**Addis Ababa University**

**School of Civil and Environmental Engineering,**

**Stream of Geodesy and Geomatics Engineering**

# GIS Based Evaluation of Urban Road Network Structure and their Accessibility to service areas in case study of Addis Ababa Ethiopia

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# GIS Based Evaluation of Urban Road Network Structure and their Accessibility to service areas in case study of Addis Ababa Ethiopia

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A Thesis Submitted to School of Graduate Studies in Partial Fulfillment of the Requirement for Degree of Master of in Geodesy and Geometrics engineering

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## Approval sheet

This undersigned hear by certify that they have read and recommend to Addis Ababa university institute of technology school of civil and environmental engineering for acceptance a thesis entitled: "GIS Based Evaluation of Urban Road Network Structure and their Accessibility to service areas in case study of Addis Ababa Ethiopia" By YETNAYET ABDULE In partial fulfillment of the Requirement for the Degree Masters of Science in Geodesy and Geomatics (specialization in Geomatics).

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**DECLARATION**

I hereby declare that the thesis entitled "GIS Based Evaluation of Urban Road Network Structure and their Accessibility to service areas in case study of Addis Ababa Ethiopia" has been, carried out by me under the supervision of Dr.Degife Tibebu School of Civil and Environmental Engineering, Addis Ababa University during the year 2020-2023 as a part of Master of Science in Geodesy and Geomatics (Specialization in Geomatics). I further declare that this work has not been, submitted to any other University or Institution for the award of any Degree or Diploma.

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## List of acronyms

| | |
|---|---|
| AACRA | Addis Ababa city administration road authority |
| AAUTS | Addis Ababa Urban Transport Study |
| AC | Asphalt concrete |
| AU | African Union |
| CAD | Computer Aided Design |
| CBD | Central Business District |
| CDP | Comprehensive Development Plan |
| ERA | Ethiopian road authorities |
| GDP | Gross Domestic Product |
| GIS | Geographic Information System |
| Ha | Hectare |
| LOS | Level of service |
| LULD | Land Use Land Cover |
| ND | Network density |
| OD | Origin Destination |
| SDG | Sustainable Development Goals |
| TRANSIP | Transportation System Improvement Project |
| UN | United nation |
| UNFPA | United nation population fund |

## ABSTRACT

On this research the study evaluate the road network structure, by employing GIS technology taking four selected sub cities in Addis Ababa Akaki Kality, Nefaselke Lafo,Kirkose and Arada sub-cities and accessibility of road network to service areas. The data collected by using hand GPS to collect point data which primary data and Secondary data was collected visiting relevant offices in Addis Ababa. The study area's development is negatively impacted by the poor level of road network service in some areas, which limits mobility, creates inequalities of accessibility, and people travel unnecessary distances to get there destination. Because of this reasons findings of this study revealed by determining the road density, proximity, accessibility of the road and pin point areas that has been totally loose there road connectivity are also described. Further, recommendations are made to improve the existing road network structure by using upgraded software like ARC GIS.

**Key words: Accessibility, Mobility, Proximity, Road density, Road Connectivity and Traffic volume load.**

# Chapter one

# 1. INTRODUCTION

## 1.1. Background of the study

Transportation system is a critical component of urban infrastructure and the lifeline of the city. It plays a key role in the economic system growth of that region and displays region's economic condition Praveen et al, (2013). Transportation consists of streets, highways, railroads, port and waterways and the like. It links town and villages and enable the people of one place to communicate with people of another place; it is true that good road network helps people to travel easily to places where they can work and develop their life Ndiwari,(2014) Irfan (2005) Derrible & Kennedy ( 2011)

The rapid increase in population of persons and vehicles without proper planning, design and maintenance of the available roads within the city, as well as the improper location of public facilities resulted in an inadequate transportation network. This is because the volume of traffic outweighs the road capacity, resulting in traffic congestion. According to the UN and its Habitat Organizations, five comprehensive problem fields are relevant for the enhancement of living conditions within a city UN Habitat (2003) of which transport is a part. These problems or rather challenges can be solved by employing GIS.

As road network is a most important component of urban infrastructure and is a key to the quality of life of the societies in that area. Knowing the process of city infrastructure provision and reliable information base is essential for successful infrastructure management and strategic decision-making. Lack of information contributes to problems such as ineffective infrastructure provision and management. It is true that, every day planners use geographic information system (GIS) technology to research, develop, implement, and monitor the progress of their plans. GIS provides planners, surveyors, and engineers with the tools they need to design and map their neighborhoods and cities, and they use GIS to facilitate the decision-making process Pettit, (2006).

Many researchers agree on the major changes in transport network structure affect the pattern of urban development and the location of social and economic activities, households and employment centers. In other hand major changes in land use influences the trip making behavior of people, destination and mode of choiceWaddell, (2011). The network structure also affected accessibility and destination choice of travelers Haung and Levinson (2011). Developing city where the road network is dominated mode of transport land use transport relation is highly coupled the road network provides access to different activities like business, education and employment opportunities Murray et,al (1998) and people make a trip to join this activities. Road network plans that consider the changes in the paradigm of urban plans are important for the creation of comfortable cities.

The road network of Addis Ababa has mainly radial developmental pattern that is highly influenced by topography, the nature of housing and building characteristics. It forms a dens network in the north-south direction. Mekete (1997), states that, there is an absence of direct connections, particularly in the east-west direction of the city. The designs of the road network are not satisfactory and there are many intersections. The arterial network includes all asphalted roads. The local streets are often in poor conditions. The streets between houses are narrow, unpaved and usually damaged by the heavy rain. Most of them serve as pedestrian ways. As a result, vehicular access is limited. Several studiesthat are conducted byMekete (1997),Paulos Birhanu A.D. (2014),Yetnayet Ayaleneh, A. D. (2012) studies on the nature of public transport confirmed that there is inadequacy of public transport facilities in the city.

Urban transport plan and application is based on land use plan and its implementation ministry of transport Addis Ababa(August 2011). There is increasing pressure on public transport service, low fleet size of buses, unattractive location of freight and passenger transport terminals and weak traffic management system are the main challenges to mention Aberra degefa, (2019).

On this study the current performance can be measured by assessing the accessibility level of mobility provides by the network and by analyzing the efficiency of the network in comparison with the ideal network. Accessibility in this context is ease to reach certain destination from a particular origin using transport network and efficiency in terms of minimized cost. Geographic information system can be used for better understanding of accessibility and also be used in automatic identification of missing infrastructure in existing network structure Zuidgeest,Rouwette,and Jong,(2009)

## 1.2. Statement of the problem

Transportation is the biggest energy consumer and high budget cost to constructs; this infrastructure has to be well planned and design. The present-day urban society needs an efficient system of transport network, water supply, and telecommunication services and utilities. However, the provision of such infrastructures is highly constrained by planning, institutional, technological and policy factors.

Among the main challenges facing urban centers particularly those in the developing countries is how to provide adequate level of public infrastructure and services for growing urban population. The recommendations of the Sustainable Development Goals of Africa Steering Group in 2011 clearly indicated that the sub-Saharan Africa is not only characterized by lack of infrastructural services but also not carefully installed programs that pose constraints on economic growth and expansion of poverty,( 2011).

Addis Ababa city is experiencing rapid growth of population. Thus, the demand for infrastructure and services is surpassing the current capacity. Existing infrastructural services are also unpromising rapidly and in need of urgent solution. For instance, road construction often resulted in unearthing of underground electricity and telecommunication cables, as well as water networks. A number of reasons were used to explain the poor infrastructure management system paulos Birhanu (2014). The main reasons for these problems are linked with poor infrastructure planning and an overall lack of understanding of how to effectively manage the infrastructural services. Another major problem has to do with high capacity utilization levels, characteristics among most part of the city. This is mainly due to the increasing urban population and resultant demand for infrastructure and service (Nyarirangwe, 2008).

Urban transport serves as veins to accelerate developments in Industry, trade, education, health and other services. However, there is no compatible urban transport supply and effective management to meet the increasing trip frequency and mobility needs of the people and goods, which resulted in the seriousness of the issue. While there have been studies related to urban road network evaluations that have considered the mobility and efficiency road network structure. When we look at the transport planning and decision-making strategies of cities of developing countries, most of the times, planning decisions are made based on pure speculation and it is hard to explain how decisions are made that affect the road network plan. Because of this reason, cities grow in uncontrolled manner and change into more and more inefficient transport networks (paulos Birhanu, 2014).

Only a few studies byMekete (1997),Paulos Birhanu A.D. (2014),Yetnayet Ayaleneh, A. D. (2012) have been undertaken on the entire transportation system. Most studies focus on the demand side of the transportation system, there is a gap in the research focused on the present road network layout, which could be a key cause of the transportation problem, and they do not properly employ GIS instruments for analysis. However, we can study and evaluate the road network structure using GIS. In addition, because the majority of the studies were completed at least seven years ago, there is a gap in demonstrating the current state of the road network structure. As a result, there is a pressing need to conduct research on the existing problem that is compatible with the GIS environment in order to improve planning and management.

## 1.3 Objective of the study

### 1.3.1General objective

The general objective of the study is to evaluate the road network structure, by employing GIS technology taking four selected sub cities in Addis Ababa Akaki Kality, Nefaselke Lafo,Kirkose and Arada sub cities as a case study area.

### 1.3.2 Specific objective

- ✓ To evaluate the existing road transport network structure by using indicators
- ✓ To identify the current network accessibility to different service areas
- ✓ To identify the road network deficiency and pinpoint of the study area

## 1.4 Research question

To realize the stated objectives, the following research questions are designed

- ✓ Which road transport network indicators are suited for network structure analysis and better traffic performance?
- ✓ What mode can be used for define the accessibility level of road network with service areas?

- ✓ In the existing road network structure, which areas are observed to be missing road network links?

### 1.5 Significance of the study

It is widely acknowledged that change occurs in all dimensions of the city, although different regions of the city grow at different rates. However, less attention is paid to the performance of the road network, as well as the problems with road transportation and their solutions. As a result, the study's findings aid in the gathering of valuable data and information about the city's road network structure by identifying the indicators that are used to investigate and assess the city's existing road network structure, as well as providing information on the city's recent and current road network structure condition.

The study will also serve as a resource for the city's road authority, and it will contribute to the policy-making process in this area. It will also be used as a reference for politicians, transportation agencies, road engineers, and other interested parties.

### 1.6 Scope of the study

The research area is Addis Ababa, Ethiopia's capital and largest city in the country. It is situated in the geographic center of the country, on a well-watered plateau surrounded by hills and mountains. It lies about in the northern area of Ethiopia's capital city, Addis Ababa. Addis Ababa has a total area of 527 km2with an elevation of 2,355 meters above mean sea level. The total area of road network of 5,915 kilometers up from 5,365 kilometers in 2014. Currently Addis Ababa had eleven sub cities by adding the new sub city called Lemi Kura since the city is large we try to cover and evaluate the selected four sub cities Akaki kality, Nefaslk Lafto,Kirkose and Arada sub cities road network structure by evaluating the networked roads of sub cities.

Meanwhile 2,616km of the city's roads are surfaced with asphalt, around 44% of the total network AACRA (2019). GIS is a spatial technique, which is particularly used in this research. The parameters used by this research to evaluate road network structure are selected of road network performance.

### 1.7 Limitation of the study

The main limitation of this study is the availability of required data, which is mostly at sub city level. This may cause some uncertainty in the actual data. The other limitation is the most of the study in the city is done by considering indicator of transportation network such as mobility, equity, accessibility, availability and spatial mismatch.

### 1.8 Thesis organization

The overall thesis is organized under six chapters: Introduction, Literature review, Materials and Methods, Results, Discussion and finally Conclusion and Recommendations. Chapter one gives brief introduction of the research. Chapter two briefly reviews literature on road transport network structure Chapter three research approach and data collection methods, data and software types used. Chapter four presents result of the study. Chapter five give explanations about a result Chapter six provides conclusions and recommendations made based on the result of the research.

# CHAPTER TWO

## 2. LITERATER REVIEW

### 2.1. Introduction

Road networks in urban settings are critical to facilitating transportation and living comfortably, and they are one of the most essential social infrastructures that help cities form. Because existing road networks are established based on planners' subjective opinions, there are numerous challenges in road network planning, such as poorly constructed road network plans in terms of road efficiency, safety, and comfort. Countries will struggle to meet unmet basic demands if road infrastructure does not promote growth. As a result, understanding the efficiency of these facilities and improving the service they will provide leads to a better social life.

### 2.2. Road transport network structure and economic growth

Infrastructure assets a physical structure, networks, and other facilities that provide service essential for economical production. Transportation, communication, water supply line, power distribution lines are among typical infrastructure assets Habtamu (2012). Infrastructure is key element in facilitating life. They are indispensable element in the process of urbanization by determine the economic and physical development of cities wondimu (2009). Infrastructure is usually defined as underlying the basic institutions and facilities or other essential elements that necessary to sustain and enable growth and development of community. Infrastructure therefore includes a broad spectrum of services, institutions and facilities that ranges from transportation system and public utilities to finance system and education Arenas (2012).

The road transport sector is one type of infrastructure and basic requirements for the proper functioning of societies as its demand is highly related to the movement of people from one place to another. Transport infrastructure plays a vital role in the development of the modern era as an integral part of the socioeconomic and political structure of the country. Thus, urban transport should involve optimal integration of the means and ways of mobility to create maximum ease and comfort maintaining the socio-economic and physical integration of the city.

Transportation has a direct impact on the day-to-day activities of people, especially in large cities where the distance to be traveled is too far to cover on foot or by bicycle within a reasonable time. Economically, transport is an essential element of city development that in turn is a major source of national economic growth. Simply stated, poor transport inhibits growth. Furthermore, socially, transport is the means of accessibility to jobs, health education and social services essential to the welfare of the city residents. Deteriorating transport conditions affect all city residents; they impact particularly the poor through a decline in public transport service levels, increased length of the journey to work and other essential services and the negative impacts on environment, safety and security that the poor are least able to mitigate (World Bank, 2001). Urban transport is an important factor for the location and internal structure of cities. Transportation influences the size of cities and the movement of people and commodities within and outside urban areas. According to the paper of Mekete (1999), the morphology of a city is also affected by the street patterns within a city.

The development of the transport road network plays an important role in the economic development of a country and, therefore, the kilometer-age of paved roads existing in a country is often used as an index to assess the extent of its development. The proper development of the transport road network not only reduces the cost of transportation, both in terms of money and time, but also helps in the integration of various regions within the country and the better understanding of neighboring countries at the international level. Roads contribute to the development of a country by bringing in direct benefits from their role in the development of activities such as agriculture, industry, commerce and mining and by bringing in indirect benefits from the enhancement in the value of property and the change it sets in the way of life and thinking of its people.

As a result, no surprise that all industrialized countries have completed road networks and other transportation infrastructure, whereas developing countries invest heavily in constructing and expanding their transportation systems, including road networks. Most development projects have necessitated the construction of new roadways, whether for governmental services, religious purposes, agriculture, or industrial.

In Ethiopia, the findings reveal that the total road network has significant growth spurring impact. When the network is disaggregated, asphalt road also has a positive sectorial impact, but gravel roads fail to significantly affect both overall and sectorial Gross Domestic Product growth, including agricultural GDP. By way of recommendation, donors need to strengthen their support on road financing, the government needs to expand the road network with the aim of increasing the current rural accessibility, and more attention has to be given for community road management and accountancy. Lastly, gravel road expansion has to be made to meet the target level of the road network and simultaneously ascertain rural accessibility, thereby improving agricultural productivity and market access of the poor rural population Ibrahim Worku (2011)

### 2.2.2 Transport Infrastructure and Urbanization

Urbanization patterns differ markedly between the developed and developing regions. The developing regions are undergoing rapid urbanization but it has slowed down in the developed regions. Moreover, most of the expected urban growth will take place in developing countries, where the urban population is expected to double, from 2.6 billion in 2010 to 5.2 billion in 2050 (UN, 2011). Addis Ababa is one of the rapidly urbanizing cities in Africa. However, empirical evidences on the impact of urbanization of the city on its peri-urban environment and livelihoods are scanty.

Urbanization has been one of the dominant economic and social changes of the 20th century, especially in the developing countries. Although cities played a significant role throughout the human history, it is not until the industrial revolution that a network of large cities started to emerge in the most economically advanced parts of the world. Since 1950, the world's urban population has more than doubled, to reach nearly 4.2 billion in 2018, about 55.2% of the global population. This transition is expected to go on well into the second half of the 21st century, a trend reflected in the growing. Size of cities and the increasing proportion of urbanized population by 2050, 70% of the global population could be urbanized, representing 6.4 billion urban residents. Cities also dominate the national economic output as they account for the bulk of the production, distribution, and consumption. Urbanization is the transition from a rural to an urban society. Statistically, urbanization reflects an increasing proportion of the population living in settlements defined as urban, primarily through net rural to urban migration. The level of urbanization is the percentage of the total population living in towns and cities, while urbanization is the rate at which it grows. UNFPA, (2007).

Transportation and urbanization are inseparable. Transportation is one of the basic requirements for the proper functioning of societies as its demand is highly related to the movement of people from one place to another. Transport infrastructure plays a vital role in the development of the modern era as an integral part of the socioeconomic and political structure of the country. Thus, urban transport should involve optimal integration of the means and ways of mobility to create maximum ease and comfort maintaining the socio-economic and physical integration of the city. Urban transport is an important factor for the location and internal structure of cities. Transportation influences the size of cities and the movement of people and commodities within and outside urban areas. According to the paper of Mekete (1999), the morphology of a city is also affected by the street patterns within a city.

### 2.3. Transport Network evaluation indicator

In transport studies, different kinds of indicators may be used to measure the performance of the network. There are different categories that can be used to describe transport indicators. Some are grouped broadly as Economic, Social, Environmental and System indicators. Others are also grouped as Demand and Supply based indicators (Derrible & Kennedy, 2011).Demand based indicators are indicators that measure people's use of the transport network while Supply based indicators are indicators that measure the performance of transport networks. Conventional transport indicators measure mostly traffic conditions. These include Roadway Level of service (LOS), average travel speeds, average congestion delay, and system-wide travel time, unused capacity in the network and volume to capacity ratio. There are no standardized indicator sets for comprehensive transport planning Littman (2007). Each institution develops their own set of indicators based on the need and institutions abilities.

The performance of the road can be also evaluated based on the different considerations. The first point to examine is the structure of the road network can be classed as Sub Grade, Sub Base, Base, and Surface when it comes to road construction. The natural material beneath a manmade road, pavement, or railway track is known as sub grade. It is also known as the forming level. The phrase can also apply to material that has been imported and utilized to construct an embankment. Sub underlying support placed beneath what is generally understood as a foundation: such as the lowest horizontal part of an architectural base or of a baseboard or pedestal pervious fill (such as crushed stone) placed beneath a roadbed. The base layer consists primarily of an unbound mixture of course and fine crushed stone, as well as crushed sand, to achieve the desired load-bearing capacity and absorb traffic loads so that the underlying subgrade is not deformed. The base course serves as the paving's foundation. The surface course is the layer that comes into direct contact with traffic and is usually made of high-quality materials. They are frequently made of densely graded asphalt concrete (AC). This layer has the following functions and requirements: It gives qualities such as friction, smoothness, drainage, and so on.

The second consideration indicator that is utilized to evaluate the road network performance is accessibility and mobility (briefly describe in 2.3.1 and 2.3.2) The third consideration point is demand and supply equilibrium, which indicates the supply of travel and demand for travel is equal, which is not true in reality because it assumes a finite number of travelers. When a road expands, it will be beneficial until the road travel time is equalized after a period of time, because new drivers will be generated as the road expands.

In this study, we examine the current road network layout by measuring the regional mismatch between demand and supply using indicators described in the next section.

### 2.3.1. Road availability

The availability of adequate transport infrastructure is one of the major factors affecting the performance of the road network. Transport infrastructures include road and vehicles. The road surface, total road area, road width and symbols have direct effect on the speed of the service, quality of ride, reliability and accident rate Vasconcellos, (2002).This indicator is important in the case of Addis Ababa, as with the case many developing cities give deprivation of the society from enjoying acceptable level of transport availability some area may be justified to have specific link constructed purely on social bases as opposed to economic once.

