0.000
87	0	0	0	0	0.000	0.000
88	0	0	0	0	0.000	0.000
89	0	0	0	0	0.000	0.000
90	0	0	0	0	0.000	0.000
91	0	0	0	0	0.000	0.000
92	2.35	3	32	18304	1.015	0.829
93	0	0	0	0	0.000	0.000
94	0	0	0	0	0.000	0.000
95	0	0	0	0	0.000	0.000
96	0	0	0	0	0.000	0.000
97	0	0	0	0	0.000	0.000
98	0	0	0	0	0.000	0.000
99	0	0	0	0	0.000	0.000

Appendix 10: Total capacity, frequency and coverage score

Woreda ID	Total capacity score	Total frequency score	Total coverage score
1	0.5688	165.500	1.340
2	0.2566	68.000	1.131
3	0.0000	0.000	0.000
4	0.1206	89.000	0.504

5	4.4984	418.500	7.886
6	0.0646	20.500	6.518
7	0.1421	110.500	2.711
8	0.2905	89.500	3.035
9	0.3710	177.000	3.041
10	1.3135	355.500	8.938
11	0.5094	139.500	5.238
12	3.0974	585.500	12.737
13	0.4867	164.000	5.357
14	4.4137	706.000	6.804
15	1.7697	581.000	7.895
16	4.0536	687.000	9.500
17	1.2691	302.000	5.556
18	1.0874	286.000	2.074
19	7.7034	948.000	11.769
20	0.2978	127.500	1.480
21	0.5090	160.500	1.356
22	0.3837	95.500	4.294
23	0.0303	9.000	0.349
24	1.5561	519.000	0.492
25	4.8074	515.000	0.972
26	1.6397	697.000	2.041
27	0.5861	259.000	0.634
28	2.7384	417.000	4.651
29	2.6750	396.000	5.200
30	0.4526	136.000	5.102
31	0.8500	218.000	5.089
32	0.1797	111.000	5.855
33	0.2256	164.000	3.805
34	1.0434	293.000	4.034
35	1.6028	415.000	5.673
36	1.0794	303.000	9.229
37	1.2194	382.000	8.139
38	0.2168	181.500	6.750
39	0.0047	2.000	4.494
40	0.3516	198.000	3.066
41	1.2022	456.000	1.819
42	1.5058	214.000	6.299
43	0.1527	83.000	1.505

44	0.9571	111.000	1.394
45	0.4287	216.000	2.390
46	0.3444	97.000	0.954
47	2.0260	125.000	2.089
48	0.0989	159.500	2.154
49	0.0823	21.000	2.507
50	0.1858	78.000	0.333
51	2.4903	366.000	4.212
52	0.3342	180.500	5.862
53	6.6610	549.500	11.845
54	0.0666	40.500	3.906
55	0.1806	45.000	3.600
56	0.0735	51.000	4.865
57	2.3965	404.500	9.123
58	3.0612	543.000	5.248
59	5.4634	595.500	4.081
60	2.5559	247.500	6.450
61	11.3052	772.500	7.128
62	1.3828	172.500	7.063
63	2.8255	271.500	5.524
64	1.3214	216.000	3.979
65	1.2963	132.500	2.815
66	0.7528	120.000	2.563
67	0.1875	118.000	3.676
68	0.1023	65.000	4.225
69	0.5500	172.500	4.622
70	5.5738	426.500	8.421
71	0.9975	89.000	4.000
72	1.2204	180.000	4.603
73	0.5389	134.000	1.484
74	1.1794	143.000	1.898
75	4.7591	538.000	4.044
76	1.4492	174.000	2.243
77	0.0133	8.500	0.685
78	0.5608	266.000	1.006
79	1.9058	168.000	0.301
80	0.3823	93.500	0.503
81	0.1803	11.000	0.095
82	0.3326	170.500	3.000

