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Addis Ababa University

Addis Ababa Institute of Technology (AAiT)

School of Civil and Environmental Engineering

Post Graduate Studies in Geodesy and Geomatics Engineering

Performance assessment of road transport network and urban land use interaction: The case of Burayu Town using GIS and Remote sensing, Ethiopia

By Dereje Daba GSR/0856/11

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Submitted to the school of Civil and Environmental Engineering Graduate Studies of Addis Ababa Institute of Technology in Partial Fulfillment of the Requirement for the Degree Masters of Science in Geodesy and Geomatics Engineering

March 2022

Addis Ababa, Ethiopia

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

The undersigned have examined the thesis entitled "Performance assessment of road transport network and urban land use interaction: The case of Burayu Town using GIS and Remote sensing" presented by Dereje Daba, a candidate for the degree of Master of Science in Geodesy and Geomatics and hereby certify that it is worthy of acceptance.

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This is to certify that this research work entitled "Performance assessment of road transport network and urban land use interaction: The case of Burayu Town using GIS and Remote sensing" is my work under the supervision of Dr. Belew Dagnew. This work has not been presented elsewhere for assessment. All relevant materials used in this research have been duly acknowledged.

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As Master research advisor, I hereby certify that I have read and evaluated this MSc thesis prepared under my guidance.

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Acknowledgments

First and foremost I would like to thank GOD, the almighty, for endowing me the endurance and courage of going through all ups and downs to reach the stage where I am now. I would like to express my deepest gratitude to my Major advisor Dr. Belew Dagnew for his inspiration and scholarly guidance throughout the different stages of this project. His advice and criticism have shaped the structure of this project. I would like also to thank Mr. Wako Kumela (M.Sc.), for his support in reading by taking the time from his busy schedule and giving valuable comments for the successful completion of the project.

I would also like to extend my deepest gratitude to different organizations mainly, to the Burayu Town land-use management, Burayu Town municipality, and Burayu Town road and transport bureau, especially to the staff of the organizations for their cooperation in providing me the necessary data for my research.

Lastly, I would like to express my deepest appreciation to my family, friends, and to all the participants who directly or indirectly participated and have willingly shared their precious time and valuable support in completing this research.

Abstract

This research modeled the transport system to estimate the land use transport interaction to ultimately determine the level of infrastructure that is required to support the economic activity in the study area. To investigate the assessment of road transport network and urban land use interaction, the research employed GIS techniques and Remote Sensing for the cross-sectional efficiency of the system. The objectives of this study have to provide information on urban land use patterns, assess potential travel demand, and identify which network-based indicators can be used to identify inadequate infrastructure. Types of data i.e. data obtained through methods such as socio-economic data, land use map, current road network, and satellites data. The result of this project indicated that road density, higher trip production, and attraction are exhibited in the central areas (characterized by high population and important socioeconomic activities of the Town including jobs, service centers, and schools). Residential proximity to the roads within the central areas is 500m, allowing more people to access these roads. However, in the periphery, people have to travel more than 1km to access the existing road infrastructure, indicating the inadequacy of the system. For this study using the supervised classification method, Maximum likely hood algorithm, the overall accuracy of classified Burayu Town land use for 1990, 2000, 2010, and 2021 is 89.33%, 91.66%, 93%, and 97.33 respectively and it is acceptable. Burayu Town land-use land-cover classes changes from (1990-2021) are: Settlement area is increased by 4668.68ha (51.61%), the road is increased by 406.52ha (4.26%), forestland is decreased by 1668.48ha (18.47%), agriculture land is decreased by 904.93ha (9.72%), shrub land is decreased by 2501.71ha (27.68%), and water body is neither increased nor decreased.