### 2.3.2. Proximity to the Road network

The term "proximity" refers to how close you are to your destination. The proximity of transportation infrastructure to end users is one of the characteristics that indicate its availability. According to Vasconcellos (2001), road infrastructure in most developing countries is quite restricted in terms of length and width. This means that travelers spent a significant amount of time navigating the transportation system. In general, proximity refers to the distribution of transportation infrastructure in a given area. People’s mobility in the developing countries is limited due to a lack of suitable infrastructure and transportation modes Zuidgeest, (2005). This is a direct result of underlying transportation and socioeconomic issues such as poverty, traffic congestion, and safety.

### 2.3.3. Road network density

Network density (ND)is the kilometer of road network per square kilometer of surface. Network density measures transport network development depending on the scale of analysis. Cities with limited infrastructure score low (like less than 10%).Where ND denotes the network density l is the total length of transport network in study area depending on scale. A represents the area of say the city, district or traffic analysis zone the dimensions are normally in [km/km2] depending on scale of network. A smaller area might be more meaningful to represent in m/m2. This indicator can be measured at various degrees of aggregation at the city scale Yonas minalu (2014)

### 2.3.4. Road accessibility

Accessibility is the individual’s possibility to take advantage of resources with fixed location in space that requires presence. It is obvious that access to resources is restricted by the possibility of distance. It is evaluated based on the time, money, discomfort and risk (the generalized cost) required reaching opportunities. Accessibility is one of the important characteristics of urban transport and it shows the relationship between transport and land use Liu and Zhu, (2004). Accessibility is used as a key element in efficiency analysis of transport network and infrastructure planning Gutierrez, et al., (1998), and to generate the travel demand on public transport O‟Sullivan, et al,(2000).

Accessibility is a much broader concept than mobility that can describe travel pattern entirely and defined it as “mobility for opportunities” Abreha (2007) Accessibility measures include a density of opportunities enabled by transportation services. For example, a number of households within a 30 minute derive of key regional centers or number of employment opportunities within a 10-minute walk of transit stops or the ability of a facility to serve a particular user group. Availability of mode and modal choice also is treated as an accessibility measure (NCHRP, 1997).

As transport officers approves, one of the goals of transport system is to increase mobility and access to facilities. Even though the definition of accessibility varies depending on its application Curl, et al, ( 2011) based on this context, it can be generally defined as the ease with which certain destinations can be reached from a particular origin using specified mode of transport O‟Sullivan et al. (2000). It can be measured by the mobility that the transport network provides and density of opportunities that can be accessed with a certain time or distance. It depends on the spatial distribution of activities, the origins of demand and transport system connecting the origin and destinations.

#### 2.3.5. Road transport network

A transportation network refers to either a continuous track (such as roadways, trains, and canals) or a regularly scheduled service (e.g. airline, public transit, train). It can be expanded to include a variety of other forms of links between sites where mobility can occur. The connection of a network determines its importance. Networks are frequently used as an example for the structure and flow of transportation systems. Transport networks fall under the umbrella of spatial networks because their design and evolution are physically constrained, as opposed to non-spatial networks like social interactions, corporate organization, and biological systems, which are usually, constrained by other factors and in which space plays a minor role. The term "network" refers to the framework of routes that exist within a system of nodes. A route is a single connection between two nodes in a larger network. It can apply to physical routes like roads and railroads, as well as intangible routes like air and sea corridors.

Several forms of transport structures that are linked with transportation networks with important elements such as nodes, connections, flows, hubs, or corridors are common in transport networks. In terms of accessibility to destinations, network structure goes from centripetal to centrifugal. A centripetal network favors a small number of locations, but a centrifugal network does not tend to provide any unique locational benefits..

On the one hand, the Addis Ababa City Road Network (AACRN) refers to a hierarchy of expressways, arterial streets, collector streets, and local streets, and on the other, radial and ring networks, iron-grid networks, organic networks, and composite networks. The CDP planning is generally ambiguous about the definition and purpose of roadways. The Addis Ababa Urban Transport Study (AAUTS) looked into travel characteristics and the transportation system, using traffic surveys as a starting point. The road network is restricted, capacity is low, and the current level of service is low, according to the report. There is a high level of traffic volume because of the Performance Evaluation of Addis Ababa City Road Network, as well as a high level of accidents.

### 2.4. Problem related to road transport in Addis Ababa

The first major constructed road, which linked Addis Ababa and Addis Alem, was constructed during the reign of Menelik II in 1902. The length of this road was about 27 miles. The road was intended to facilitate the transportation of wood for both construction and fuel from Addis Alem to Addis Ababa by gharries Tesfaye, (1986).Tesfaye (1986) in his paper states, the earliest forms of urban transport in Addis Ababa were the "*Gharries*" which came into existence by the order of Menelik II in 1900, and stayed as chief means of transportation unit until they were ordered to leave the city for the nearby towns in 1964 Tayech, (1991).

Addis Ababa's existing road system faces a variety of urban issues, making it difficult to create conventional streets. There is now a large disparity between public transportation demand and availability in Addis Ababa. The grade of service is likewise poor. The city's expanding districts are not well served by public transportation, and old neighborhoods are far from the main roadways. The city's present transportation system is characterized by a poor access network, a lack of suitable public transit services, ongoing increases in transportation expenses, a lack of smooth traffic flow and pedestrian infrastructure, and a high prevalence of traffic accidents. The government acknowledges that public transportation in the city is in insufficient supply.

Even though there are many transportation service providers, there is minimal coordination among them. The service is only available on several major highways and has a small coverage area. Due to a lack of rail service in the city, commuters rely on buses and taxis. In addition, current public transportation is of poor quality due to a scarcity of buses and taxis, as well as poor administration. The city anticipated that by putting in place a railway system, it would be able to solve its transportation issues. However, as recent events have demonstrated, the city has been unable to reach this aim due to a multitude of obstacles, including a limited number of rails, maintenance issues, and a big demand-supply mismatch.

According to the policy, the overarching purpose of the Addis Ababa City Transport Policy is to "enhance the city's status as an international seat by generating seamless traffic flow through a contemporary traffic management system." According to the policy, priority has been given to mass transit along major roads and crossings, as well as ensuring better, more efficient, and high-quality service. However, the city's road network structure continues to face significant and widespread problems due to a lack of and poor quality of transportation services and facilities, poor quality of roads and pedestrian walkways, low affordability by most urban citizens, and high rates of congestion during peak hours.

### 2.5. The role of GIS in modeling of road network

As a result, there is a great desire to use any technique that can help avert such issues. One of these technologies is the Geographic Information System (GIS), which functions as both a database and a toolbox for urban planning. The geo-relational paradigm can be used to store and link spatial and textual data in a database-oriented GIS. Transportation analysts and decision makers are increasingly using GIS-based road information management system applications in a variety of areas of transportation planning and engineering, including infrastructure planning, design, and management, traffic safety analysis, transportation impact analysis, and public transit. In road network modeling GIS is able to handle huge data and analyze a variety of network related problems by itself and can also integrated with other methods for transport network analysis by providing a spatial database and mapping platform Kuby, et, (2005) Yohannes (2005). In his paper describes about the application of Geographic Information System (GIS) in transportation (also called GIS-T). According to his view, GIS in transport has evolved from simple graphic and map-based representation of roads and geographic features to serve specific functions in highway agencies to a more complex and powerful tool for integrating data and decision making within and among agencies. It helps to study, improve, and solve problems related to transportation system Miller & Shaw, (2001). GIS data can also be transformed into functional road models for large-scale traffic simulation. GIS data can model road networks around the world as polylines with attributes. Roadmaps from a GIS database can be extrapolated to build geometrically correct and topologically coherent 3D models of large-scale road networks that can be utilized in real-time traffic simulations, interactive virtual world visualization, and autonomous vehicle navigation. Important road characteristics, such as seamlessly connected ramps, motorways, overpasses, legal merge zones, and crossroads, could be included in the final model representation for traffic simulations. Accident analysis is greatly aided by GIS, which leads to a reduction in the number of accidents on the road. The use of a geographic information system (GIS) enables for more cautious and precise data selection, screening, and reduction. It also allows for pre- and post-processing geographical analysis of the results.

## 2.6. Empirical studies

Road network are crucial for all facets of community development, including the need for and accessibility to health care and education, among other things, beyond reducing poverty. Because of this on evaluation of road network there are studies that have been working for the past few years. In the last two decades, interest has grown in the art and science of performance measurement, particularly as it applies to road and transportation systems. In general, the available research and practice reports provide perspectives as to why performance measurement is important, how it should be undertaken, and what is typically measured.

Transportation systems are recognized for the benefits they provide to the economy in terms of access and mobility but are also recognized for putting pressure on our environment. Widely held policy goals are to make progress towards sustainability while increasing economic prosperity and quality of life. In order to understand whether our systems are becoming more or less sustainable, measurement of performance against related indicators is necessary (Gudmundsson, 2001).

Demand based indicators are indicators that measure people's use of the transport network while Supply based indicators are indicators that measure the performance of transport networks. Conventional transport indicators measures mostly traffic conditions. These include Roadway level of service (LOS), average travel speeds, average congestion delay, system-wide travel time, unused capacity in the network and volume to capacity ratio (yonas menalu 2014) .

The road network size and quality of Ethiopia need to keep up with the pace of the ever increasing socio-economic activities and hence, demand in transportation services. That is particularly important in providing rural communities, such as those seventy million plus Ethiopians residing in the countryside access to better socio-economic services through rural roads (Briceno-Garmendia et.al, 2004; and Bhattacharya et.al, 2015). Researches carried out on assessing the importance of roads towards the betterment of developing nations imply that improving and expanding roads, particularly rural roads, directly increases economic opportunities (Faiz, 2012; and porter 2014)

The research by yetnayet Ayalneh (2012) identified inadequate infrastructure by analyzing the spatial mismatch within the current road network measured against Network and Transport indicators developed to evaluate how well the existing network serves prevailing demand for travel. Further, we have evaluated the existing network structure against pre-determined transport planning objectives that allow the realization of the ENUTP objectives including accessibility, equity and efficiency by using indicators such as road density, mobility and proximity indices.

## 2.7. Conceptual frame work

To evaluate the performance of road network in Addis Ababa. The road network performance will be evaluated/ expressed by several indicators like road availability, road performance, traffic load, road connectivity, proximity and other indicators are used in different studies. On this research the road network indicators are used as mainly to evaluate the road network on the study area by using ARC GIS as a main tool to analysis data gathered .Additionally the pin point area that are damaged and losing their connectivity role on road sector also indicated.

# CHAPTER THREE

# 3. MATERIALS AND METHODS

## 3.1Description of Study Area

The establishment of Addis Ababa heralded the beginning of a new era in the history of Ethiopia. Emperor Minilik ll, who aspired to create and gradually build a strong and modern Ethiopia, founded his capital on the site occupied by his forebears. It had been prophesied that Emperor Minlik ll would build city at Entoto about eight kilometers north of Felewuha. He camped there, and returned to it after his various campaigns' strategic significance of the spot was highly considered in the emperor's choice of the site, which like Ankobar was in an imposing position overlooking verdant plains.

Addis Ababa is the capital city of Ethiopia located on the central part of our country. Geographically situated at the latitudinal extent of 8° 22‟ to 9° 30‟57" N and longitudinal extent of 38°24‟ to 39°21‟ covering an area of 519.52 km2. The city was established in 1886 and has experienced several planning changes. Addis Ababa lies at a maximum altitude of 2900 meters above sea level. Because of having the highest altitudinal position, Addis Ababa ranks the fourth highest capital city in the world and takes the first rank from African cities. There is a great variation of height within the city, so that much of it is built on the slope Tesfaye, (1986).

Recently Addis Ababa is the 4th largest diplomatic center in the world as it is a headquarter of UN Economic Commission for Africa (UNECA), African Union (AU) and a home of more than 90 embassies and various international organizations UN -HABITAT, (2007). The city is often referred as the "political capital of Africa" due to its historical, diplomatic and political significance for the continent. Addis Ababa is the hub of social, political, cultural and economic activities of the country and is one of the fastest growing cities in the world. It is a "primate city" in the full sense of the term" (UN -HABITAT, 2007 as cited by Johnson, 2008).

The spatial spread is mainly guided by topography and road network development. The topography of Addis Ababa is not favorable from the transport network development point of view (Tesfaye, 1986).

The city's landscape is disorganized and prone to flooding. Addis Ababa City Administration is divided into eleven sub-cities: Addis Ketema, Akaki-Kaliti, Arada, Bole, Gulelle, Kirkos, Kolfie-Keraniyo, Lideta, Nefas Silk-Lafto, Yeka Sub-city, and the newly added Lemi Kura Sub-city. There are now eleven sub-cities in the metropolis. In this study, four networked sub cities were chosen to evaluate and depict the city's road network structure. The sub cities of Akaki-Kaliti, Arada, Nefas Silk-Lafto, and Kirkos were chosen to evaluate the road network.The main reason why this sub cities are selected for this study is Akaki kality is the main roadnetwork that used for import export exchange for the whole country but thissub city still facing many problems that related to road network beside the rest three sub citiesare connected and share boundaries with each other. By analyzing these four networked sub cities will also demonstrate the influence.

### 3.1.1 The Geographical location of the study areas

In the southern section of Addis Ababa, Akaki Kality is the city's second largest sub-city and major industrial zone. The geographical location $8^{o}$53'45"N latitude and $38^{o}$47'21"E longitude, it is 12345.4 hectares in size. The lowest position is 2,060 meters above sea level, and the highest point is 2,340 meters. Furthermore, according to the report on their official website, it shares geographical boundaries with Bole Sub-cities in the north, Nifas Silk Lafto Sub-cities in the North West, and Oromia Regional States in the south and east. According to the Emmanuel Development Association, the sub city is an industrial zone that houses 60% of Addis Ababa's metal, paints, garment, and food processing sectors. The population migration to Akaki Kality, Addis Ababa's industrial zone, is related with high urbanization. Physically, the Akaki Kality sub city is one of Addis Ababa's underdeveloped sub cities. Even though it is the city's industrial zone, it has insufficient infrastructure. It lacks the required amenities for the full operation of industries and other economic sectors, as well as for the convenience of the residents in a whole package.

Nifas silk lafto is one of the eleven sub cities in Addis Ababa city administration. The geographical location8$^{o}$57'26"N latitude and 38$^{o}$43'31"E longitude,it covers an area of 5876.02 hectare. It situated in the southwestern part of Addis Ababa, bounded from south by oromia special zone from North West by Kolfe keranio, from east by Bole and Akaki kality and from north by Lideta and Kirkos. At present, the sub city divided into 12 woredas. The land area covered by nifas silk lafto sub city is 5879.02 hectares; this constitutes 11.31%of the total land area of the city, which makes the Nifas silk lafto sub city in 5th place in land area covered from the eleven sub cities. Among the 12 woredas in nifas silk lafto, the large area is covered by woreda 01 with 2592.83hectars that is 44.12%of the sub city land area, and woreda 08 covers the smallest land area of 105.84 hectares, which is 1.8%of the sub city land area. Kirkos sub-city is geographically located at 9˚2′6″N 38˚45′28″E. Kirkos is one of the sub-cities of Addis Ababa, the capital city of Ethiopia. It covers an area of 1464.72 hectares. The sub-city is roughly situated in the central part of Addis Ababa, nearby the center, bounded from the South by Nifase silik lafto, from West by lideta, from East by Bole and from North by Arada sub-cities (Figure 3.1). It is divided into 11 woredas, 31 sub-woredas, 111 sefers, and 316 blocks.

There are several features, which makes the sub city differs from other sub city. It is the sub city where the National Palace and international organizations like African Union, which made Ethiopia the seat of Africa, Economic Commission of Africa and 23 embassies are located. In addition to this, international features like the first National Stadium, the railway station, Addis Ababa museum, Red Terror Martyrs Memorial Museum, Mesqel Square: which is multipurpose square; Exhibition center and National Theater are located in this sub city. Moreover, Filwuha spa, which is unique, features for the establishment of Addis Ababa, and the Gottera interchange the first modern and sophisticated road section as well as nations and nationalities square are located in the sub-city. The land with area covered by Kirkos sub city is 1464.72 hectares and this constitutes 2.82% of the total land area of the city.

Arada sub-city is geographically located at 9$^{o}$2'9.600"N latitude and 38$^{o}$45'8.200"E longitude. Arada is one of the 11 sub-cities of Addis Ababa, the capital city of Ethiopia. It covers an area of 950 hectares. The sub-city is roughly situated in the northern part of Addis Ababa, nearby the center, bounded from the South by Kirkos and Lideta, from West by Addis Ketema, from East by Yeka and from North by Gulele sub-cities (figure3.1).Itis divided to10woreda‟s, 31subworedas, 100 sefers, and 316 blocks. Arada is known as the center of the old and the new generation artistic, social and urban life style. The district is one of the oldest commercial and historical centers of Addis Ababa and also one of the most important parts of the city. Because the Palace, the Parliament, Addis Ababa City Administration Office, Ministry of Education, Ministry of Finance and Economic Development, National Museum, Yekatit 12 and Ras Desta Hospital, Taitu Hotel, Hager Fiker Theater, Addis Ababa University 4kilo, 5kilo and 6kilo campuses all are found within the sub city. The oldest known places in Arada sub city are Piassa, St.Georges Cathedral, the great Menelik II Square, Doro Manekia, Eribekentu, Talian sefer, Dejach Wube sefer, Sumale tera, Ginfile, Datson, Kebena, 4kilo, 5kilo, 6kilo, Ras Mekonin (Arada news, 2014).

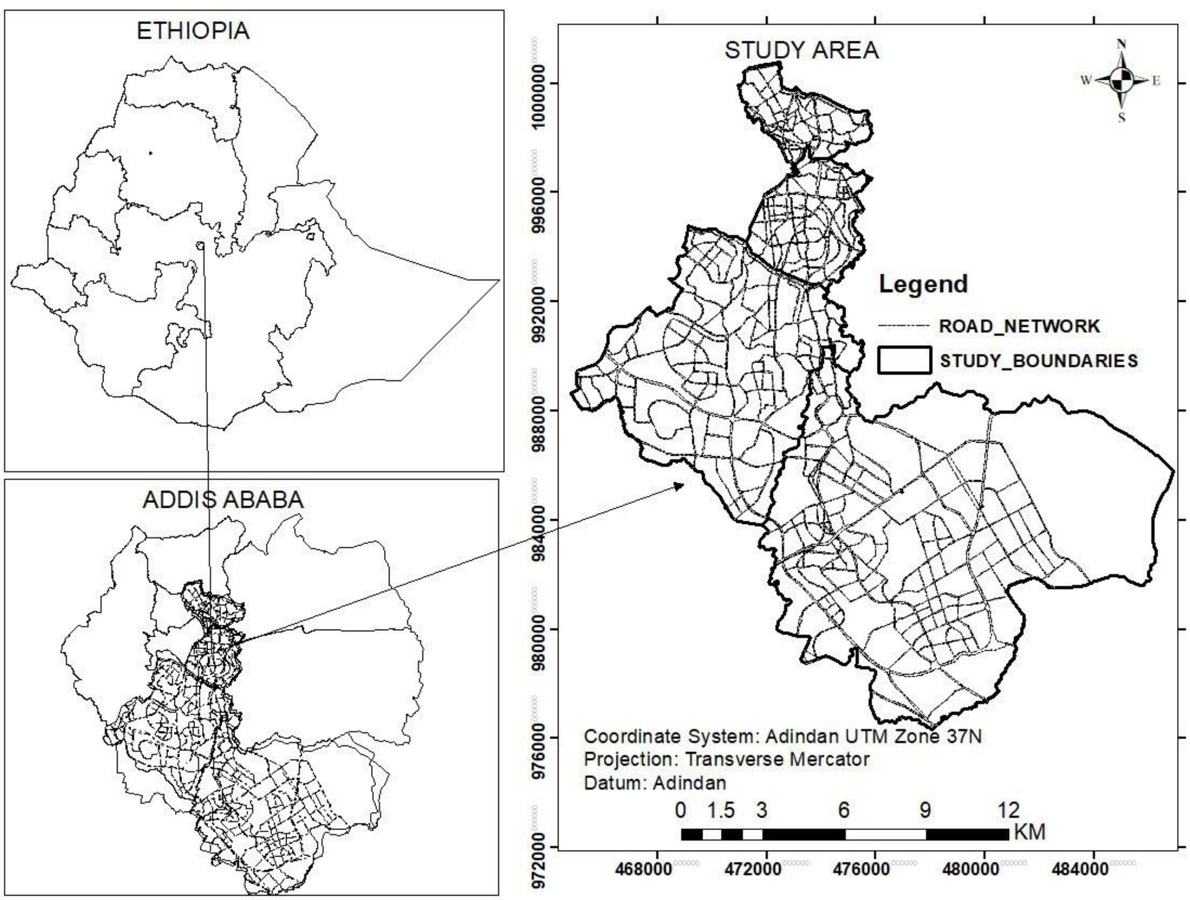



**Fig 3. 1: Location map of the study area**

### 3.1.2 Population

Based on the census data in 2007, the population of Addis Ababa was about 2.7 million out of the population of the country 73.9 million. The total administrative area is considered to be urban. Therefore, this counts for 23% of the national urban population of Ethiopia show in table 3.1. This data shows that the population in the city has doubled since 1984.the last population estimate that the growth of Addis Ababa is maintained at 2.1 (for the year 2007-2037) i.e. the population size of the city will double in size in almost 30 years

According to the 2007 census result, the total population of Addis Ababa was 2.7 million people live in the city. Recently the city divided in to eleven sub cities but since the newly added sub city called Lemi Kura is located before few months of this research it hard to include the population of the sub cities the table3.2 shows the ten-sub city population by taking the source of census data in 2007. According to yetnayet (2012) Depending on the population density, residential area classified in terms of higher density central area and lower density on the periphery. The central sub cities have relatively equal distribution of the population. Even through these areas only count for 8% of the total city area, population contained in then account for 32% of the city resident.