83	1.4362	208.500	5.189
84	1.0181	183.500	3.178
85	0.4571	109.000	1.705
86	2.1450	389.500	3.279
87	0.3448	233.500	1.507
88	5.7697	512.000	2.416
89	1.9328	362.000	0.370
90	0.0122	12.000	0.189
91	0.9832	111.000	0.759
92	2.7391	286.000	3.536
93	0.0000	0.000	0.000
94	1.0002	208.000	0.931
95	1.3469	395.000	0.626
96	0.0361	16.500	0.602
97	1.6646	171.500	1.604
98	1.0611	138.500	0.208
99	3.5344	82.000	0.206

Appendix 11: Standardized capacity, frequency, coverage and overall index

Woreda ID	Standardized capacity score	Standardized frequency score	Standardized coverage score	Woreda Index	woreda index plus five
1	-0.4949	-0.3861	-0.4987	-1.3797	3.6203
2	-0.6598	-0.8797	-0.5430	-2.0825	2.9175
3	-0.7954	-1.2239	-0.7828	-2.8021	2.1979
4	-0.7316	-0.7734	-0.6760	-2.1810	2.8190
5	1.5814	0.8945	0.8891	3.3650	8.3650
6	-0.7612	-1.1201	0.5991	-1.2823	3.7177
7	-0.7203	-0.6645	-0.2081	-1.5930	3.4070
8	-0.6419	-0.7708	-0.1394	-1.5521	3.4479
9	-0.5993	-0.3279	-0.1381	-1.0654	3.9346
10	-0.1014	0.5756	1.1121	1.5863	6.5863
11	-0.5262	-0.5177	0.3277	-0.7163	4.2837
12	0.8411	1.7398	1.9175	4.4984	9.4984
13	-0.5382	-0.3937	0.3529	-0.5790	4.4210
14	1.5366	2.3498	0.6597	4.5461	9.5461
15	0.1397	1.7171	0.8909	2.7476	7.7476
16	1.3463	2.2536	1.2312	4.8312	9.8312
17	-0.1248	0.3048	0.3950	0.5749	5.5749
18	-0.2208	0.2238	-0.3431	-0.3401	4.6599

19	3.2747	3.5748	1.7122	8.5617	13.5617
20	-0.6381	-0.5785	-0.4692	-1.6857	3.3143
21	-0.5264	-0.4114	-0.4954	-1.4333	3.5667
22	-0.5926	-0.7405	0.1275	-1.2056	3.7944
23	-0.7793	-1.1783	-0.7088	-2.6665	2.3335
24	0.0268	1.4032	-0.6786	0.7514	5.7514
25	1.7446	1.3830	-0.5767	2.5508	7.5508
26	0.0710	2.3042	-0.3502	2.0250	7.0250
27	-0.4857	0.0872	-0.6484	-1.0470	3.9530
28	0.6514	0.8869	0.2032	1.7416	6.7416
29	0.6180	0.7806	0.3196	1.7182	6.7182
30	-0.5563	-0.5355	0.2988	-0.7929	4.2071
31	-0.3463	-0.1204	0.2962	-0.1705	4.8295
32	-0.7004	-0.6620	0.4584	-0.9040	4.0960
33	-0.6762	-0.3937	0.0239	-1.0460	3.9540
34	-0.2441	0.2593	0.0723	0.0875	5.0875
35	0.0514	0.8768	0.4200	1.3482	6.3482
36	-0.2251	0.3099	1.1738	1.2586	6.2586
37	-0.1511	0.7098	0.9427	1.5014	6.5014
38	-0.6808	-0.3051	0.6482	-0.3378	4.6622
39	-0.7929	-1.2137	0.1700	-1.8366	3.1634
40	-0.6096	-0.2216	-0.1328	-0.9640	4.0360
41	-0.1602	1.0843	-0.3971	0.5270	5.5270
42	0.0002	-0.1406	0.5526	0.4122	5.4122
43	-0.7147	-0.8037	-0.4637	-1.9822	3.0178
44	-0.2897	-0.6620	-0.4873	-1.4391	3.5609
45	-0.5689	-0.1305	-0.2761	-0.9754	4.0246
46	-0.6134	-0.7329	-0.5806	-1.9269	3.0731
47	0.2750	-0.5911	-0.3400	-0.6561	4.3439
48	-0.7431	-0.4165	-0.3261	-1.4858	3.5142
49	-0.7519	-1.1176	-0.2514	-2.1208	2.8792
50	-0.6972	-0.8290	-0.7122	-2.2385	2.7615
51	0.5204	0.6288	0.1102	1.2593	6.2593
52	-0.6188	-0.3102	0.4600	-0.4690	4.5310
53	2.7239	1.5576	1.7283	6.0099	11.0099
54	-0.7602	-1.0189	0.0453	-1.7337	3.2663
55	-0.6999	-0.9961	-0.0196	-1.7156	3.2844
56	-0.7566	-0.9657	0.2485	-1.4737	3.5263
57	0.4708	0.8237	1.1513	2.4457	7.4457
58	0.8220	1.5247	0.3297	2.6764	7.6764
59	2.0912	1.7905	0.0823	3.9640	8.9640