Keywords: *land-use, Burayu Town, Proximity, Trip production, and Trip Attraction*

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List of Abbreviations

ATIS	Advanced Traveler Information Systems
ATMs	Advanced Traffic Management Systems
CAD	Computer-Aided Design
CBD	Central Business District
CSA	Central Statistics Agency
DSS	Decision Support Systems
ERA	Ethiopian Road Authority
ESRI	Environmental Systems Research Institute
FSUTM	Four Steps Urban Transport Model
GIS	Geographic Information System
GPS	Geographic Positioning System
LULC	Land Use and Land Cover
SMI	Spatial Mismatch Index
OD	Origin-Destination
ODM	Origin Destination Matrix
SPSS	Statistical Package for Social Sciences
TAZ	Traffic Analysis Zone
WGS	World Geodetic System

CHAPTER ONE

1. INTRODUCTION

1.1 Background of the study

The transportation system is the basic part of human day-to-day activities by providing the efficient and safe movement of freight and passenger from one place to another. It is important for any nation's development and plays a significant role by facilitating trade, commerce, and social interaction while consuming a considerable portion of time and resources. Any city's economic success and urban growth are dependent on its transportation system. Transportation planning coming up may be a complicated method involving the careful study of current travel arrangements in cities and forecasting future needs (Brömmelstroet et al, 2017).

With the ever-increasing level of urbanization, the problem of developing an associate economic strategy for urban transportation has been thought-about in varied scientific and technical works, particularly within the context of developing countries. Several researchers agree that major changes in transport network structure affect the pattern of urban development and the location of social and economic activities in home and employment centers. On the other hand, a major change in land use influences the trip, making the behavior of people, destination, and mode is chosen (Ayalneh, 2012). The network structure also affects the accessibility and destination choices of travelers. The land use-transport relationship is highly coupled in developing cities where the road network is the major means of transportation (Tesfahun, 2014).

Land-use investigation incorporates diverse spatial scopes like urban at the level Towns, local at the level of a municipality, regional at the level of districts, national at the level of countries, and even that is observed about land use and transport interaction. The land-uses type such as industrial, residential, commercial, or free land on the urban area shows the situations of human activities such as working, living, education, shopping or leisure, and human activities requires connections or transportation services that lead to trips in the traffic system crossing places between the locations of activities (Rodrigue, 2019).

The urban road network plays a key role in the urban spatial structure. It is the main city's social-economic activities and transportation carrier. More researchers are focusing on the road network these days, and one of the most pressing issues is determining how to measure the accessibility of road networks. Accessibility in this context is easy to reach certain destinations from a particular origin using a transport network. Geographic information systems can be used for a better understanding of accessibility and also be used in the automatic identification of missing infrastructure in existing network structures (Ayalneh, 2012). When planning to construct transport infrastructure, study and analysis of the land-use of the area appear to be a pillar concern. Transport influences the amount of land available for development and the spatial distribution of economic activity. It is feasible to make urban regions more efficient by connecting transportation and land use, allowing for the development of denser and more productive economies. Transportation infrastructure determines how many people can get to a location using a given amount of space and set infrastructure, with some modes of transportation capable of delivering greater benefits more efficiently (Banister and Hickman, 2006).

Ethiopia has a number of the foremost dangerous roads within the world associated has pursued a formidable road enlargement policy within the past 10 years. The Ethiopian national road safety coordination workplace sites a road crash death rate of 10,000 deaths per year (WHO, 2019). In Burayu Town, because of the rapid economic growth and transformation, there is a high quality of products and people leading to high transportation demand.

It is worth noting that no assessment of the performance of road transport networks and urban land use interactions in the Burayu Town study area was conducted, which has a direct impact on the public transportation system. Therefore, the study has been focused on modeling of urban land-use and road network interactions of Burayu Town by determining the trip generation by analyzing the travel behavior at the household level regarding trip purpose, distributing the generated trip into each traffic analysis zone. Even though no transport network can serve all travel demands perfectly, the amount by which it fails to do so can be useful to study existing networks and identify areas with the inadequacy of infrastructure (Lyons and Davidson, 2016).