Beside this since the census report was published in 2007 almost 15 years before on this research, we are not used this population number data because of there is a very long time gap the change in population number is very increasing because of this reason, on the research used estimation population of ten sub cities in Addis Ababa as of July 2021 CSA report.

**Table 3. 1: CSA Estimation report of population in Addis Ababa July 2021(CSA report)**

| Sub city zone | Male | Female | Total |
|---|---|---|---|
| Akaki kality | 121,105 | 128,557 | 249,662 |
| Arada | 135,371 | 156,030 | 291,401 |
| Nefas silk-Lafto | 203,380 | 232,372 | 435,752 |
| Kolfe Keraniyo | 283,435 | 307,314 | 590,767 |
| Gulele | 176,640 | 191,994 | 368,634 |
| Lideta | 131,422 | 146,454 | 277,876 |
| Kirkose | 141,289 | 163,528 | 304,817 |
| Addis Ketema | 170,500 | 181,223 | 351,723 |
| Yeka | 220,591 | 257,058 | 477,649 |
| Bole | 198,248 | 227,470 | 425,718 |
| **Addis Ababa Total** | **1,917,370** | **2,148,030** | **3,818,999** |

### 3.1.3 Land use land cover

Land cover is document, which shows how much of a region is covered by forest, wetland, imperious surfaces, agriculture and other land and water types, Water types include wetland or open water. Land use shows how people use land scape for development conservation or mixed assess (Ocean service noaa.gov 2020) In Addis Ababa land use land cover distribution built up area that including all artificial futures, urban agriculture, urban forest, river and river side green and urban parking. (Silegn Azagew 2020). Artificial futures include all type of infrastructures. The selected four sub cities of land use and land cover data presented on map and table format. The modification of Earth's terrestrial surface by human activities is commonly known as Land use/land cover change (LULCC) around the globe. Although modification of land by humans to obtain livelihoods and other essentials has been there for thousands of years, the extent, intensity and rate of LULCC are far greater now than were in the past. These changes are driving forces for local, regional and global level unprecedented changes in ecosystems and environmental processes. Thus, LULC changes play an important role in the study and analysis of global changed scenario today as the data available on such changes is essential for providing critical input to decision-making of ecological management and environmental planning for future (Zhao et al 2004). Change detection has emerged as a significant process in managing and monitoring natural resources and urban development mainly due to provision of quantitative analysis of the spatial distribution of the population of interest. There are many available techniques that serve purpose of detecting and recording differences and might also be attributable to change. On the next chapter the land use land cover of the study area is shown.

### 3.1.3.1. Land use of Akaki Kality sub city

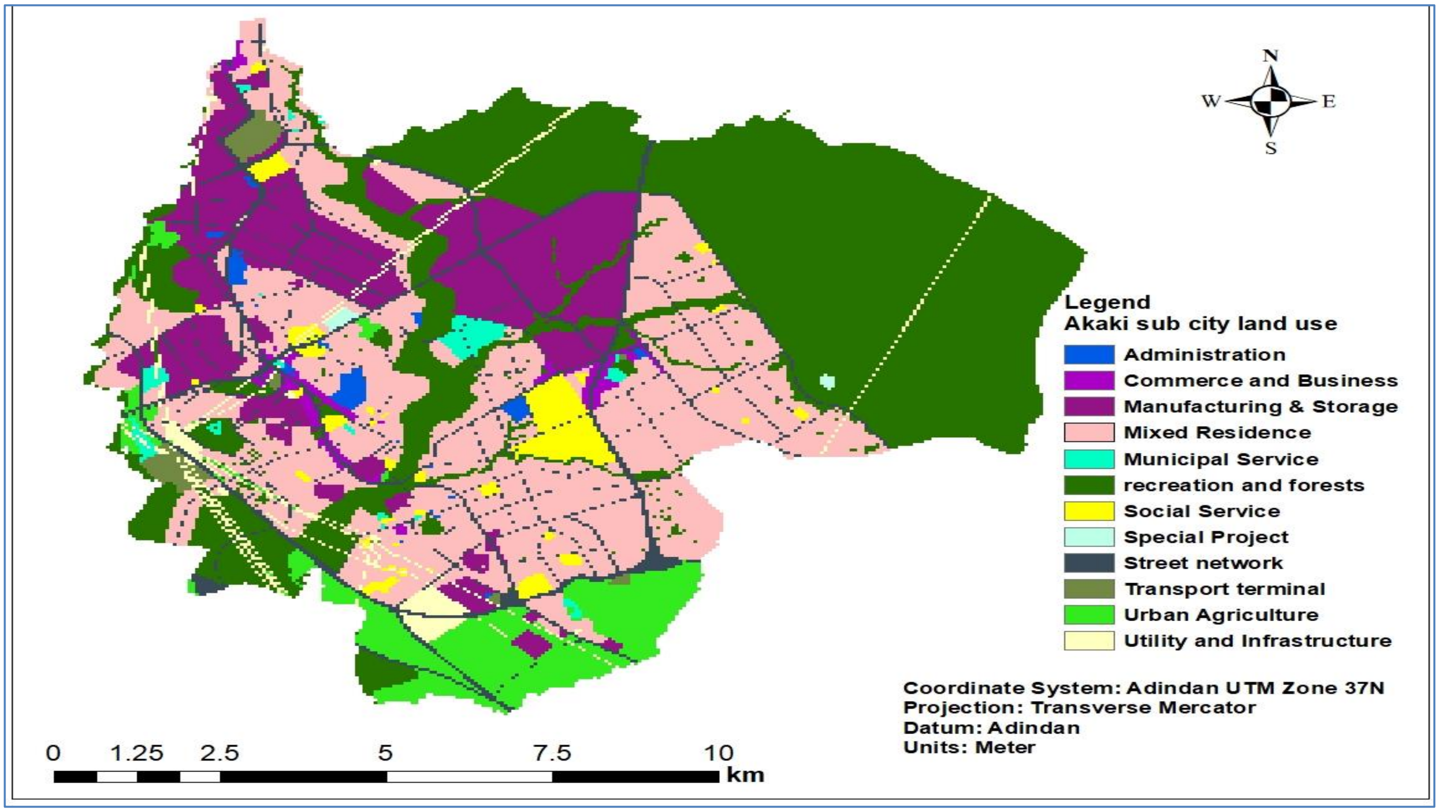
Akaki kality sub city is one of the eleven sub cities in Addis Ababa and covers an area of 12,220 hectares. About 249,662 people live in the sub city and have an average density of 223 people per hectare.(CSA Estimation report of population in Addis Ababa July 2021).It is situated in the rural part of the city, and is one of the industrial zones of the city. (Ethiopia Transportation System Improvement Project)

**Table 3. 2: LULC of Akaki kality sub-city Source :(Akaki kality Sub-City Land Management Office, 2018)**

| FID | land use | Area(Ha) | Area(%) |
|---|---|---|---|
| 1 | Commerce and Business | 114.369 | 0.937 |
| 2 | Manufacturing & Storage | 1665.996 | 13.653 |
| 3 | Mixed Residence | 3438.534 | 28.178 |
| 4 | Urban Agriculture | 776.740 | 6.365 |
| 5 | Social Service | 290.897 | 2.384 |
| 6 | Utility and Infrastructure | 295.830 | 2.424 |
| 7 | Transport terminal | 111.710 | 0.915 |
| 8 | Municipal Service | 104.487 | 0.856 |
| 9 | Historical Building and Site | 0.045 | 0.000 |
| 10 | Administration | 79.847 | 0.654 |
| 11 | recreation forests | 4500.419 | 36.880 |
| 12 | Special Project | 17.720 | 0.145 |
| 13 | Street network | 806.159 | 6.606 |

| | | | |
|---|---|---|---|
| | Total | 12202.752 | 100.000 |

**Fig 3. 2: LULCof Akaki kality sub-city (Source: Akaki Kality Sub-City Land Management Office, 2018**



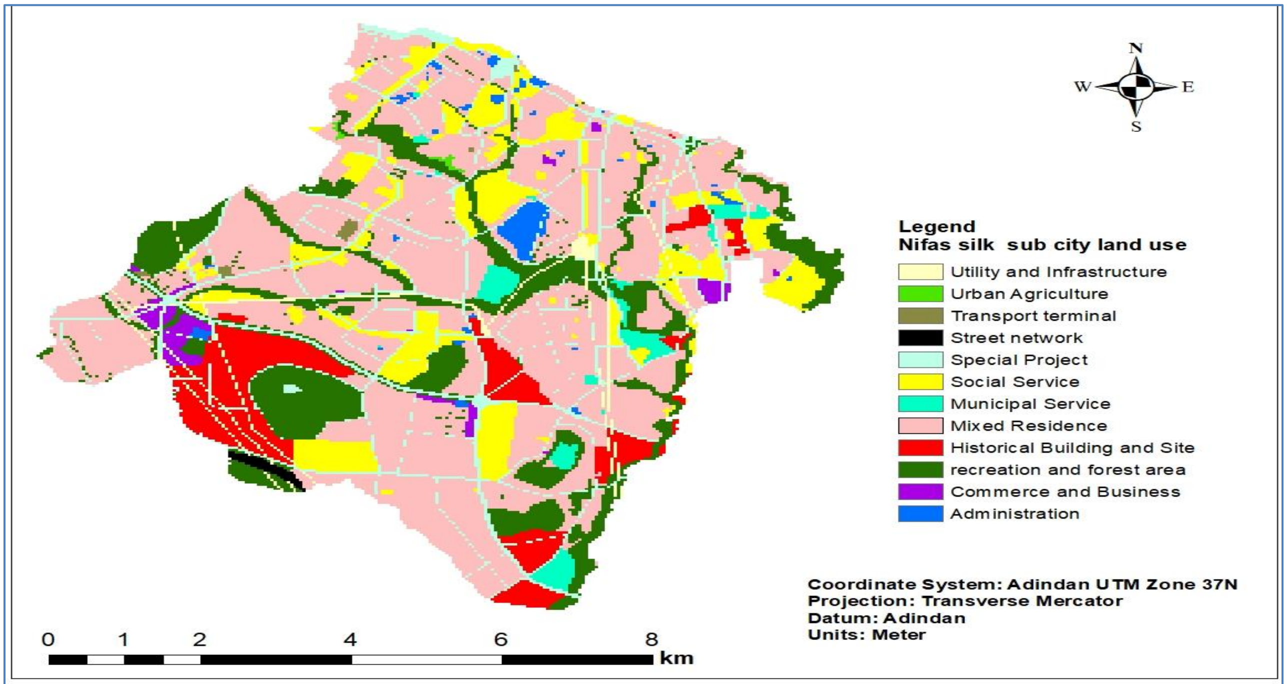

### 3.1.3.2. Land use of Nefaselke Lafto sub city

Nefaselke Lafto sub city is one of the eleven sub cities in Addis Ababa and covers an area of 5874 hectares. About 435,752 people live in the sub city and have an average density of 223 people per hectare. It is situated in as central part of the city, and is one of the business district area of the city. (Ethiopia Transportation System Improvement Project)

**Table 3. 3Land use type and Areal Coverage of Nefaselke Lafto sub-city Source: (Nefaselke Lafto Sub-City Land Management Office, 2018)**

| FID | Land use | Area(Ha) | Percent |
|---|---|---|---|
| 1 | Administration | 81.597 | 1.389 |
| 2 | Commerce and Business | 83.509 | 1.421 |
| 3 | Environment | 957.665 | 16.301 |
| 4 | Historical Building and Site | 462.773 | 7.877 |
| 5 | Mixed Residence | 2868.163 | 48.820 |
| 6 | Municipal Service | 125.960 | 2.144 |
| 7 | Social Service | 657.603 | 11.193 |
| 8 | Special Project | 485.786 | 8.269 |
| 9 | Street network | 18.374 | 0.313 |
| 10 | Transport | 15.565 | 0.265 |
| 11 | Urban Agriculture | 7.162 | 0.122 |
| 12 | Utility and Infrastructure | 110.806 | 1.886 |
|  | Total | 5874.964 | 100.000 |

**Fig 3. 3: LULCof Nifas-Silke Lafto sub-city Source (:Nefaselke Lafto Sub-City Land Office, Management 2018)**




### 3.1.3.3. Land use of kirkose sub city

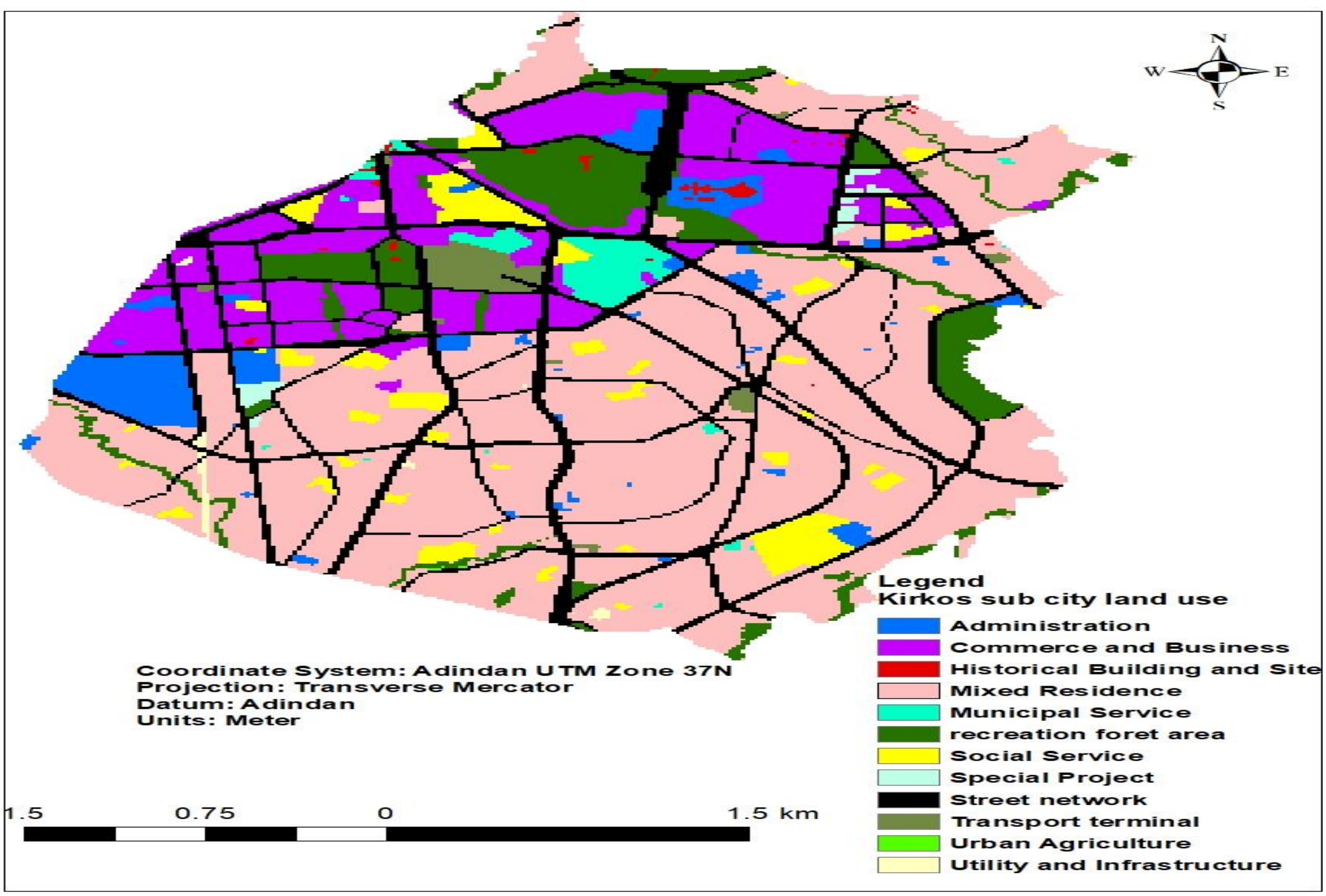
Kirkos, one of the inner sub cities, is the second sub city one of the selected road corridor crosses. Acording to CSA Estimation report of population in Addis Ababa July 2021 about 220,991 people live in Kirkos sub city and is one of the most commercially vibrant sub city that covers 1464.72 hectares and have an average density of 90.6 people per hectare. At present, the sub city is divided in to 11 woredas and 41 sub woredas, 146 sefers and 474 blocks. (Ethiopia Transportation System Improvement Project)

**Table 3. 4 Land use type and Areal Coverage of Kirkose sub-city Source: (kirkose Sub-City Land Management Office, 2021)**

| FID | Land use type | Area(Ha) | Percent |
|---|---|---|---|
| 1 | Mixed Residence | 753.986 | 51.478 |
| 2 | Social Service | 61.205 | 4.179 |
| 3 | recreation area | 122.982 | 8.397 |
| 4 | Commerce and Business | 202.082 | 13.797 |
| 5 | Administration | 61.016 | 4.166 |

| | | | |
|---|---|---|---|
| 6 | Special Project | 6.300 | 0.430 |
| 7 | Municipal Service | 24.961 | 1.704 |
| 8 | Utility and Infrastructure | 4.046 | 0.276 |
| 9 | Historical Building and Site | 4.472 | 0.305 |
| 10 | Urban Agriculture | 0.247 | 0.017 |
| 11 | Transport | 19.277 | 1.316 |
| 12 | Street network | 204.089 | 13.934 |
| | Total | 1464.662 | 100.000 |

**Fig 3. 4:LULC of Kirkose sub-city (Source:Kirkose Sub-City Land Management**



**Office,2018 2021)**

#### 3.1.3.4. Land use of Arada sub city

Arada sub city is one of the eleven sub cities in Addis Ababa and covers an area of 950 hectares. According to CSA Estimation report of population in Addis Ababa July 2021 about 212,009 people live in the sub city and have an average density of 223 people per hectare. It is situated in the central part of the city, and is one of the early developed parts of the city. The sub city is divided in to 10 woredas and 31 sub woreda and 100 seferes and 316 blocks. The current land use function of the sub city shows that out of the total 950 hectare (Ethiopia Transportation System Improvement Project)