60	0.5550	0.0289	0.5845	1.1685	6.1685
61	5.1777	2.6864	0.7283	8.5924	13.5924
62	-0.0648	-0.3507	0.7146	0.2991	5.2991
63	0.6975	0.1504	0.3882	1.2361	6.2361
64	-0.0972	-0.1305	0.0607	-0.1670	4.8330
65	-0.1105	-0.5532	-0.1861	-0.8497	4.1503
66	-0.3976	-0.6164	-0.2396	-1.2536	3.7464
67	-0.6963	-0.6266	-0.0034	-1.3263	3.6737
68	-0.7413	-0.8948	0.1130	-1.5232	3.4768
69	-0.5048	-0.3507	0.1970	-0.6584	4.3416
70	2.1495	0.9350	1.0025	4.0870	9.0870
71	-0.2684	-0.7734	0.0652	-0.9765	4.0235
72	-0.1506	-0.3127	0.1931	-0.2703	4.7297
73	-0.5107	-0.5456	-0.4683	-1.5245	3.4755
74	-0.1723	-0.5000	-0.3803	-1.0526	3.9474
75	1.7191	1.4994	0.0745	3.2930	8.2930
76	-0.0297	-0.3431	-0.3073	-0.6801	4.3199
77	-0.7883	-1.1808	-0.6376	-2.6068	2.3932
78	-0.4991	0.1226	-0.5696	-0.9461	4.0539
79	0.2115	-0.3735	-0.7191	-0.8810	4.1190
80	-0.5934	-0.7506	-0.6762	-2.0202	2.9798
81	-0.7001	-1.1682	-0.7627	-2.6311	2.3689
82	-0.6196	-0.3608	-0.1468	-1.1273	3.8727
83	-0.0365	-0.1685	0.3172	0.1122	5.1122
84	-0.2575	-0.2950	-0.1091	-0.6616	4.3384
85	-0.5539	-0.6721	-0.4215	-1.6475	3.3525
86	0.3379	0.7477	-0.0877	0.9980	5.9980
87	-0.6132	-0.0419	-0.4633	-1.1184	3.8816
88	2.2530	1.3678	-0.2705	3.3503	8.3503
89	0.2258	0.6085	-0.7044	0.1299	5.1299
90	-0.7889	-1.1631	-0.7427	-2.6947	2.3053
91	-0.2759	-0.6620	-0.6220	-1.5599	3.4401
92	0.6518	0.2238	-0.0332	0.8424	5.8424
93	-0.7954	-1.2239	-0.7828	-2.8021	2.1979
94	-0.2669	-0.1710	-0.5854	-1.0233	3.9767
95	-0.0837	0.7756	-0.6501	0.0418	5.0418
96	-0.7763	-1.1403	-0.6551	-2.5718	2.4282
97	0.0841	-0.3558	-0.4428	-0.7145	4.2855
98	-0.2348	-0.5228	-0.7388	-1.4963	3.5037
99	1.0720	-0.8088	-0.7391	-0.4759	4.5241