1.2 Statement of the problem

The transport sector is the backbone of economic development and the road network remains the basic and critical component of the transport system in the country. In recent years, Burayu Town is one of the fastest-growing Towns regarding population size as well as building infrastructure. A large part of this rapid growth of population has been due to both natural increase and high level of immigration from a rural area to an urban area (Shiferaw, 2017). Due to this reason, there is a fast growth of public transport users to travel from other places to home or from home to other places within the Town to achieve their own needs or activities. Burayu Town also facing a great rate of urban land-use change due to urban development activities and private sectors mostly constructions of industrial, residential, and other developmental activities such as the construction of roads. There is the high mobility of the passenger and goods, which leads to high transportation demand. However, the existing transportation system is characterized by high traffic congestion, unsafe public transportation, negative environmental impacts, and low accessibility level. Because of these issues, the road network of Burayu Town is poor and inadequate road infrastructure, public transport network, poor interaction between land use and transport planning, and low transport network density. The existing road network of Burayu is currently faced with bad conditions and a narrow route (Fantahun et al, 2012). The current public transportation demand is accommodated by using different means of transportation services. However, in Burayu Town, there is no properly affordable and efficient public transportation service. As a result special during the peak periods amount of waiting for passengers in the Town, taxi stations are left behind and this shows that there is insufficient availability of the transportation services in the Town resulting in more waiting time and hence delay from the planned time of activities, due to the absence of adequate properly structured policy to satisfy public transportation demand. To suit the expanding quantities of traveler requests, transportation administrations should be extended both in size and in quality. However, the current supply of transportation services is not proportional to the demand due to limited numbers of buses as well as routes. As stated by (Stead and Marshall, 2001) during peak hours, the demand extremely exceeds the supply of service. The waiting time to get transportation service is high and passengers struggle hard to get the services.

In Addis Ababa, there is little research conducted with regard to the whole transportation system. For example, (Ayalneh, 2012) tried to evaluate the whole status of the transport network structure of Addis Ababa. In the study trip, attraction and production are computed for each TAZ using the regression model (Trans-CAD) based on household survey and depending on trip purpose. (Tesfahun, 2014) spatial investigation and modeling of the road network structure of Addis Ababa by using Trans CAD. (Tsegaye, 2020) evaluation of urban land use characteristics and transportation system using statistical analysis model /category analysis. According to (Minalu, 2014) researchers have conducted studies on the performance evaluation of the Addis Ababa city road network. In the examination, there were a few investigations about the assessment of the street arrange execution utilizing markers for suburban communities/organizes in Addis Ababa. Furthermore, some studies used nearly the same criteria and approach. However, their methodologies have a gap of focusing on the current road transport networks and urban land use Interaction and not effectively using GIS instruments for the analysis part. Overall, no investigations led about how to analyze urban public transportation demands in the study area to indicate its major problem and their remedial action to alleviate the indicated problems. Generally, there is no study carried out previously in this area concerning study the urban land use patterns, assessing potential travel demand and identifying inadequate infrastructure, evaluating road network performance using indicators, and developing a map that shows the network analysis, as well as recommendations for policymakers to improve performance of road network and to find better other options and methods of getting things done. This exploration was expected to fill this gap. Therefore, this study will fill the gap and try to approve performance assessment of existing road transportation network and land use transport interaction characteristics by using GIS and remote sensing by thinking about the sustainable development of the Town.

1.3 Objectives of the study

1.3.1 General objective

The main objective of this study is to assess the performance of road transport networks and urban land-use interaction in Burayu Town using GIS and Remote Sensing.

1.3.2 Specific objectives

Based on the above general objective the specific objectives are formulated as follows:

1) To analyze the urban land-use patterns in the Town.
2) To assess potential travel demand in the study area.

3) To explore which network-based indicators can be used to identify inadequate road infrastructure.
4) To assess trends of road network performance in the study area.
5) To develop a map that shows the network analysis.

1.4 Research questions

Based on the specific objectives identified, the following questions are forwarded.

1) What are the nature and a characteristic of urban land-use patterns in Burayu Town?
2) What is the potential travel demand in the study area?
3) What models can be used for the estimation of travel demand in an urban area?
4) How can inadequate infrastructure in the existing road transportation network identify?
5) How is the trend of road network performance in the study area?
6) What special techniques are needed to develop a map that shows the network analysis?

1.5. Significance of the study

Transport modeling and modeling accurate, timely, and cost-effective urban land-use and land-cover changes of the years 1990, 2000, 2010, and 2021 is highly required to Burayu Town urban planners and land administration management office. modeling transport and urban land-use and land-cover changes are highly required to Burayu Town for conflict resolution related to transport, for better land-use management and environmental development, for monitoring the negative consequences and increase the benefits, and for estimating the effect of traffic congestion, loss of agricultural land, and urbanization of the Town. Generally, the research has the following advantages for Burayu Town transport management and urban planners: It provides valuable information on change of urban land-use patterns and their associated relationship with the transportation system in the study area. The research to know existing transportation demands and infrastructural service requirements based on the current situations of the study area by using different engineering techniques. Performance assessment of existing road transportation in Burayu Town is not studied until now and the result of this research will be important for designing and improving the performance of road transportation in the future for the Town.