**Table 3. 5 Land use type and Areal Coverage of Arada sub-city Source: (Arada Sub-City Land Management Office, 2018)**

| FID | Land use | Area(Ha) | Area(%) |
|---|---|---|---|
| 1 | recreation area | 66.747 | 7.028 |
| 2 | Commerce and Business | 31.557 | 3.323 |
| 3 | Administration | 60.218 | 6.340 |
| 4 | Social Service | 80.698 | 8.496 |
| 5 | Municipal Service | 22.209 | 2.338 |
| 6 | Mixed Residence | 551.973 | 58.115 |
| 7 | Historical Building and Site | 6.329 | 0.666 |
| 8 | Utility and Infrastructure | 0.950 | 0.100 |
| 9 | Transport terminal | 6.455 | 0.680 |
| 10 | Urban Agriculture | 0.096 | 0.010 |
| 11 | Special Project | 3.106 | 0.327 |
| 12 | Street network | 119.448 | 12.576 |
| | Total | 949.786 | 100.000 |

**Fig 3. 5: Land use Map of Arada sub-city Source :(Arada Sub-City Land Management Office, 2021**

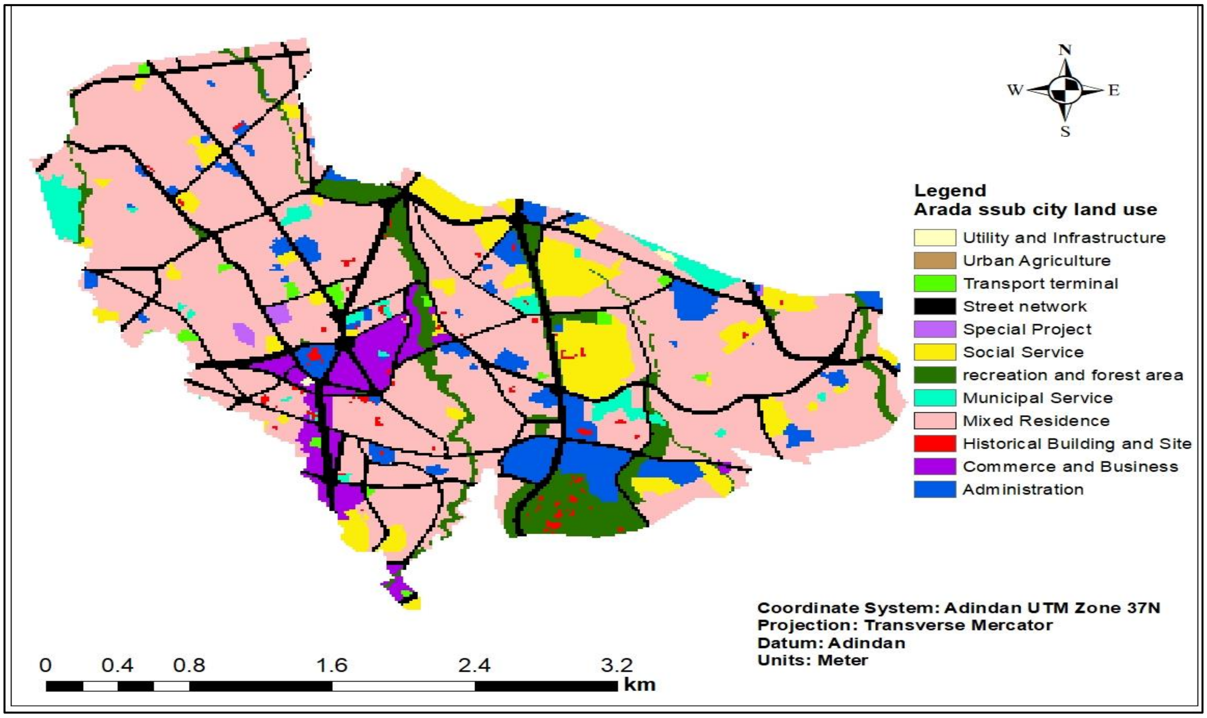



**Table3. 6: Land use land coverage data of the four sub cities**

| No | FID | Land use | Area(Ha) |
|---|---|---|---|
| 1 | Administration | 317.2 | 1.548 |
| 2 | Commerce and Business | 1983.144 | 9.678 |
| 3 | Historical Building and Site | 3912.108 | 19.091 |
| 4 | Manufacturing & Storage | 776.74 | 3.790 |
| 5 | Mixed Residence | 4465.019 | 21.789 |
| 6 | Municipal Service | 468.96 | 2.288 |
| 7 | Recreation forests | 1259.104 | 6.144 |
| 8 | Social Service | 903.993 | 4.411 |
| 9 | Special Project | 495.237 | 2.417 |
| 10 | Street network | 421.758 | 2.058 |
| 11 | Transport terminal | 4541.716 | 22.163 |

| | | | |
|---|---|---|---|
| 12 | Urban Agriculture | 25.225 | 0.123 |
| 13 | Utility and Infrastructure | 921.961 | 4.499 |
| | Total | 20492.165 | 100.000 |

## 3.2 Data source and methods of data collection

### 3.2.1 Source of Data

For the case of the study there are two types of data sources primary and secondary data sources. The type and the availability of data evaluated before commencement of the field work. The types of data used in this research comprise of two types that is primary data and secondary data. Both primary and secondary sources were explored to collect the required data.

primary data was collected by using hand GPS to collect point data and Secondary data was collected visiting relevant offices like Addis Ababa City Road Authority (AACA) and different offices under four selected sub cities Administration. From the city and sub-city administration, Akakai kality,Nefaselke Lafto ,Kirkose and Arada sub cities land administration Office, AACRA, as well as from published and unpublished materials.

**Table3. 7: Types and Source of Data to Carry Out This Study.**

| Data | Source | Format | Remark |
|---|---|---|---|
| Point data (x,y coordinate) | Collected data | point | Primary data |
| Demographic Data | CSA office 2021 estimation report | Tabular data | Secondary data<br>Aggregated in sub city level |
| Land use data | Arada,Akaki Kality,Nefaselke lafto and Kirkose sub-cities land management office | Shape file format | Secondary data<br>This data is obtained from land management offices in shape file format and converted to raster format |
| Current road network | AACRA | Excel | Secondary data<br>Aggregated in north, south, west, east and central level |

| | | | |
|---|---|---|---|
| Road profile data | AACRA | Excel | Secondary data<br>Aggregated in IRI, length and ratio value of the road |
| Transport data deployment of public transport services vehicles | Addis Ababa City Road Transport office | Excel | Secondary data<br>Aggregated in code number of public transport services vehicles and there deployment |

### 3.2.2 Software and Tools

The following software are used for data analyses that are very vital for the achieving the objectives of the research efficiently and effectively (table 3.8)

**Table 3. 8 Software and tools**

| No | Software & tools | Purpose and description |
|---|---|---|
| 1 | Arc GIS | To design and map the road network structure |
| 2 | Auto Cad 2007 | To visualize different type of road network data |
| 3 | Google earth | The date of Google earth and temporal Landsat images were similar. To collect validation (x, y) points of burned area in a similar time of Landsat images |
| 4 | MS Excel , word and Power point | To create word Document and presentation, data calculation, graph and point coordinates data preparation. |

### 3.2.3 Method of data collection

The primary data was field survey will assess the condition and accessibility of the existing network structure Conducted by using hand GPS(X,Y) coordinate data on the road network in Akaki kality and Nifaselke sub-city where the most road networks are damaged. The secondary data was conducted from AACRA, Addis Ababa City Road Transport office and from four sub cities land management and administration office to get more information about road transport network and the performance of the road network structure of the entire sub cities.

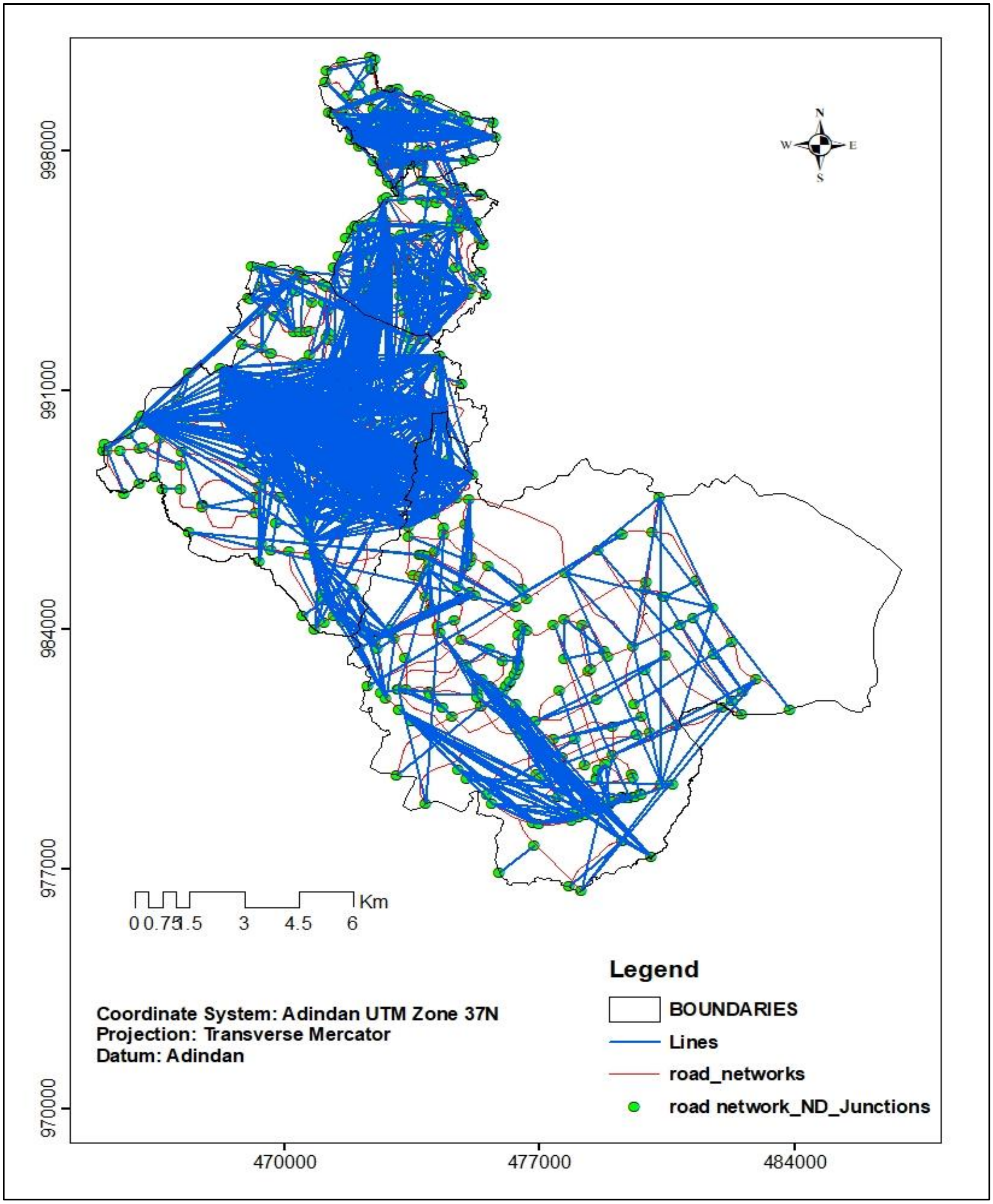
### 3.2.4. Data Preparation

After gathering all the necessary data, the first requirement is to prepare the data for analysis. Since the data collected are from different sources and period, converting them in to same form and analysis period is essential to obtain accurate result in later stages. This is done by unifying data changing data formats, building the road network, updating the demographic and socio data, joining with map and adding missing attribute to road network. Most maps were collected in AutoCAD format and for analysis in ArcGIS these data were converted into ArcGIS shape file. The method used is export the data in ArcGIS 10.7. This is done by unifying data, changing data formats, building geo-database, updating the demographic data, joining with map and adding missing attributes. The available data in AutoCAD format was also converted into ArcGIS shape files. Before exporting these files to ArcGIS, the data was cleaned and topological rules were defined in AutoCAD based on ArcGIS Topological rules. All shape files were transformed to Ethiopian coordinate system (WGS1987 zone 37 N).

## 3.3 Building the Network Dataset

The real network is generated in ArcGIS utilizing the collected data using the following approach. The network topology of the road network data found in AutoCAD format is specified, and the data is cleaned. The data must then be converted from AutoCAD to a Shape file. A well-developed and managed database is always at the heart of any GIS system. In ArcGIS, a Geo database was defined after the data format conversion. To double-check the network data, topological rules are defined. In order to have a smooth road network analysis, topology is developed for the tracked roads of the sub-city. The data is exported to a new feature class after validating and repairing the topological defects for the road network layer.

**Fig 3. 6: OD-COST Matrix**


998000
991000
984000
977000
970000
470000
477000
484000
N
W
E
S
0 0.75 1.5 3 4.5 6
Km
Legend
BOUNDARIES
Lines
road_networks
road network_ND_Junctions
Coordinate System: Adindan UTM Zone 37N
Projection: Transverse Mercator
Datum: Adindan

### 3.4 Data analysis

For the purpose of data analysis, the study employed, Excel, ARC GIS, Auto cad and Microsoft word. Arc GIS and AutoCAD tools is used to analyze spatial data. The expected output for the first specific objectives one describing the existing condition of road network infrastructure by using indicators. For second objective, the expected output to show potential of travel demand and current network. Third specific objective the expected output will try to show road network deficiency and pinpoint of the study area

#### 3.4.1Road network Evaluation Indicators

A key component of the most successful road projects and programs is a well-defined set of goals and objectives. However, the use of performance indicators goes well beyond simply evaluating the degree to which goals and objectives have been achieved. The use of performance indicators by a road administration depends on the particular needs for development or improvement in performance. The evaluation of accessibility is one of the most important aspects in defining the performance of a road network structure. The present study is concerned with proposing a methodology for the city level opportunity (or) urban services and distance based accessibility evaluation. The study attempts to define the level of road network accessibility at different locations in the study area. By using the following indicators the road network structure of the selected four sub cities road structures is evaluated.

##### 3.4.1.1Road Density/Availability

Road density is a ratio between total road lengths with area width or total population. Road density has a unit $km/km^2$. The road density explains how dense the road network is in the study area and we have to compare the result with some standards. If the value of road density shows a decreasing trend through years, it implies that there is a need to construct new roads for meeting the demand. The data needed to compute road density are the trend of total road length constructed (which is collected from AACRA) and total area/population size of the study area (Arada, kirkos, akaki kality and nefas silk sub cities).

The formula for road network density given as: The dimensions are normally in [km/km$^2$] depending on scale of network.

**Road Density = Total Road Length (km) /Total Area (km$^2$) --------------- Eq3.1 (yonas minalu 2014)**

#### 3.4.1.2Road Proximity

Proximity measures how many people can access the infrastructure within certain distance, shows the availability of transport infrastructure and its closeness to the end user, when road proximity is very good each road users can access the road and get their destination easily. Proximity measures the distribution level of transport infrastructure in the area

#### 3.4.1.3Traffic volume load

The ratio of total road length to the number of vehicles is known as traffic load in road transport. The unit for this indication is km/no of vehicle. This metric depicts the percentage of vehicles that use the city's developed roads. Total length of road created in the research region from AACRA and total number of registered vehicles in the sub-city from Addis Ababa Transport Office are the data needed to calculate this indicator. To compute the traffic volume load, the study utilizes the following formula:

**Traffic load = Total Asphalt Road length / Total number of vehicles -------- Eq3.2(Adiss Ababa transport office)**

#### 3.4.1.4 Road Connectivity

The study area's road network was examined for connectedness using the Beta index of connectivity. This was accomplished by dividing the total number of arcs or straight-line roads in the road network by the number of nodes or junctions. The straight lines between the nodes must be found, which can be done manually by counting the nodes on the master road network. The density of connections in a path or road network, as well as the directness of links are referred to as connectivity. The extent to which nodes in a network are directly connected to one another determines the connectedness of a road network. The number of segments (in this case, links or arcs) to which a specific segment is directly connected is known as connectivity.

**Beta index =Arc/Nodes--------------------------------------------Eq3.3 (Kofi 2010)**

Where the nodes are the number of road junctions and arcs are connections (straight lines) between the nodes as straight lines. Road connectivity = Straight lines/Road Junction (Nodes)

#### 3.4.1.5 Road performance

The ratio of stable road lengths to total road length is referred to as road network performance. There is no unit for road performance. This indicator depicts the percentage of roads that are in good/stable condition, indicating that they do not require repair and roads in a bad condition or that need repair or maintenance. In AACRA the international roughness index (IRI) is the roughness index most commonly obtained from measured longitudinal road profiles.

### 3.4.2ThePotential of Travel Demand and Current Road Network

#### 3.4.2.1Road Accessibility

Road accessibly measures by providing an access to different infrastructure such as market, educational centers and health facilities. Accessibility are essential for understanding many significant social, economic and political issues have increasingly become key factors in defining the quality of  life and potential for development. The accessibility of the road measure seek to define the level of opportunity and choice  taking by minimizing the travel time spent to get on destinations. When the people use the road network can access this service areas easily by using road so we can say there is good accessibility of road in that area. On this research take different hospital and the sub cities administration office how people living in that area can access these facilities by taking travel time it take to get the destinations.

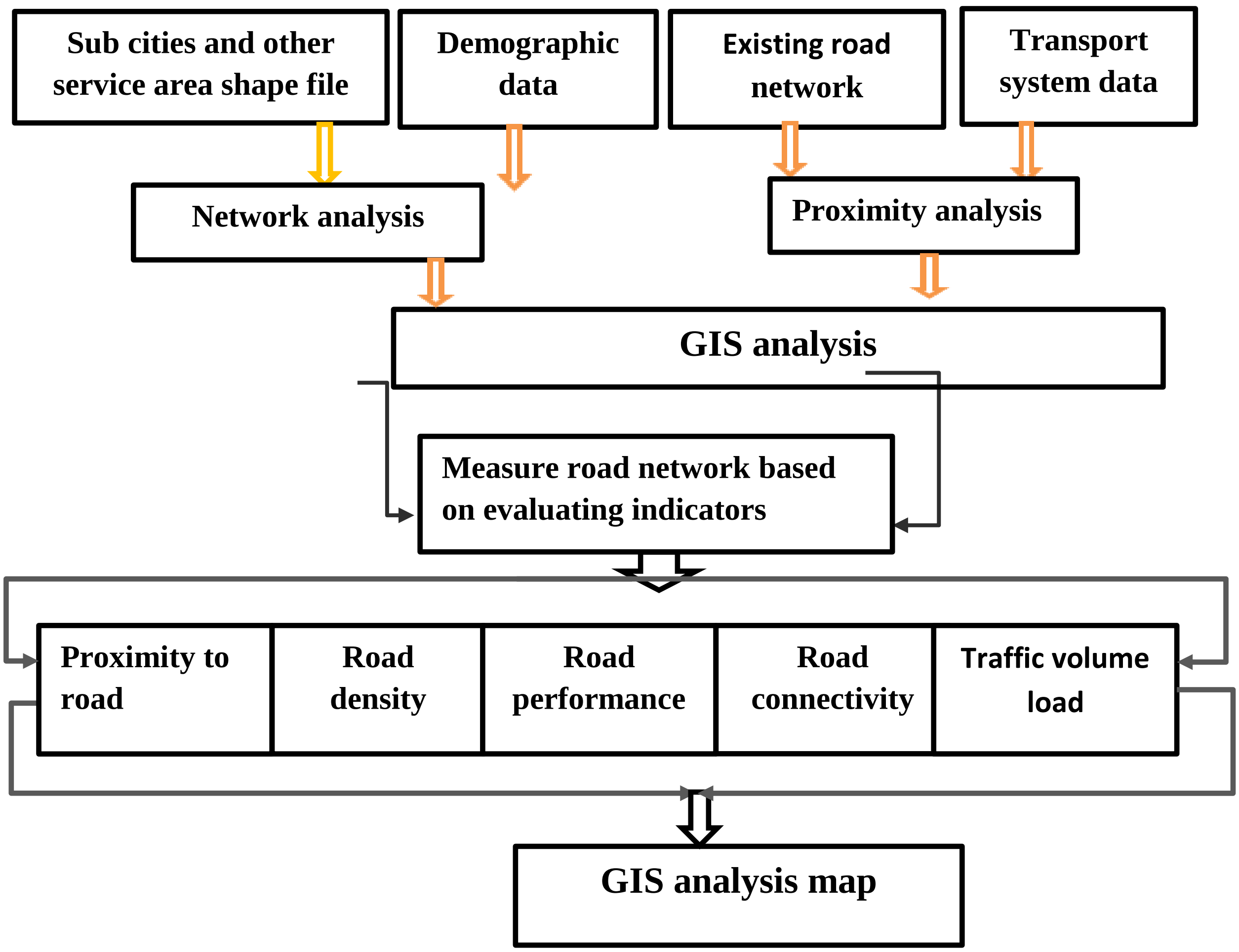
### 3.4.3Road Network Deficiency and Pinpoint of the Study Area

Road network deficiencies can caused by different reasons Good road network has so many benefits for the people. It can facilitate the movement of good and people from one place to another but when there is road network deficiency it had a big effect on the population living area road network deficiency can be caused by many reasons lack of good planning road network and insufficient road capacity and inadequate road network .on this research Pinpoint of the Study Area are selected from Akaki kality and Nefaselke lafto sub cities.

## 3.5Methodological Flow Chart of the Study

To execute the intended objectives, different data was collected from various sources. The shape files of road networks, boundaries of sub cities, demographic data and transport system data were involved by using GIS technique in the current study. To accomplish this study the following flowchart was applicable (Fig.3.7).

**Fig 3. 7: The overall flow chart of the study**



# CHAPTER FOUR

# 4. RUSULT

## 4.1Evaluate the Existing Road Network Structure Using Indicators

### 4.1.1. Road Density/Availability

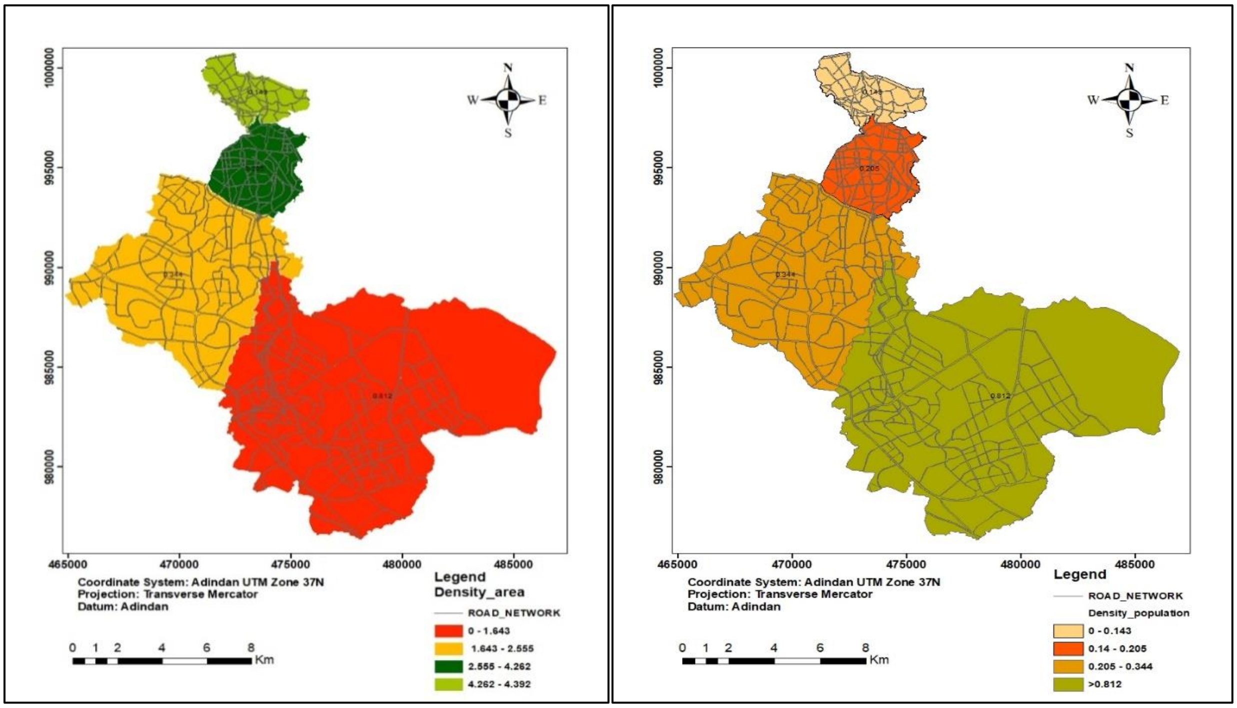
The road density per unit of population shows the availability of road distance per person. Based on the result, there are areas and population suffering from road network; specially, areas that are situated at south east of the study area.

These areas have relatively low population density in Nefaselke Lafto and Akaki Kality and there is low value of road per population in Nefaselke Lafto and Akaki Kality (table 4.1).

**Table 4. 1: Road density of the study area( Addis Ababa Transport office)**

| No | Sub City | Population (thousands) | Area ($km^2$) | road length(km) | road density (km/1000person) | road density ($km/km^2$ ) |
|---|---|---|---|---|---|---|
| 1 | Akaki-kality | 249,662 | 123.452 | 202.79 | 0.812 | 1.643 |
| 2 | Arada | 291,401 | 9.498 | 41.71 | 0.143 | 4.391 |
| 3 | Kirkos | 304,817 | 14.647 | 62.43 | 0.205 | 4.262 |
| 4 | Nifas-Silk | 435,752 | 58.759 | 150.11 | 0.344 | 2.555 |
| | Sum | 1,281,632 | 206.356 | 457.04 | | |

**Fig4. 1: Road density map**




In the (Fig 4.1) the left side of the figure is road length per area (km/km$^2$) and the right side of the figure indicates road length per population (km/1000 person).

In the current study with respect to road length per area, the interval of the road density from low to high is (0 - 1.643, 1.643 - 2.555, 2.555 - 4.262 and 4.262 - 4.392). In addition, with respect to road length per 1000 person the interval of the road density is (0- 0.143, 0.143-0.205, 0.205-0.344 and 0.344-0.812). The low road density indicated low infrastructure availability (Fig 4.1).

The road density per unit of population shows the availability of road distance per person. Hence, road infrastructure exist in more quantities in areas where there is high population density, though the vice versa could be true. There is an area that has more infrastructure and higher population density. This implies there is high road density per population in Arada and Kirkose sub cities. There are also areas that have lower value of road per population. These areas have relatively low population density and there is low value of road per population inAkaki kality and nefaselke lafto. From this we can conclude that, because of they are having larger area in Akaki kality and Nefaselke Lafto sub cities have lower road transportation infrastructure availability with respect to road density per area and per population. On other hand, Arada and Kirkose sub cities have relatively higher road infrastructure with respect to road per population. Most of areas that are found in the Akaki kality and Nefaselke Lafto sub cities have lower infrastructure. When we consider spatial equity, those areas that are far away from the central part of the sub-city have low share of roads. While central part of the sub-city has considerable amount. The same is true when considering equality by the share of road density per person.

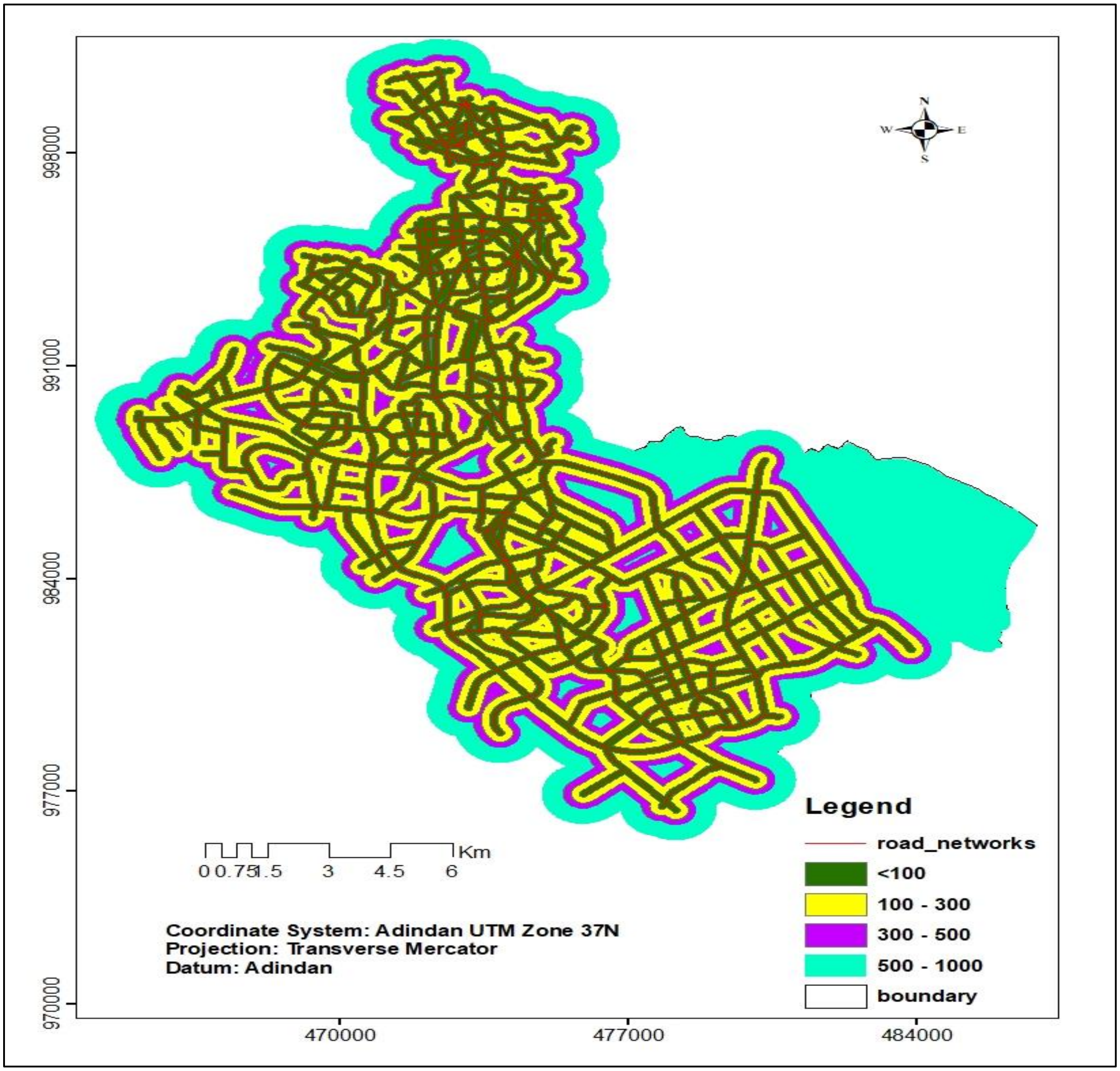
### 4.1.2. Proximity to road network

One of the parameters that indicate the availability of transportation infrastructure and the proximity of the road network to end users is proximity to the road network. According to the current analysis, 39% of the population in the study area can access to major asphalt road within 100m. 40% of the population with in the interval of 100-300m, 17% of the population can access the asphalt road in the interval of 300-500 m distance and the least 4% of the study area population can access with in the distance greater than 500m (Fig 4.2 and table 4.7).

**Table4. 2: population proximity to asphalt road of the study area**

| Asphalt road distance | Area($km^2$) | Population | Area(%) |
|---|---|---|---|
| <100 | 80.103 | 425269 | 39 |
| 100-300 | 82.799 | 439578 | 40 |
| 300-500 | 34.567 | 183518 | 17 |
| 500-1000 | 8.886 | 47177 | 4 |
| | 206.356 | 1095542 | 100 |

**Fig4. 2: Proximity map of the study area**




Areas with the green color are closest to the main asphalt road network, according to this result. Given the size of the entire area, it would take about 100 meters to go from this location to the asphalt road network. Additionally, some neighborhoods are not very close to a major asphalt road (areas in purple color of figure 4.3).After 500–1000 meters, travelers from these places can access any type of large asphalt route. Travelers from this region have a low level of proximity to the major road network due to the poor road network.

### 4.1.3. Traffic volume Load

According to the data gained from the study areas Transport Office, the total number of registered vehicles under the four sub cities (Arada, Kirkos, Nifas-silk and Akaki-kality) accounts about 3861 this number of vehicles only included, code 1 taxi, code 3 minibus, sheger regular, sheger supporter and kitikit ) other code vehicles number data couldn't found in transport office of Addis Ababa so on this research we only used vehicles mentioned above.

. The number of vehicles grows in line with the growth of the road network and population number in the sub-city. Therefore, the average traffic volume load of Arada, Kirkos, Nifas-silk and Akaki-kality is 0.075, 0.101, 0.107 and 0.169respectively.

Based on the analysis result, several roads that are found in the study area are dated many years back before they are maintained. For this and many reasons, the road network of the sub-city need maintenance and reserve road networks. In the number of vehicles, code 1 taxi, code 3 minibus, sheger regular, sheger supporter and kitikit are mainly included.

**Table 4. 3: Calculated result of road length/ number of vehicles**

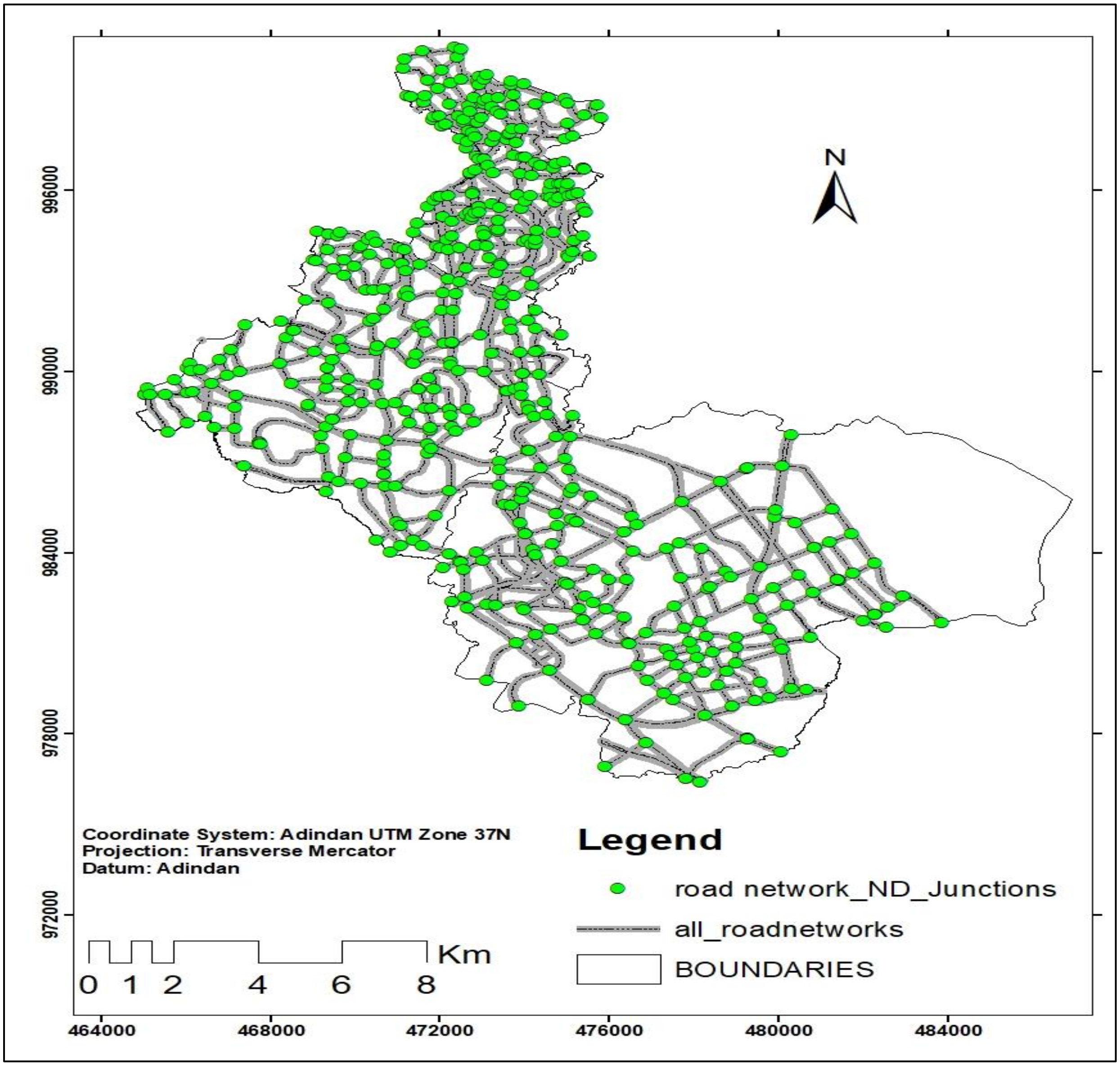
| No | Sub city | Road length(Km) | Number of vehicles | Traffic volume load |
|---|---|---|---|---|
| 1 | Arada | 47.71 | 640 | 0.075 |
| 2 | Kirkos | 62.43 | 621 | 0.101 |
| 3 | Nifas-silk lafto | 150.11 | 1400 | 0.107 |
| 4 | Akaki-kality | 202.79 | 1200 | 0.169 |

The result indicated, the study area having the traffic volume load from high to low in Arada, Kirkos, Nifas-silk lafto and Akaki-kality. Arada sub city has the highest traffic volume load compared to the other three sub cities, 74.55km/1000 public service provider vehicles.

### 4.1.4. Road network Connectivity

The study area's road network was examined for connectedness using the Beta index of connectivity. This was accomplished by dividing the total number of arcs or straight-line roads in the road network by the number of nodes or junctions. This result shows that, on the average there is 0.7 links for each vertex of the route in the study area. However, any route with Beta index value less than 1.0 such route network is considered to have low level of connectivity and such route is not viable for adequate road network transport service.

**Fig 4. 3: Major asphalt road network nodes and arcs of the study area**




According to the study of Kofi (2010), for an adequate connectivity, the road network should have a minimum connectivity index of 1.40. A connectivity index of 1.40 is a reasonable standard to ensure a connected roadway network. However, there are some cities that require a smallest sometimes as low as 1.20.on our study area beta index value is 0.7 which is less than 1.4 also 1.2any route with Beta index value less than 1.0 such route network is considered to have low level of connectivity and such route is not viable for adequate road network transport service.

### 4.1.5. Road performance

**Table4. 4: Road performance of south and central part of the city**

| NO | Region | total road length | poor condition | fair condition | Performance value |
|---|---|---|---|---|---|
| 1 | Central | 239.405 | 53.97 | 80.815 | 0.437 |
| 2 | South | 259.32 | 65.47 | 124.63 | 0.267 |

The complete length of the central section of the road (Kirkos and Arada) has a road performance value of 0.437, less than one (1). It is unsafe to ride on this kind of road system. This indicates that the road networks require immediate maintenance. Delaying maintenance could result in higher costs because maintaining roads is expensive. The same is true for the southern half, which has worse road conditions and provides poor service to the populace as indicated by the road performance value of 0.267 (Table 4.8). When comparing the two, the central portion is in better condition than the southern portion.