1.6 Scope of the study

This study spatially focuses on Burayu Town, which is located in the Oromiya regional state around the central part of Ethiopia. It is about 15 km from Addis Ababa. Thematically, the study focuses on the performance of road transport networks and urban land-use Interaction in Burayu Town using GIS and remote sensing. This research conducted urban land-use land-cover changes of Burayu Town for the last three decades (1990-2021) using Remote sensing, and GIS. The total area of Burayu Town is 90.57 km^2 with a total road network length of 570 km including all types of roads.

1.7 Limitation of the study

The drawback of this study is mainly the availability of data, which is mostly city is not subdivided into smaller zones; this may cause some uncertainty in the actual demographic and socio-economic data. The study of urban land-use changes using medium resolution Landsat is used and the overall accuracy for classified images are above 85%, in my assumption using high spatial resolution satellite image such as IKONOS, Quick bird, and SPOT will provide better and more detailed information with good quality to map land-use land-cover classes and overall accuracy may greater than the value obtained.

1.8 Organization of the thesis

The overall project is organized under five chapters as follows: introduction, literature review, materials and methods, results and discussion, and conclusion and recommendations. Chapter one gives a brief introduction of the research and identification of research problems define research objectives, research question, the significance of the study, the scope of the study, and organization of the study. Chapter two briefly reviews literature, which defines and describes the theoretical concept of performance assessment of road transport network and urban land use interaction, briefly reviews the literature on travel demand modeling, a criterion that is used to performance measures for the road network, and findings of other relevant studies are discussed. Chapter three briefly describes the study area based on its topography, demography, socioeconomic characteristics, land use, and methods of analysis applied, describes data collection methods, data and software types used by this project, and has a methodology part. Chapter four explains the result and discussion part of transport modeling and investigation of the current network. Furthermore, results of land use pattern and urban expansion of the town. Chapter five conclusions and recommendations are made based on the results of the project.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Introduction

This section tries to review literature related to the performance assessment of existing transportation scenarios and interaction of urban land-use characteristics GIS techniques and Remote sensing theoretically as well as a conceptual framework. The main factor that affects urban settlement is the transportation network. The settlement of people or urban may be depending on the availability of transport infrastructure and transport infrastructure may be constructed where demand is at the most. The primary factor that influences urban settlement is the transportation network. The settlement of individuals or urban might be contingent upon the accessibility of transport foundation and transport framework might be built where the request is and no more.

2.2 Theoretical framework

2.2.1 The concepts of urban land-use study and planning

The term land-use refers to land-cover types planned to use and managed by human beings such as agriculture, infrastructure, and forestry. However, land-cover is biophysical cover found above the earth's surface, including distribution of vegetation, bare soil, water, and artificial structures (Tsegaye, 2020). According to (Herold et al, 2006) land-use is defined as the arrangement, activities, and inputs taking place by a human being in a specific land cover type to maintain the land-cover and produce goods. land-use and land-cover change means conversion and modification of one land-use land-cover type to another land-use land-cover by changing the physical, functional attribute land-use land-cover for example green area converted to residential, forest converted to buildings. Land use is determined by human activities on lands.

According to Goibov et al. (2012) defined land-use by two interrelated phenomena land-cover and land utilization. Land-cover describes each the natural and human-altered land surface wherever human actions present themselves, whereas human actions confirm land utilization. Each phenomenon is necessary for land-use designing because, on the one hand, human actions are limited by the land-cover settings and on the other hand, human activities alter the land-cover (Hofe, 2019). It is acknowledged that transportation networks influence land use and the other way around. Land-use is the concept of distribution of activities. This distribution generates traffic, for peoples move from one activity to a different. In the long run, changes in transportation have an impact on land use: Residents gradually tend to shift to more accessible sites due to changes in accessibility. Increased density tends to slow traffic, increase congestion, and restrict parking supply, making driving less appealing in comparison to other forms of transportation (Herold et al, 2006).