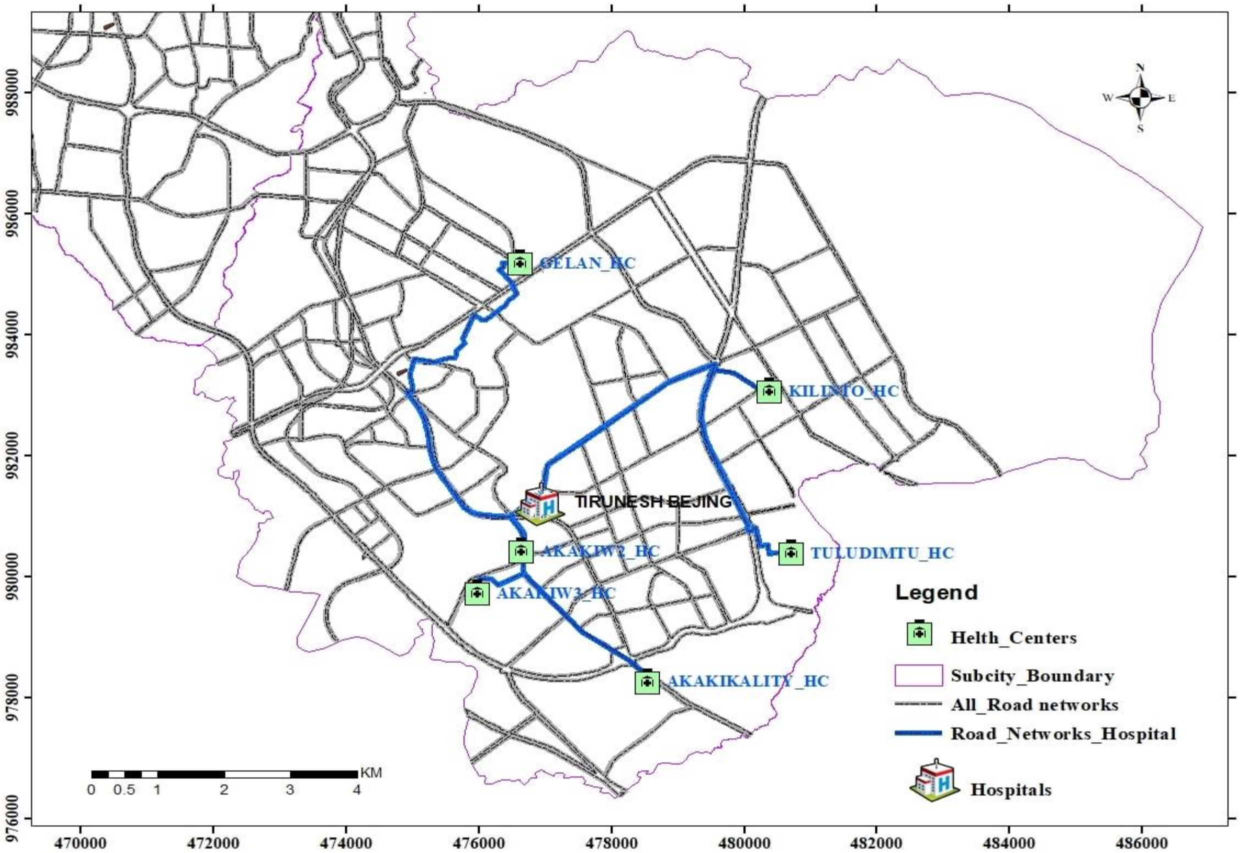
### 4.2. Road Accessibility and Demand to Service Areas

Accessibility measures should reflect the ability of people and goods to reach different destinations. In this study, accessibility is mainly concerned with the travel time of a place to another place on the road network.  In the current study, the three hospitals were selected as a destination because the people living in these areas go to hospitals to get advanced health care services more than any other clinics. The main reason why we selected these service areas is in everyday life people will go and visit places such as hospitals, governmental other health care centers and woreda administration

**Table 4. 5: road network accessibility from health centers to hospitals**

| Origin | Destination | Distance (Km) | Travel time(minute) |
|---|---|---|---|
| Akaki H C | Tirunesh Beijing General Hospital | 1.9 | 7 |
| Woreda 02 HC | Tirunesh Beijing General Hospital | 4.1 | 10 |
| Woreda 03 HC | Tirunesh Beijing General Hospital | 3.3 | 13 |
| Kality HC | Tirunesh Beijing General Hospital | 6.1 | 16 |
| Tulu Dimtu HC | Tirunesh Beijing General Hospital | 5.8 | 18 |
| Kilinto HC | Tirunesh Beijing General Hospital | 8 | 20 |
| Gelan HC | Tirunesh Beijing General Hospital | 7.4 | 21 |
| Arada HC | Yekatit 12 hospital | 2 | 7 |
| Janmeda HC | YEKATIT 12 hospital | 0.9 | 3 |
| Kirkos HC1 | Gandhi memorial hospital | 0.85 | 5 |
| Kirkos HC3 | Gandhi memorial hospital | 3.3 | 17 |
| Kirkos HC4 | Gandhi memorial hospital | 2.8 | 14 |
| Kirkos HC5 | Gandhi memorial hospital | 3.2 | 13 |
| Kirkos HC7 | Gandhi memorial hospital | 3.6 | 22 |
| Nifas silk woreda 01 HC | Gandhi memorial hospital | 6.3 | 26 |
| Nifas silk Woreda 5 HC | Gandhi memorial hospital | 10.7 | 34 |

**Fig 4.4 the accessibility level of different area within the sub-cities to reach Tirunesh Beijing**




General Hospital, Yekatit 12 hospital and Gandhi memorial hospital were measured. Based on their accessibility result, hospitals are more accessible to travelers from woreda health centers when the woreda health centers refer to hospitals. In Akaki kality sub city, As a result of sharing border and being neighbor to each other, travel times and distances from Akaki, Woreda 02, Woreda 03, Kality, Tulu Dimtu, Kilinto, and Gelan health centers to Tirunesh Beijing General Hospital are recorded from lowest the highest time to reach the destination. There are also road networks within Arada and Janmeda health centers that are accessible to reach Yekatit 12 hospital using the major asphalt roads. Using this road networks traveler from Arada and Janmeda health centers can reach Yekatit 12 hospital within 7 and 3 minutes respectively. In the current study in addition to the two hospitals, Tirunesh Beijing general hospital and Yekatit 12 hospital Gandhi memorial hospital also selected as a destination. Moreover, the travelers originate from Kirkos health center 1, 3, 4, 5, 7, Nifas silk woreda 01 and 05 health centers to reach the destination (Table 4.2

**Table4. 6: road network accessibility from Akaki kality woreda office to the sub city office**

| Origin | Destination | Distance (Km) | Travel time(minute) |
|---|---|---|---|
| woreda 01 | Akaki kality sub city administration office | 8 | 25 |
| woreda 02 | Akaki kality sub city administration office | 18.3 | 27 |
| woreda 03 | Akaki kality sub city administration office | 5.3 | 22 |
| woreda 04 | Akaki kality sub city administration office | 1.8 | 6 |
| woreda 05 | Akaki kality sub city administration office | 4.2 | 14 |
| woreda 06 | Akaki kality sub city administration office | 8.7 | 27 |
| woreda 07 | Akaki kality sub city administration office | 2.2 | 7 |
| woreda 08 | Akaki kality sub city administration office | 0.35 | 5 |
| woreda 09 | Akaki kality sub city administration office | 9.6 | 27 |
| woreda 10 | Akaki kality sub city administration office | 14 | 34 |
| woreda 11 | Akaki kality sub city administration office | 7.3 | 21 |

In the study area, Akaki kality sub city the researcher the network between the woreda administrations and the sub city administration. To reach from the woreda administration to the sub city the distances and the time taken were assessed. As the study indicated, Akaki kality woreda 8 is the shortest distance and the least time to reach the destination (sub city) and woreda 02 and woreda 09 is longest distance and time to reach the sub city (Table 4.3).

**Table4. 7: Road network accessibility from Nefaselke Lafto woreda offices tosub city office**

| **Origin** | **Destination** | **Distance (Km)** | **Travel time(minute)** |
|---|---|---|---|
| woreda 01 | Nefas silk Lafto sub city administration office | 1.8 | 9 |
| woreda 02 | ,, | 3.7 | 12 |
| woreda 05 | ,, | 3.5 | 11 |
| woreda 06 | ,, | 4.8 | 17 |
| woreda 08 | ,, | 10.3 | 21 |
| woreda 09 | ,, | 4.1 | 16 |
| woreda 10 | ,, | 4.8 | 16 |
| woreda 12 | ,, | 1.9 | 9 |

Based on their accessibility result, Nefas silk lafto sub city is more accessible to travelers from woreda 01 and 12 because the two-woreda administrations are the shortest distance and the least time to reach the sub city. As a result of sharing border and being neighbor to each other, travel time and distance from Woreda 01 and 12 to the sub city administrations office is less than the other woredas. Using the major asphalt road network, which connects the two Woreda‟s, travel, originated from Woreda 01 and 12 takes not more than 9 minutes. On the contrary woreda 08 is the farthest distance and longest time to reach the sub city of nefas silk lafto sub city which accounts about 10.5km and 21 minute respectively (Table 4.4).

**Table4. 8: Road network accessibility from Arada sub city woreda offices to the sub city office**

| Origin | Destination | Distance (Km) | Travel time(minute) |
|---|---|---|---|
| woreda 01 | Arada sub city administration office | 1.6 | 6 |
| woreda 02 | ,, | 2.6 | 11 |
| woreda 03 | ,, | 2.7 | 11 |
| woreda 6 | ,, | 1.9 | 7 |
| woreda 09 | ,, | 0.26 | 2 |

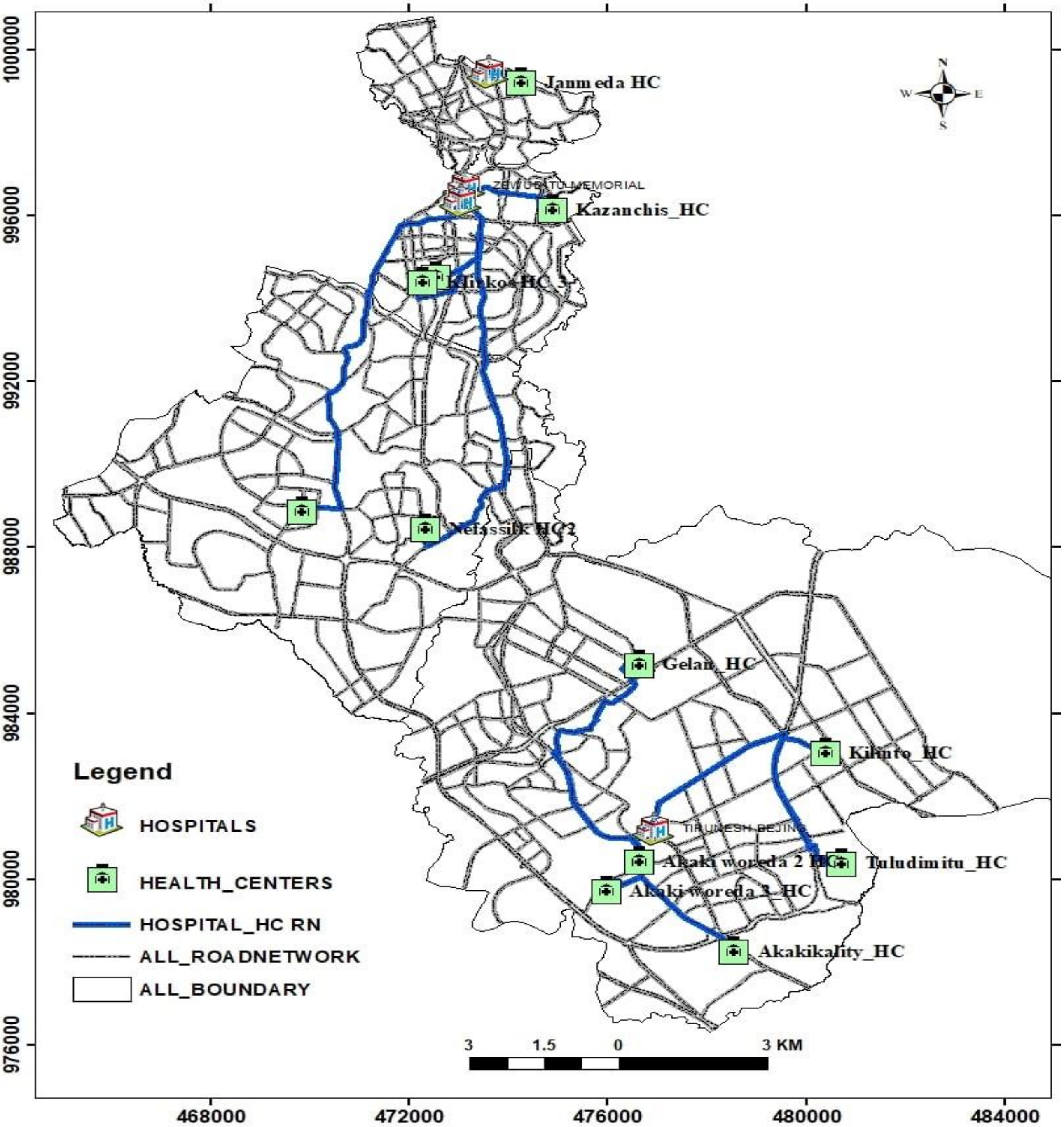
Accessibility result of Arada sub city showed that travelers from woreda 09 administration is the traveled shortest distance and the least time to reach the sub city. As a result of sharing border and being neighbor to each other, travel time and distance from Woreda 09 to the sub city administrations office is less than the other woredas. But to trvel from woreda 02 and 03 took the farthest distance and longest time to reach sub city compared to other woredas, takes greater than 2.6km and 11 minute (Table 4.8).

**Table 4. 9: Road network accessibility from kirkos sub-city woreda offices to the sub-city office**

| Origin | Destination | Distance (Km) | Travel time(minute) |
|---|---|---|---|
| Kirkose woreda 01 | Kirkose sub city office | 1.1 | 7 |
| Kirkose woreda 02 | ,, | 3.7 | 16 |
| Kirkose woreda 04 | ,, | 4.4 | 16 |
| Kirkose woreda 05 | ,, | 4.5 | 15 |
| Kirkose woreda 07 | ,, | 2.1 | 15 |
| Kirkose woreda 09 | ,, | 1.5 | 7 |
| Kirkose woreda 10 | ,, | 4.4 | 13 |

Accessibility result of kirkos sub city showed that travelers from woreda 01 and 09 administration is the traveled shortest distance and the least time to reach the sub city. Because of sharing border and being neighbor to each other, travel time and distance from Woreda 01 to the sub city administrations office is less than the other woredas. However, to trvel from woreda 02 and 04 took the farthest distance and longest time to reach sub city compared to other woredas, takes greater than 4.4km and 16 minute (Table 4.9)

**Fig 4. 4 road network accessibility from health centers to hospitals**



### 4.3. Road Network Deficiency and Pinpoint of the Study Area

#### 4.3.1. Deficiency and Pinpoint of the Study Area

According to the detailed analyses of global accident statistic by the UK transport research laboratory (TRL), the change in road accident fatalities in the low and middle income countries starting from 1965was found increasing highly. This due to highly damaged road and road on maintained take much longer time than there proper time of construction. Figure 4.6and 4.7 shows damaged road in the study area of different locations, which is the other entity described on the roads of the study area. A damaged road is an area or section of the road that has to be repaired or maintained.

Fig 4.6 indicates road found in akaki kality subcity which states from kality menehariyta to maseltegna which is totally damaged for the past seven years and it's still under construction more than five years this road is called Debrezeyete road which the main route for import export to port Djibouti. Because of this road problem people live in sub city suffer many transport problems and the characteristics of a road have a great influence on traffic accidents Improper standards of road construction and maintenance hare a relationship with accident. The road can bring immeasurable change in the accident rate. This road is one of pin point area that road totally lose the connectivity, accessibility and proximity level.

**Fig 4. 5 Damaged road from kality menhariya to maseltegna**

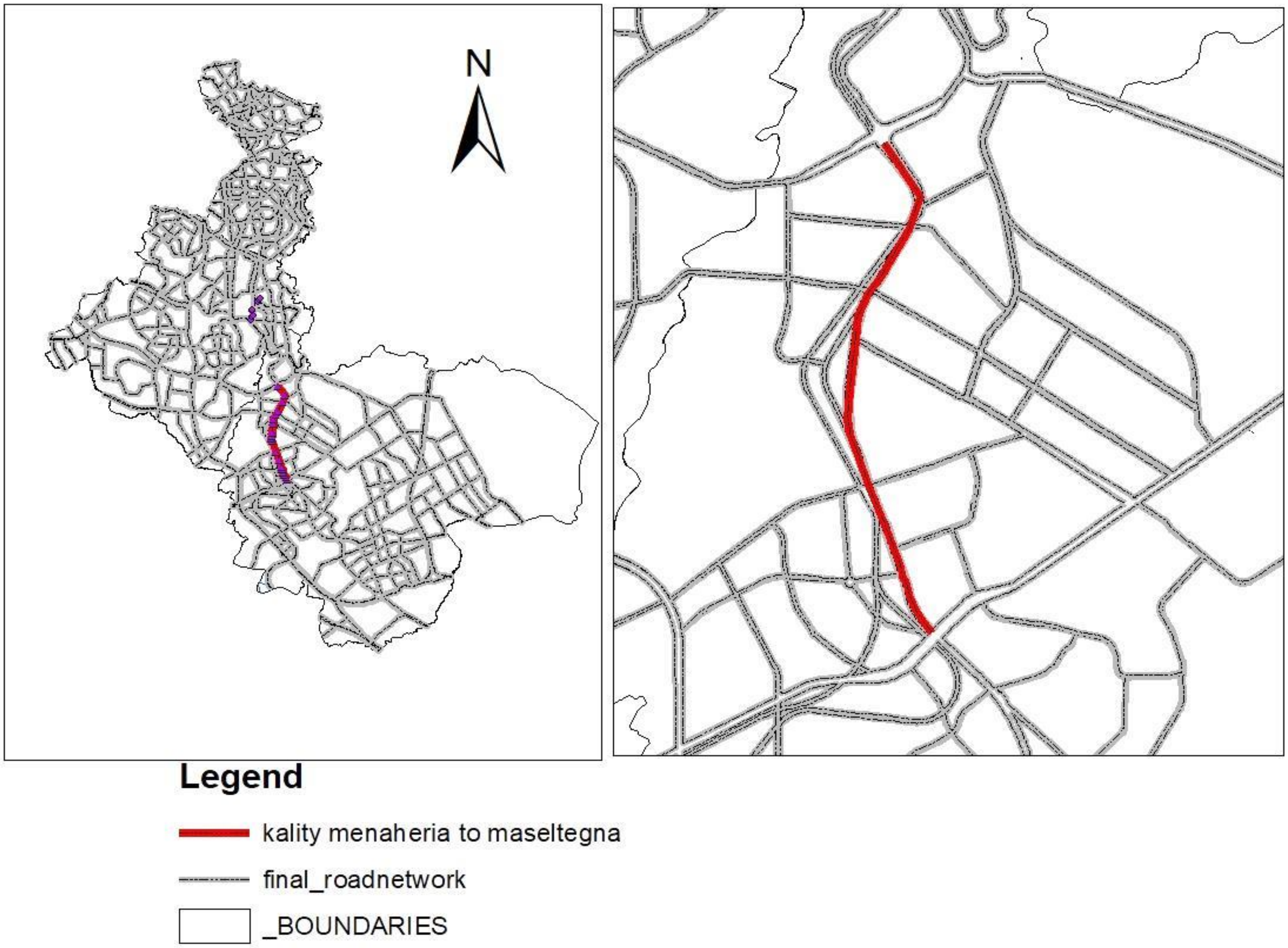
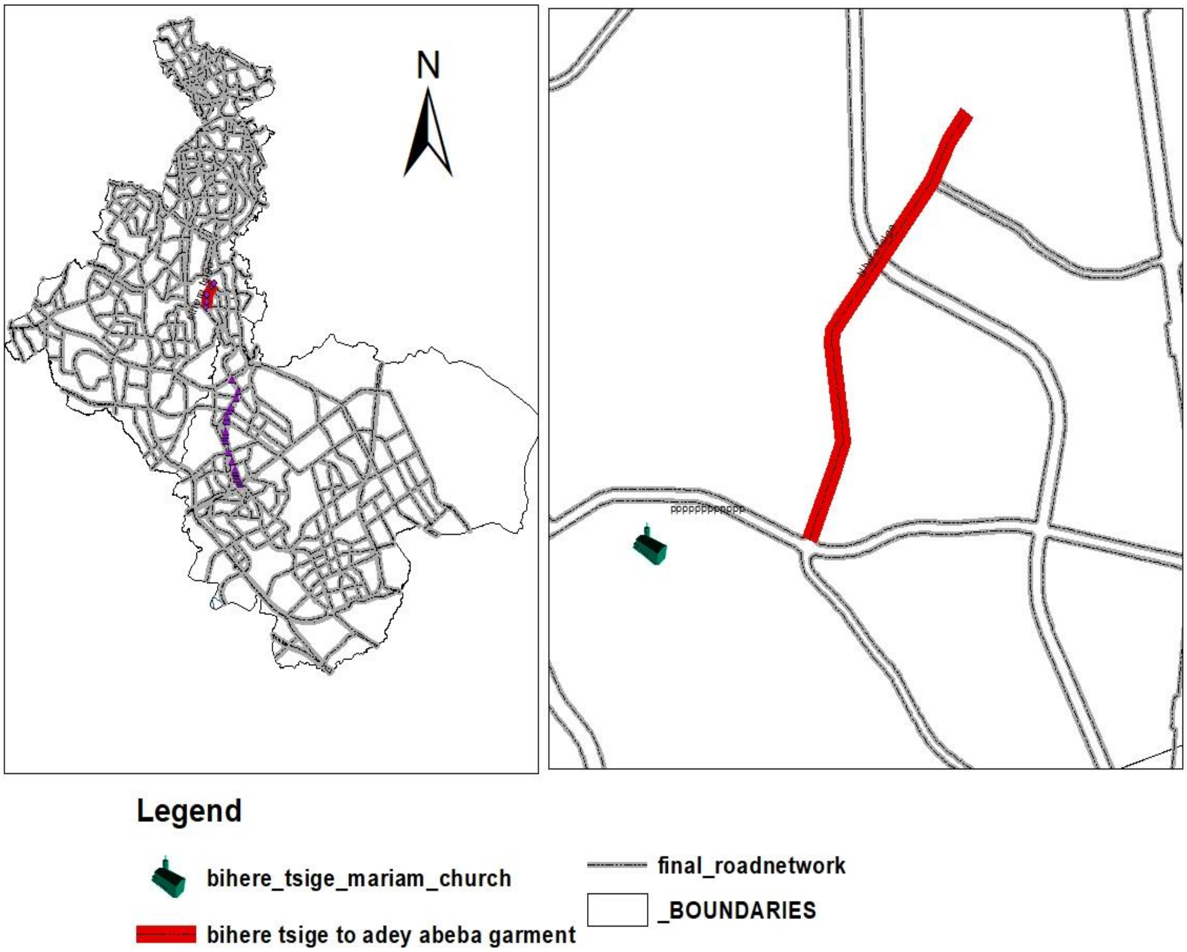


**Fig 4. 6 Damaged road from Bihere tsege mariyam to Adey Ababa garment**




The road showed in fig 4.7 found in Nefaselke lafto sub city from Bihere tsege mariyam to Adey Ababa garment it's damaged road and the maintenance of the road starts about four years. People live in this area suffer by transport shortage and traffic volume load problem factors behind traffic congestion include road works, accidents, traffic overload on the same route, and large numbers of pedestrians holding up the vehicles.