Land-use planning can play an important role in sustainable development as well as for sustainable urban development. A basic proponent for land-use planning is to classify land based on proposed and existing human activities. Growing urbanization necessitates the growth of urban areas while also altering existing land-use patterns within the city. Land-use planning is a useful tool for managing potential changes and protecting the land from incompatible changes in order to achieve such changes in a sustainable manner. land-use land-cover change is influenced by the different factor that is directly or indirectly related to human population growth, economic development, technology, and environmental changes (Goibov et al, 2012).

2.2.2 Interaction of land-use and transportation

Because transportation in cities is so complicated, the urban transportation system is inextricably related to the city's form and spatial organization. The core idea of transportation analysis and forecasting is the spatial separation of human activities, which causes the need for travel and products transportation. It is feasible to build urban regions more efficiently by combining transportation and land use, allowing for the development of denser, more productive economies. Transportation also can affect the health and wellbeing of the population, in terms of air quality, safety, and levels of participation in work and training, and social interaction (Higgins et al., 2021). Urban form is both shaped by transportation and determines travel patterns, with the efficiency and price of transportation systems determining how urban areas develop. The interaction between transportation and wider areas of designing policy, like housing, shapes the transportation options that are hospitable to us and the way we travel. Understanding this relationship is significant for urban function as not all sorts of transport are equal, with some enabling more productive urban economies that are better for the environment and protect the quality of life (Higgins et al, 2021).

2.2.3 Land-use and land-cover change

Land-use and land-cover change can be defined as the modification of surface features on the earth's landscape which is realized by the difference in their surface appearance assessed at two different times (Pontius, 2019). In most cases, the terms land-use and land-cover are used interchangeably. Land-cover describes the physical material at the surface of the earth. It comprises various land-cover types such as trees, bare soil, grass, water, etc. Land-use, on the other hand, is a description of how people use the land for socioeconomic activity, such as urban land, agricultural land, forest land, river land, pasture land, and so on (Pontius, 2019).

2.2.4 Urbanization and classification of urban areas

Urbanization and urban growth have accelerated worldwide. Within two decades, the population of cities has doubled or even tripled. At the beginning of the nineteenth century, only about 3 percent of the world's population lived in urban places (Herold et al, 2006). The expansion of urban sprawl is mainly caused by the high rate of population growth, the accompanying loss of agricultural lands, forests, and wetlands, escalating infrastructure cost, increases in traffic congestion (Lencho, 2019). Rapid urbanization without economic growth, an increase in slums, and the lack of basic criteria amenities leading to adverse living conditions and rapid urbanization call for decisive and effective planning, policies, and large-scale investments. One of the major impacts of urban land-cover change is diminished in surrounding forest and agricultural land. It is also likely that large amounts of valuable agricultural or irrigated lands are converted to non-agricultural areas (e.g. built-up areas). Urban land-cover change is a very important phenomenon, which characterizes the nature of the cities and their surrounding areas

2.2.5 Forms of urban expansion

Urban expansion takes place in different forms. The two major forms of urban expansion are:

a. Positive effects (orderly) form of urban expansion properly laid such as the center of the market area, center for production and distribution of goods and services, an opportunity for access to employment, economic development, full facilities, and technology development.

b. Negative effects Loss of prime agricultural acreage, displacement of farm communities, solid waste disposal, and soil degradation, confining neighboring rural areas to urban territory, overexploitation of natural resources, and conflict are all examples of (unorderly) urban expansion. The rapid rate of population growth, as well as the loss of agricultural lands, woods, and wetlands, rising infrastructure costs, increased traffic congestion, and deteriorated habitats, all contribute to the expansion of urban sprawl (Litman, 2016).

2.2.6 Road transportation network and GIS

The movement of commodities and people from one location to another is referred to as transportation. Transport is performed by different modes, such as rail, street, air, pipeline, water, and space. Roads are the remaining supply routes of present-day society's framework, contributing vigorously to the dissemination of people and products. GIS gives many accommodating applications to guarantee a smooth flow, by aiding design, traffic control, routing, and real-time. GIS is a significant tool in the process of planning and designing roads. It is utilized to communicate and visualize the effects of roads on their environment. By social events, significant information for the entire system, fixes, and works planning would be progressively solid and can be determined ahead of time. First creating the best route between locations by using GIS to choose how and where to sign, improved directions and movements in the road network, and helped in avoiding traffic congestion (Kumar et al, 2017).