# CHAPTER FIVE

## 5. DISCUSION

### 5.1. Evaluation of existing Road Networks

In this thesis, the Urban Road Transport Network Structure of the four sub cities (Akaki Kality, Nefas-silk Lafo,Kirkose and Arada) was evaluated by using the evaluation indicators(Accessibility, Proximity to road density, Road performance, Road Traffic volume load connectivity).

According to the study conducted by paulos (2016), the road density of Arada sub city was2.76 $km/km^2$.However, in the current study since the road lengths increased from 26.29 to 41.71km the road density is 4.39. This indicates there is a great change between the years 2016 and 2021. From the four sub cities, the road density of Arada and kirkos sub cities showed greater density value. Akaki Kality sub city indicated low road density. Road density can be calculated as the ratio of area's total road network to its total land area or population. A higher road density (road length per area or people) means a higher availability of alternative routes person (Bogale, 2012). The road density can evaluate the network structure only considering the supply side whereas the road density per unit of population measure the availability of network distance per person (Cai et al., 2013).

### 5.2. Accessibility of Road Network to service areas

In this study, accessibility is mainly concerned with the travel time of a place to another place on the road network. Therefore, considering the available mode of public transport, the accessibility level of different area within the sub-cities to reach the hospitals and sub city administration offices. The time and distance were measured from the woreda health centers to the hospitals and from the woreda administration office to sub city administration offices. According to Paulos (2016) measuring the performance of road network accessibility is hence an important part of quantifying the performance of the system in terms of traffic efficiency. In the context of transport studies, accessibility indicates the ability of people to reach their destinations, which they must visit in order to meet their needs, and desire to visit to fulfill their wants(Sahitya & Prasad, 2020).

The distance to the road network is one of the factors that reflect the accessibility of transportation infrastructure and the proximity of the road network to end users. In the research area, 39 percent of the population has access to a major asphalt road within 100 meters, according to the present analysis. In the research region, 40% of the population can access the asphalt road within a distance of 100 to 300 meters, 17% can do so within a range of 300 to 500 meters, and at least 4% can do so within a range of more than 500 meters.

### 5.3. Road Network performance

The total length of the central segment of the road (between Kirkos and Arada) has a road performance value of 0.437. Riding on this kind of road infrastructure is dangerous. This suggests that the road systems need maintenance immediately. Because maintaining roads is expensive, postponing repair may result in greater costs. The same can be said about the southern half, where the roads are in inferior shape and the population receives subpar service, as shown by the road performance value of 0.267. The middle section is in better shape than the southern section when comparing the two. According to paulos (2016), this indicator shows the proportion of roads, which are in good /stable condition which means they do not need maintenance. This type of road network has high comfortable, high-level mobility and movement of vehicles in the road network of the sub-city.

Based on the analysis result, several roads that are found in the study area are dated many years back before they are maintained. For this and many reasons, the road network of the sub-cities need maintenance and reserve road networks. With the extensive construction of roads, road safety has become a matter of great concern to both the government and people. Among these road safety issues, the maintenance of roads is one of the most important tasks.

The overall findings of this study revealed that despite the fact that an efficient road transport service is the best way to maximize urban mobility, in reality this mode of transport is in a critical condition with in sub-cities.

# CHAPTER SIX

## 6. CONCLUSION AND RECOMMENDATION

### 6.1. CONCLUSION

For evaluating urban road transport network, structure GIS is effective technology. This study analyzes and discuses to weigh the existing road transport network structure, to identify the potential of travel demand and current network. In addition, identify the road network deficiency and pinpoint of the study area.

The ArcGIS Network Analyst extension toll allows as solving common network problems, such as finding the best route across a Sub cities, finding the closest health center and woreda administration facility, identifying a service area around a location, finding the performance of the road networks, to find the connectivity of road and proximity of the road also determined by using GIS.

The trend of the total road length built (which is obtained from AACRA) and the total area/population size of the research area are the data required to calculate road density. According to the findings, there are communities and populations that are negatively impacted by the road system, particularly those located to the south east of the research region. If the value of road density shows a decreasing trend through years, it implies that there is a need to construct new roads for meeting the demand.

The key destination places in the study area may be reached in a maximum of 34 minutes of journey time, according to the survey results of this study. When we compare the overall area of the four sub-cities with the travel time to get there, the findings are not adequate. Within the study region, it is difficult to go to the desired location in a reasonable amount of time. This is a result of the area's congested and poor road system.

300-meter proximity to the local road network, which makes it easier for more people to access the local road networks. To access the existing road infrastructure, however, people in the study area's western and southeast must go more than 300 meters. This outcome shows how inadequate the local road system is. This situation shows that there are less road networks in the research areas southeast, indicating a need for more road networks there.

The research area's road network connectivity is roughly 0.7 beta index. However, a route's network is considered to have inadequate connectivity if the Beta index value is less than 1.0, and such a route is not practical for providing acceptable road network transport service.

According to data received from the Addis Ababa City Road Authority, the majority of the current road networks were determined to be performing poorly. More care must be taken with this type of road network than in the past.

The total road length of Kirkos and Arada has a road performance value of 0.437, which is lower than one. Riding on this type of road infrastructure is dangerous. This suggests that the road networks need maintenance immediately. The same is true for the southern half, where the roads are in poorer shape and the population receives poor service, as shown by the road performance value of 0.267.

The total number of registered vehicles under the four sub cities (Arada, Kirkos, Nifas-silk, and Akaki-kality) is around 3861, according to data obtained from the study area Transport Office. The number of cars increases in line with the sub-population city's and road network. The research region with the highest to lowest traffic volume load, as shown by the results, is Arada, Kirkos, Nifas-silk lafto, and Akaki-kality. With 74.55km/1000 public service provider vehicles, Arada sub city has the largest traffic volume load when compared to the other three sub cities.

Finding the efficiency of the current road network, as well as information on the local travel demand and the current state of the road network, were some of the goals of measuring road network performance. To establish the level of infrastructure needed to support economic and social activities in the study area, the researcher in this particular project examined the effectiveness of the current road network structure by using GIS. Additionally, a number of road network performance indicators were used to calculate the performance of the road network.

Overall, the current road maintenance and transportation network in the sub cities of Akaki Kality, Nefaselke Lafto, Kirkose, and Arada suffer from a variety of deficiencies. The study area's development is negatively impacted by the poor level of road network service in some areas, which limits mobility, creates inequalities in spatial accessibility, and makes it necessary to drive unnecessary distances to get where you're going. This limits how easily people and commodities can move around the research area. The center area has a high degree of transportation infrastructure; however the roads are poorly maintained and have limited capacity.

### 6.2. RECOMMENDATION

*Depending on the research findings of the analysis, the following recommendations are forwarded to overcome the existing problems.*

- *Transport services especially in the two sub cities (Akaki Kality and Nefas-silk lafto)occurs lack of adequate and efficient road network. Therefore, for better transport service deliverance, the road network must have evaluated and improved.*
- *The study's findings show that the main asphalt road is far from the residents that have settled around the sub-cities in Akaki Kality and Nifas-Silk Lafto. The population and socioeconomic activities in the study region are changing rapidly, thus the city road authority must act right now to improve and build a new road network.*
- *In different location of the study area, the walkways are damaged by telecom, water workers, ELPA after the AACRA built up the road. Due to such problem, the resources dissipate and damaged. There to resolve the problem the concerned bodies the above-mentioned organizations should work cooperatively.*
- *Increasing land use clustering and mix can increase accessibility by enhancing walkability in addition to increasing vehicle flow and individual mobility. Therefore, expanding the land use of the road network is crucial for improving the study area's accessibility to road transportation.*
- *By using ARC GIS software starting from the planning of road network in the governmental responsible offices to construct a new road and maintain a damaged road train well professionals to use ARC GIS software apply it well to phase the challenges on road network of the city.*
- *Lack of an appropriate and effective road network is the biggest obstacle to delivering road transportation services. Therefore, the road network needed to*

*be assessed and enhanced in order to provide better transport services. A target aim for the efficiency parameters in the strategy should be established for this reason. The concerned government offices for transport infrastructure have to work together using GIS which helps to improve the road network.*

- *Due to the city's constant changes in population, lifestyle, and socioeconomic activities, the master road network must be updated often*

*In general, the concerned bodies, primarily AACRA, and other stakeholders involved with road transport should focus their efforts on the road transport system by assessing the overall effectiveness of the road network in the study area. It is therefore recommended that government should formulate a good road infrastructure policy that will enhance the sustainability of road infrastructure and should also encourage public participation in road infrastructure by using upgraded software like ARC GIS.*

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# Appendixes

Table

lines

| FID | Shape * | ObjectID | Name | OriginID | Destinatio | Destinat_1 | Total_Leng |
|---|---|---|---|---|---|---|---|
| 3023 | Polyline | 3503 | Location 467 - Location 442 | 467 | 442 | 3 | 3598.41563 |
| 3024 | Polyline | 3505 | Location 468 - Location 463 | 468 | 463 | 2 | 346.594589 |
| 3025 | Polyline | 3507 | Location 469 - Location 457 | 469 | 457 | 2 | 1873.896632 |
| 3026 | Polyline | 3509 | Location 470 - Location 471 | 470 | 471 | 2 | 0.169515 |
| 3027 | Polyline | 3510 | Location 470 - Location 478 | 470 | 478 | 3 | 2638.257484 |
| 3028 | Polyline | 3512 | Location 471 - Location 470 | 471 | 470 | 2 | 0.169515 |
| 3029 | Polyline | 3513 | Location 471 - Location 478 | 471 | 478 | 3 | 2638.087969 |
| 3030 | Polyline | 3515 | Location 472 - Location 475 | 472 | 475 | 2 | 1194.135383 |
| 3031 | Polyline | 3516 | Location 472 - Location 480 | 472 | 480 | 3 | 1194.135383 |
| 3032 | Polyline | 3518 | Location 473 - Location 466 | 473 | 466 | 2 | 983.571212 |
| 3033 | Polyline | 3520 | Location 474 - Location 482 | 474 | 482 | 2 | 3794.422151 |
| 3034 | Polyline | 3523 | Location 475 - Location 472 | 475 | 472 | 3 | 1194.135383 |
| 3035 | Polyline | 3525 | Location 476 - Location 481 | 476 | 481 | 2 | 1267.211501 |
| 3036 | Polyline | 3526 | Location 476 - Location 448 | 476 | 448 | 3 | 3411.983871 |
| 3037 | Polyline | 3527 | Location 476 - Location 437 | 476 | 437 | 4 | 4238.291153 |
| 3038 | Polyline | 3528 | Location 476 - Location 422 | 476 | 422 | 5 | 7607.743844 |
| 3039 | Polyline | 3529 | Location 476 - Location 435 | 476 | 435 | 6 | 9436.590898 |
| 3040 | Polyline | 3531 | Location 477 - Location 454 | 477 | 454 | 2 | 3228.65089 |
| 3041 | Polyline | 3533 | Location 478 - Location 471 | 478 | 471 | 2 | 2638.087969 |
| 3042 | Polyline | 3534 | Location 478 - Location 470 | 478 | 470 | 3 | 2638.257484 |
| 3043 | Polyline | 3536 | Location 479 - Location 467 | 479 | 467 | 2 | 2799.734775 |
| 3044 | Polyline | 3537 | Location 479 - Location 442 | 479 | 442 | 3 | 6398.150406 |
| 3045 | Polyline | 3540 | Location 480 - Location 472 | 480 | 472 | 3 | 1194.135383 |
| 3046 | Polyline | 3542 | Location 481 - Location 476 | 481 | 476 | 2 | 1267.211501 |
| 3047 | Polyline | 3543 | Location 481 - Location 448 | 481 | 448 | 3 | 4679.195372 |
| 3048 | Polyline | 3544 | Location 481 - Location 437 | 481 | 437 | 4 | 5505.502654 |
| 3049 | Polyline | 3545 | Location 481 - Location 422 | 481 | 422 | 5 | 8874.955345 |
| 3050 | Polyline | 3546 | Location 481 - Location 435 | 481 | 435 | 6 | 10703.802399 |
| 3051 | Polyline | 3548 | Location 482 - Location 474 | 482 | 474 | 2 | 3794.422151 |

2 (0 out of 3052 Selected)

Lines lines

Table Of Contents Network Analyst Table

| IRI | Length | Ratio % |
|---|---|---|
| 0 - 1 | 22,095 | 8.5% |
| 1 - 2 | 41,775 | 16.1% |
| 2 - 3 | 43,845 | 16.9% |
| 3 - 4 | 39,010 | 15.0% |
| 4 - 5 | 29,740 | 11.5% |
| 5 - 6 | 21,790 | 8.4% |
| 6 - 7 | 13,940 | 5.4% |
| 7 - 8 | 11,305 | 4.4% |
| 8 - 9 | 9,110 | 3.5% |
| 9 - 10 | 6,525 | 2.5% |
| 10 - | 20,185 | 7.8% |
| | 259,320 | 100.0% |

| Road Class | Sum of R_Leng | Average of IRI |
|---|---|---|
| C | 69,180.00 | 5.42 |
| P | 114,070.00 | 3.74 |
| R | 43,945.00 | 5.41 |
| S | 32,125.00 | 5.02 |
| **Grand Total** | **259,320.00** | **4.64** |

**South IRI value 2013 data EC data**

| IRI | Length | Ratio % |
|---|---|---|
| 0 - 1 | 4,935 | 2.3% |
| 1 - 2 | 17,500 | 8.0% |
| 2 - 3 | 30,105 | 13.8% |
| 3 - 4 | 33,210 | 15.3% |
| 4 - 5 | 31,635 | 14.5% |
| 5 - 6 | 30,405 | 14.0% |
| 6 - 7 | 19,090 | 8.8% |
| 7 - 8 | 14,120 | 6.5% |
| 8 - 9 | 9,730 | 4.5% |
| 9 - 10 | 5,550 | 2.6% |
| 10 - | 21,165 | 9.7% |
| | 217,445 | 100.0% |

| Road Class | Sum of R_Leng | Average of IRI |
|---|---|---|
| C | 29,020.00 | 8.40 |
| P | 118,060.00 | 5.22 |
| R | 16,850.00 | 3.20 |
| S | 53,515.00 | 5.28 |
| **Grand Total** | **217,445.00** | **5.52** |

**Central IRI value 2013 data EC data**

| FID * | Shape * | Name | X | Y |
|---|---|---|---|---|
| 1 | Point ZM | road line | 983460 | 983460 |
| 2 | Point ZM | road line | 983539 | 983539 |
| 3 | Point ZM | road line | 983639 | 983639 |
| 4 | Point ZM | road line | 983746 | 983746 |
| 5 | Point ZM | road line | 983855 | 983855 |
| 6 | Point ZM | road line | 983897 | 983897 |
| 7 | Point ZM | road line | 983985 | 983985 |
| 8 | Point ZM | road line | 984261 | 984261 |
| 9 | Point ZM | road line | 984604 | 984604 |
| 10 | Point ZM | road line | 985031 | 985031 |
| 11 | Point ZM | road line | 985156 | 985156 |
| 12 | Point ZM | road line | 985237 | 985237 |
| 13 | Point ZM | road line | 985384 | 985384 |
| 14 | Point ZM | road line | 985765 | 985765 |
| 15 | Point ZM | road line | 985968 | 985968 |
| 16 | Point ZM | road line | 986149 | 986149 |
| 17 | Point ZM | road line | 986279 | 986279 |
| 18 | Point ZM | road line | 986654 | 986654 |
| 19 | Point ZM | road line | 986909 | 986909 |
| 20 | Point ZM | road line | 987331 | 987331 |