2.2.7 Network analysis

The main important aspect of the spatial arrangement of lines is their ability to form networks. The network system is an arrangement of the directly connected feature. Networks occur in many forms and are both natural (streams and river) and anthropogenic (transportation networks such as rail lines and communication networks such as telephone lines (Rodrigue, 2019). The most common application of network analysis in GIS is to find solutions to transportation problems. When it comes to transportation, using GIS brings up a world of possibilities as diverse as the field of transportation itself. Whether these are trucks and cars, street trains on a track, ships over the sea, or airplanes in the sky, all applications make them think the same way: they are objects that move away in space. A GIS allows the administrative body to observe the situation and plan as needed, and GIS can be a useful tool for dealing with these problems in a geographically referenced setting, such as observing the routes as transportation organizes (Sotoudehnia et al, 2009).

2.2.8 Modeling transport network

Transport demand modeling helped us to understand the travel demand, which itself provides an understanding of the relationship between urban structure and transportation (Esztergár-Kiss et al., 2020). Transports modeling is utilized to comprehend the movement design and gives a comprehension of the connections between the transport plane and the urban structure (Ayalneh, 2012). Travel requests occur at the space and at a specific time. To catch the time-based and spatial nature of movement request the flexible side of the street foundation can be spoken to by organizing. A network model can be categorized as a line diagram, which is made obtainable of connections representing straight channels of flows and nodes representing their associations (Lupien et al, 2007). As it were, a network appears as edges or bends associating sets of nodes or vertices. Nodes can be junctions and edges can be portions of a street or a pipeline. For a network to act as a certifiable model, an edge should be related with a bearing and with a proportion of impedance, deciding the opposition or travel cost along with the system. The transportation system is a combination of supply and demand. Travel demand is created by the need of people to join the activity. It relies upon the land use characteristics, accessibility of zones, and socio-economic activity of the people. Trips made also differ depending on the time at which the trip is made, the purpose of the trip, socio-economic activity like income, car ownership, household size, and the mode choice. Supply includes transport networks, services, and infrastructure (Liu and Zhu, 2004).

2.2.9 Performance measurement

The science and art of performance measurement have sparked a surge of interest in the last two decades, owing to its relevance to road transportation systems (Helali and Ayed, 2012). The purpose of road transport services is to make road transport safe and secure, fast, environmentally friendly, alleviation and cost-effective, integrated with different modes, accessible by all aid true distribution and land region, development and stability to drive vehicles, to the motor, and to support national development at a low cost to the community. Analysis of the road networks' performance (such as Indonesia, Canada, Turkey) A performance evaluation is required that takes into account safety, efficiency, effectiveness, accessibility, distribution, affordability, and compatibility with other modes of transportation (Helali and Ayed, 2012). Several indicators, such as road availability, road performance, and road serviceability, will be used to analyze and express the performance of the road network. The research examines the availability/road density, road serviceability, traffic load, road safety, and road connectivity using the following selected road network performance indicators(Wells and Raad, 1999).

2.3. Traffic analysis zone

The most prevalent unit of geography in traditional transportation planning models is the traffic analysis zone. Urban transport modeling depends on traffic analysis zones as its basic unit of analysis (Nedović-Budić and Kim, 2008). The centered traffic analysis zone is used to represent trip origins and destinations. Every shopping center, employment center, household, and other activities of the planning region are aggregated into zones and are further simplified into single nodes assuming they are concentrated at the center. Although there are no technological reasons why zones can't be as small as single buildings, adding more zones increases the computing load. By dividing the study, area into traffic analysis zones, distinct study areas can be created for tabulating trip-related data based on the study's specific characteristics. Traffic analysis zone boundaries are usually major roadways, and geographic boundaries are defined by homogeneous land uses to the extent possible. The traffic analysis zone structure in a sub-area of particular interest may be denser than in other areas further away. In general, there is a direct relationship between the size and number of zones and the level of detail of the analysis being performed using the model; greater detail requires a larger number of zones where each zone covers a relatively small land area (Nedović-Budić and Kim, 2008).