**Collected Point data**

**Road defects In Akaki kality Sub City**

**Road defects in Nefaselke LaftoSub City**

| ተ.ቁ | | መነሻ | መተላለፊያ | መድረሻ | የመንገዱ ርዝመት(ኪ.ሜ) | ታሪፍ በሚኒባስ | ታሪፍ በሚድባስ | ኮድ 1 ታክሲ | ኮድ 3 ሚኒባስ | አንበሳ | የሸገር መደበኛ | ሸገር ድጋፍ ሰጪ | ቅጥቅጥ | ምርመራ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | አደይ አበባ | በብሔረፅጌ | ጎፋ መ/ኃ | 2.1 | 2.5 | 4 | 34 | 4 | | | | | |
| 1 | 2 | | በቀበሌ 08 | አቃቂ ገበያ | 11.3 | 12.5 | 6 | 15 | 1 | | | | | |
| | 3 | ከሃና ማርያም | በመካኒሳ | ሜክሲኮ | 10.6 | 12.5 | 6 | 9 | 41 | | | 6 | | |
| | 4 | | በለቡ መ/ኃይል | አየር ጤና | 8.9 | 10 | 6 | 16 | 20 | | | | | |
| 2 | 5 | | በጋርመንት | ሰፈራ | 3.8 | 5 | 4 | 31 | 0 | | | | | |
| | 6 | ከኃይሌ ጋርመንት | በለቡ መ/ኃይል | ጀሙ/ፉሪ | 4.8 | 5 | 4 | 32 | 0 | | | | | |
| | 7 | | በመካኒሳ | ሜክሲኮ | 8.8 | 10 | 6 | 0 | 38 | | | 7 | | |
| | 8 | | በቦሌ | መገናኛ | 15 | 15 | 7 | 0 | 40 | 6 | 6 | | | |
| | 9 | | ና ማርያም ማሰልጠ | ቃሊቲ ቶታል | 9.4 | 10 | 6 | 0 | 6 | | | | | |
| 3 | 10 | | በሠፈራ | ገላን ኮንደሚኒዬም | 9.3 | 10 | 6 | 0 | 12 | | | | | |
| | 11 | ከለቡ መ/ኃይል | በመካኒሳ | ሜክሲኮ | 8.6 | 10 | 6 | 3 | 21 | | | | | |
| | 12 | | በጀሞ መንደር | ፉሪ | 5.5 | 7.5 | 4 | 0 | 4 | | | | | |
| 4 | 13 | | በጀሞ ሚካኤል | አየር ጤና | 4.4 | 5 | 4 | 0 | 3 | | | | | |
| | 14 | ከላፍቶ | በጎፋ መ/ኃይል | ሜክሲኮ | 8.2 | 10 | 4 | 11 | 32 | 4 | | 6 | 32 | |
| 5 | 15 | | በጎፋ መ/ኃይል | ሜክሲኮ | 7.8 | 10 | 4 | 0 | 27 | | | | | |
| | 16 | ከመካኒሳ | በሸበሌ ፖስታ ቤት | ፒያሳ | 9.1 | 10 | 6 | 12 | 8 | | | | | |
| | 17 | | በአብነት | ምዕራብ /ሆ | 9.6 | 10 | 6 | 3 | 2 | | | | | |
| | 18 | | በጎማ ቁጠባ | ሲኒማ ራስ | 9.2 | 10 | 6 | 6 | 6 | | | | | |
| 6 | 19 | | በድል ቀለም | ሜክሲኮ | 5.2 | 7.5 | 4 | 8 | 4 | | | | | |
| | 20 | ሥፈራ አትክልት ተ | በጋርመንት | ሜክሲኮ | 11.2 | 12.5 | 6 | 0 | 19 | 14 | | | | |
| | 21 | | በሜክሲኮ ብሔራዊ | ፒያሳ | 12.5 | 12.5 | 7 | 0 | 4 | | | | | |
| | 22 | | ኣዲሱ መንገድ አብነ | አውቶቢስ ተራ | 12.6 | 15 | 7 | 0 | 5 | | | | | |
| | 23 | | በጀሞ-3 | ኬንቴሪ | 9.6 | 10 | 6 | 0 | 7 | | | | | |
| 7 | 24 | | በጀርመን አደባባይ | አየር ጤና | 10.2 | 12.5 | 6 | 0 | 8 | | | | | |
| | 25 | ከሳሪስ ሸዋ ዳቦ | በማሰልጠኛ | ቀበሌ 09 | 9.2 | 10 | 6 | 0 | 7 | | | | | |
| | 26 | | በማሰልጠኛ | ቃሊቲ ቶታል | 7.3 | 10 | 4 | 2 | 10 | | | | | |
| | 27 | | በማሰልጠኛ | ገላን ኮንደሚ | 10.2 | 12.5 | 6 | 0 | 10 | | | 12 | | |
| | 28 | | በቀበሌ 09 | የሺ ቶታል | 11.3 | 12.5 | 6 | 2 | 4 | | | | | |
| | 29 | | በቀበሌ 08 | አቃቂ ገበያ | 11.3 | 12.5 | 6 | 0 | 18 | | | | | |
| | 30 | | በኃይሌ ጋርመንት | ገላን ኮንደሚኒዬም | 15 | 15 | 7 | 0 | 10 | | | | | |
| | 31 | | በኃይሌ ጋርመንት | ቱሉ ዲምቱ | 20 | 20 | 11 | 0 | 25 | | | | | |
| 8 | 32 | | በማሰልጠኛ | 08 ደራርቱ | 8.7 | 10 | 6 | 0 | 0 | | | | | |
| | 33 | ከቄራ | በሜክሲኮ | ፒያሳ | 6.2 | 7.5 | 4 | 0 | 1 | | | | | |
| | 34 | | በአብነት | አ/ተራ | 7.2 | 7.5 | 4 | 0 | 1 | | | | | |
| | 35 | | በሳር ቤት | ቶታል | 4.6 | 5 | 4 | 21 | 4 | | | | | |
| | 36 | | በጎተራ ሳሪስ | ቃሊቲ ቶታል | 11.8 | 12.5 | 6 | 0 | 32 | | | | | |
| | 37 | | በተራ ላንቻ | ስቴዲዩም | 6.2 | 7.5 | 4 | 23 | 18 | | | | | |
| | 38 | | በጎፋ መ/ኃይል | ላፍቶ 54 | 5 | 5 | 4 | 5 | 8 | | | | | |
| | 39 | | በጎተራ ዴፖ | ሳሪስ አቦ | 5.2 | 7.5 | 4 | 0 | 0 | | | | | |
| 9 | 40 | | በመካኒሳ | ሜክሲኮ | 7.2 | 7.5 | 4 | 8 | 6 | | | | | |
| | 41 | ከዳማ ሆቴል | በኮኮብ | 58 ማዞሪያ | 2.1 | 2.5 | 4 | 36 | 0 | | | | | |
| | 42 | | 58 ማዞሪያ | ላፍቶ | 4.3 | 5 | 4 | 38 | 0 | | | | | |
| | 43 | | 58 ማዞሪያ | ሃና ማርያም ሰፈራ | 5.6 | 7.5 | 4 | 0 | 0 | | | | 14 | |
| 10 | 44 | | 58 ማዞሪያ | ሃና ማርያም | 3.1 | 5 | 4 | 37 | 0 | | | | | |
| | 45 | ከጀሞ 1 | በአብነት | ምዕራብ | 11.9 | 12.5 | 6 | 15 | 4 | | | | | |
| | 46 | | በሜክሲኮ | ሲኒማ ራስ | 11.9 | 12.5 | 6 | 8 | 20 | | | | | |
| | 47 | | በኖክ ፉሪ | ኬንቴሪ | 8.6 | 10 | 6 | 0 | 4 | | | | | |
| | 48 | | በሃና ማርያም | ማሰልጠኛ | 7.2 | 7.5 | 4 | 0 | 5 | | | | | |
| | 49 | | በመካኒሳ | ፒያሳ | 12.9 | 15 | 7 | 0 | 30 | 6 | 6 | | | |
| | 50 | | በለቡ መ/ኃይል | ላፍቶ | 5.4 | 7.5 | 4 | 0 | 7 | | | | | |
| | 51 | | በመካኒሳ | ሜክሲኮ | 8.7 | 10 | 6 | 9 | 0 | 0 | 11 | 24 | | |
| 11 | 52 | | በሃና ማርያም | ቃሊቲ መነከሪያ | 12.8 | 15 | 7 | 38 | 17 | | | | | |
| 12 | 53 | ከጀሞ2 | በመካኒሳ | ሜክሲኮ | | | | | | | 11 | 2 | | |
| | 54 | ከጀሞ ሚካኤል | በቆሬ አብነት | አ/ተራ | 9.8 | 10 | 6 | 0 | 6 | | | | | |
| 13 | 55 | | በቆሬ ድል ቀለም | ምዕራብ ሆቴል | 11.2 | 12.5 | 6 | 0 | 3 | | | | | |
| | 56 | | በቆሬ አብነት | ሞርካቶ | 0 | | | 0 | | 5 | | | | |
| | 57 | | በመካኒሳ | ሜክሲኮ | | | | | | | 4 | | | |
| | 58 | | በሜክሲኮ ፒያሳ | 6 ኪሎ | | | | | | 4 | | | | |
| 14 | 59 | ከጀሞ3 | በሜክሲኮ | ለገሀር | | | | | | 5 | | | | |
| | 60 | ከጀርመን አደባባይ | በጎፋ ካምፕ | ቄራ ጫፍ | 4.2 | 5 | 4 | 18 | 7 | | | | | |
| | 61 | | በሜክሲኮ | ፒያሳ | 9.6 | 10 | 6 | 0 | 25 | | | | | |
| 15 | 62 | | በቄራ | ሜክሲኮ | 6.5 | 7.5 | 4 | 0 | 11 | | | | | |
| | 63 | ከጎፋ መ/ኃይል | በብሔራዊ | ፒያሳ | 8.5 | 10 | 6 | 2 | 28 | | | | | |
| 16 | 64 | | በሜትሮሎጂ | አ/ተራ | 9.4 | 10 | 6 | 2 | 20 | | | | | |
| 17 | 65 | ከጎፋ ካምፕ | በተግባረዕድ | ተ/ማኖት | 7 | 7.5 | 4 | 0 | 11 | | | | | |
| | 66 | ከጎፋ ገብርኤል | በቄራ | ሜክሲኮ | 4.6 | 5 | 4 | 2 | 0 | | 8 | | | |
| | 67 | | በጀርመን አደባባይ | አየር ጤና | 8.9 | 10 | 6 | 10 | 15 | | | | | |
| 18 | 68 | | በጀርመን አደባባይ | ጀሞ መንደር ኬንተሪ | 7.2 | 7.5 | 4 | 53 | 19 | | | | | |
| | | | ድምር | | | | | 509 | 698 | 44 | 46 | 57 | 46 | |

| የአቃቂ ቃሊቲ ትራንስፖርት ቅርንጫፍ ጽ/ቤት የትራንስፖርት ስምሪት መረጃ ማጠቃለያ፣ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ተ.ቁ | ማሳሻ (መጨሻ ማውረጃ ቦታ) ስም | የስምሪት ማስመር ብዛት | የተሽከርካሪ አይነት እና ብዛት | | | | | | |
| | | | ኮድ -3 | ኮድ -1 | ሀይገር | ቅጥቅጥ | አንበሳ | ሸገር | ፐብሊክ |
| 1 | አደይ አበባ | 3 | | | | | | | |
| 2 | ሳሪስ ሸዋ ዳቦ | 4 | | | | | | | |
| 3 | ሳሪስ አቦ | 8 | | | | | | | |
| 4 | ማሰልጠኛ | 1 | | | | | | | |
| 5 | ቃሊቲ መናኸሪያ | 4 | | | | | | | |
| 6 | ቃሊቲ ቶታል | 11 | | | | | | | |
| 7 | 09 ቀበሌ | 1 | | | | | | | |
| 8 | ገላን ኮንደሚኒየም | 4 | | | | | | | |
| 9 | ደራርቱ ት/ቤት | 1 | | | | | | | |
| 10 | አቃቂ መሿ | 1 | | | | | | | |
| 11 | አቃቂ ን/ባንክ | 1 | | | | | | | |
| 12 | አቃቂ ገበያ | 6 | | | | | | | |
| 13 | አቃቂ ቆርቆሮ | 1 | | | | | | | |
| 14 | የሺ ቶታል | 1 | | | | | | | |
| 15 | ቱሉዲምቱ | 1 | | | | | | | |
| 16 | ሳንስና ቴክ ዩኒቨ. | 1 | | | | | | | |
| 17 | ሰፈራ ድልድይ | 1 | | | | | | | |
| 18 | ኮዬ ፈጬ | 1 | | | | | | | |
| 19 | ወርቁ ሰፈር | 1 | | | | | | | |
| ድምር | መጨሻ ማውረጃ ቦታ ብዛት 19 | 52 | 666 | 230 | 142 | 117 | 15 | 30 | የለም |

| የቂርቆስ ትራንስፖርት ቅርንጫፍ ጽ/ቤት የትራንስፖርት ስምሪት መረጃ ማጠቃለያ፣ | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ተ.ቁ | ማሳሻ (መጨሻ ማውረጃ ቦታ) ስም | የስምሪት ማስመር | የተሽከርካሪ አይነት እና ብዛት | | | | | | | |
| | | | ኮድ -3 | ኮድ -1 | ሀይገር | ቅጥቅጥ | አንበሳ | ሸገር | ሸገር ድጋፍ | ፐብሊክ |
| 1 | አንባሳደር | 1 | | | | | | | | |
| 2 | ለገሃር | 4 | | | | | | | | |
| 3 | ሜክሲኮ | 9 | | | | | | | | |
| 4 | ቂርቆስ | 2 | | | | | | | | |
| 5 | ቄራ | 6 | | | | | | | | |
| 6 | ቡናናሻይ | 5 | | | | | | | | |
| 7 | ብሄራዊ | 1 | | | | | | | | |
| 8 | እስቴድየም | 6 | | | | | | | | |
| 9 | ወሎሰፈር | 1 | | | | | | | | |
| 10 | ደንበል | 1 | | | | | | | | |
| 11 | ካዛንችስ | 7 | | | | | | | | |
| ድምር | መጨሻ ማውረጃ ቦታ ብዛት 11 | 43 | 283 | 172 | 0 | 8 | 20 | 58 | 60 | 20 |

**በአራዳ ክ/ከተማ ቅርንጫፍ በሁሉም የህዝብ ተሸከርካሪ አይነት፣ ብዛት፣ እና የስምሪት መስመር**

| ተ.ቁ | | የመስመር ስም | | | የመንገዱ እርዝመት (ኪሎ..ሜ) | ታሪፍ በሚኒ ባስ | ታሪፍ በሚዲ ባስ | ዝብ ትራንስፖርር | | የብዙሀን ትራንስፖርት | | | ጠቅ/ተሸከርካሪ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | መነሻ | መተላለፊያ | መድረሻ | | | | ኮድ-03 | ኮድ 1 ሚኒባስ | ፐብሊክ | አንበሳ | ሸገር | |
| 1 | 1 | ከ4 ኪሎ | በካዛ.ሃናን | መገናኛ ተርሚናል | 7.2 | 7.5 | 4 | 5 | | | | | 5 |
| | 2 | | በ6ኪሎ | ቤላ | 4.7 | 5 | 4 | | | | | | 0 |
| | 3 | | በእስጢፋኖስ | ቦሌ | 7.6 | 10 | 4 | 12 | | | | 0 | 12 |
| | 4 | | በ6ኪሎ | እየሱስ | 4.9 | 5 | 4 | | | | | | 0 |
| | 5 | | በ6ኪሎ | ካራማራ | | | | | | | | | 0 |
| | 6 | | በ6ኪሎ | ፈረ. ብረት. ድልድይ | 5.5 | 7.5 | 4 | 5 | | | | 2 | 7 |
| 2 | 7 | ከመገናኛ | በካዛ.ቶታል | ፒያሳ | 8.4 | 10 | 6 | 23 | | | | | 23 |
| | 8 | | በቀበና | ፒያሳ | 7.9 | 10 | 4 | 6 | | | | | 6 |
| 3 | 9 | ከሚኒሊክ ት/ቤት | ጎተራ | ቃሊቲ | 13.5 | 15.0 | 7.0 | 8 | | | | | 8 |
| 4 | 10 | ከሚኒሊክ አደባባይ | በሜክሲኮ | አጀንባ | | | | | | | 8 | | 8 |
| | 11 | | በሜክሲኮ | ቆሬ | | | | | | | 4 | | 4 |
| | 12 | | በአብነት/ጦር | ቤተል | | | | | | | 8 | | 8 |
| | 13 | | በሜክሲኮ | ቀራኒዮ | | | | | | | 4 | | 4 |
| | 14 | | በአንባሳደር | ቦሌ ቡልቡላ | | | | | | | 5 | | 5 |
| 5 | 15 | ከሲኒማ ኢትዮ. | በ4ኪሎ/ካዛ/22 | መገናኛ | 9.1 | 10 | 6 | 25 | | | | | 25 |
| | 16 | | በ4ሎ/ቀበና | መገናኛ | 7.9 | 10 | 4 | 61 | | | | | 61 |
| | 17 | | በ4ኪሎ/ካዛ/22 | ቴሌ | 9.3 | 10 | 6 | 13 | | | 4 | | 17 |
| 6 | 18 | ከስላሴ | በመገናኛ | ኮተቤ ኮሌጅ | 9.6 | 10 | 6 | 2 | | | 7 | | 9 |
| | 19 | | በመገናኛ | ኮተቤ ካራ | 11.8 | 12.5 | 6 | 12 | | | | | 12 |
| 7 | 20 | ከቱሪስት | በን/ማተሚያ | አምባሳደር | 2.4 | 2.5 | 4 | 1 | | | | | 1 |
| 8 | 21 | ከቸርችል | በሜክሲኮ | መካኒሳ | 8.7 | 10 | 6 | 5 | | | | | 5 |
| | 22 | | በአንባሳደር | ቦሌሚካኤል | 7.5 | 7.5 | 4 | 4 | | | | | 4 |
| | 23 | | በሜክሲኮ | ጎፋ መ/ኃይል | 9 | 10 | 6 | 7 | | | | | 7 |
| 9 | 24 | ከአቡነጴጥሮስ | በዊንጌት | አስኮ | 8.9 | 10 | 6 | | 42 | | | | 42 |
| 10 | 25 | ከአያሌው ሙ/ቤት | በሾላ | አዲሱ ገበያ | 3.3 | 5 | 4 | 6 | 37 | | | | 43 |
| | 26 | | በሾላ | ድልበር | 5.1 | 7.5 | 4 | 2 | | | | 3 | 5 |
| | 27 | | በሾላ | ቀጨኔ | 3.9 | 5 | 4 | | 12 | | | | 12 |
| 11 | 28 | ከጊዮርጊስ | በአቶቢ.ተራ | አጠናተራ | 5.0 | 5.0 | 4.0 | | 29 | | | | 29 |
| | 29 | | በሾላ | ቀጨኔ | 3.0 | 5.0 | 4.0 | | 22 | | | | 22 |
| | 30 | | በሾላ | አዲሱገበያ | 2.8 | 5.0 | 4.0 | | 12 | | | | 12 |
| | 31 | | በሾላ | ሰሚንማዘጋጃ | | | | | 5 | | | | 5 |
| | 32 | | በ6ኪሎ | ፈረ. ብረት. ድልድይ | 6.9 | 7.5 | 4 | 5 | | | | 6 | 11 |
| | 33 | | በአቶቢ.ተራ | ልኳንዳ | 5.7 | 7.5 | 4 | 2 | | | | 2 | 4 |
| | 34 | | በሰሜን ማዘጋጃ | ድል በር | 4.6 | 5 | 4 | | 5 | | | | 5 |
| 12 | 35 | ከፒየሳ ሸዋ ዳቦ | በአብነት/ጦር ኃ. | ካራቆሬ | 11.2 | 12.5 | 7 | 8 | | | | | 8 |
| | 36 | | በአብነት/ጦር ኃ. | አለምባንክ | 12.5 | 12.5 | 7 | 6 | | | 6 | | 12 |
| | 37 | | በአብነት/ጦር ኃ. | አየር ጤና | 8.9 | 10 | 6 | 1 | | | 9 | | 10 |
| 13 | 38 | ከፒየሳ | በአዲሲ ገበያ | ቶታል | | | | | 6 | | | | 6 |
| | 39 | | በመገናኛ | ኮተቤ | | | | | | | 6 | | 6 |
| | 40 | | ጎተራ | ቃሊቲ | 16.9 | 17.5 | 9.0 | 13 | | | | | 13 |
| | 41 | | በሜክሲኮ | ጀሞ | | | | | | | 6 | 2 | 8 |
| | 42 | | በመገናኛ | የካ አባዶ | | | | | | | | 2 | 2 |
| | 43 | | በአቶቢ.ተራ | 18ማዞርያ | | | | | 11 | | | | 11 |
| 14 | 44 | ከፒያሳ ማዘጋጃ | በአንባሳደር | ቦሌ | 8.8 | 10 | 6 | 42 | | | | 7 | 49 |
| | 45 | | በለገሃር | አደይ አበባ | 9.8 | 10 | 6 | 12 | | | | | 12 |
| | 46 | | በለገሃር | ሳሪስ አቦ | 9.9 | 10 | 6 | 11 | | | | 7 | 18 |
| 15 | 47 | ከፒያሳ አራዳ ህ. | በዊንጌት | አዲስ ሰፈር | 9.7 | 10 | 6 | | | | | | 0 |
| | 48 | | በዊንጌት | ሚኪሊላንድ | 8.2 | 10 | 6 | | | | 6 | | 6 |
| | 49 | | በዮሐንስ | መድኀኒያለም /ት/ቤት | 4.5 | 5 | 4 | | | | | | 0 |
| | 50 | | በዮሐንስ | ሸጎሌ መንደር 7 | 7.0 | 7.5 | 4 | | | | | | 0 |
| | 51 | | በጎጃም በረንዳ | ልኳንዳ | 4.7 | 5 | 4 | | | | | | 0 |
| | 52 | | በጎጃም በረንዳ | አጣና ተራ | 5.4 | 7.5 | 4 | 2 | | | | | 2 |
| | 53 | | በዊንጌት | ሳንሱሲ | | | | | | | 46 | 10 | 56 |
| **ድምር** | | | | | | | | 299 | 181 | 0 | 119 | 41 | 640 |