2.4 Network evaluation indicator

Evaluating rules set depending upon the goal of improvement of every city. Indicators and measures may vary essentially relying upon a few factors, for example, local transportation vision, city type, and travel conduct (Ayalneh, 2012).

2.4.1 Mobility

Transport networks are intended to move goods and people to where they want to go quickly and inexpensively (Zhu et al, 2006). The movement of goods and people is affected by the safety of travel and the cost. Mobility is the capacity to move goods and people. In developing countries with inadequate road infrastructure like environmental quality, ratability, safety, and cost of travel are the main factor affecting mobility. Mobility can be influenced by the condition and network structure. The network structure is used to determine how fast the vehicles can travel. Mobility can indicate the quality of movement of people and goods and also the quality of moving from one location to another location (Porter, 2008).

2.4.2 Equity

Equity refers to the distribution of resources and if the distribution is considered appropriate. In the case of transport, equity is a different concept and the way to analyze may be difficult due to various ways to measure recourse, the number of recourses to consider, and to categorize people. Equity in transport can be divided into two types (van Wee et al, 2013)

A) Horizontal equity: it emphasizes the distribution of recourse between the group and individual with comparable ability and needs. Equity groups and individuals could share equal pay costs, share equal resources, and must be treated in the same way.

B) Vertical equity: is concerned with the delivery of resources between groups and individuals that vary in need and ability. From this idea, transport networks are equity if they favor economically and socially disadvantaged groups.

Planning road network it is very valuable that the road network is suitability development for all zones, to promote social development and economic development. The main concern in the assessment or evaluation of new road projects is generally the economic viability (van Wee et al, 2013)

2.4.3 Accessibility

Availability is one of the primary thoughts in transportation and is used to show the relationship between land uses and transport (Liu and Zhu, 2004). One of the reasons for the transportation framework is to develop access to offices and portability. The most significant part of movement request displaying is land used. The action centers like the mall, school, social and regulatory focuses, and others are spatially spread by the land use advancement plan of the city under examination. Land employments of various kinds need an extraordinary class of streets to rely upon the sum and sort of traffic it potentially pulls in or creates.

2.4.4 Spatial mismatch

It has been used by different authors to detect the availability of jobs for the low-income group within their reach depending on the cost of travel (Åslund et al, 2010) and to analyze transport mode chosen and ethnic groups (Åslund et al, 2010). Considering the jobs as supply and employees as demand, this concept is used to analyze the spatial difference that exists between demand and supply. This indicator compares trip distribution among traffic analysis zones considering the resistance (impedance) travelers experience by using the existing real network and that experienced in the direct route or Euclidean distance between two zones (Ayalneh, 2012). Trips equation:-

Tij = TijED/ TijND Spatial mismatch index 1

Tij = TijED - TijND Spatial mismatch index 2

2.4.5 Transportation infrastructure availability

The essential factor affecting the performance of the transport network is the availability of adequate transport infrastructure. Transport infrastructures include: road width, road length, public centers, and similar road furniture and this entire factor affects the accessibility of the transportation system. Especially road length per unit population and road length per area indicate the accessibility of the road network (Hsu and Chang, 2013).

2.5 Types of travel demand models

There are a variety of travel demand modeling techniques employed in transportation planning. Strategic planning, sketch planning, Travel demand modeling techniques are very common (Hsu and Chang, 2013).

2.5.1 Strategic planning models

Strategic-planning models are often narrow in scope but incorporate significant detail in specific areas of analysis. These models often are used when there is a desire to analyze many scenarios quickly and implement using basic software and hardware tools; these models are less expensive to develop and apply may not provide detailed output information. Strategic-planning models are useful for testing a wide range of large-scale policy and investment alternatives but may be less appropriate for analyzing detailed project alternatives large-scale longer-term policy and investment decision making (Tsitsi and Moyo, 2019)

2.5.2 Sketch planning models

The sketch-planning models are designed to produce rough estimates of travel demand where order-of-magnitude information is all that is required. These models are typically simple and easy to implement, require less data, and often are implemented using common desktop software tools such as spreadsheets and Trans CAD (Ortúzar and Willumsen, 2011). However, although these tools are less expensive to develop and apply, they may not provide the level of detail required to analyze certain types of policy and investments decisions, and may not provide detailed output information. As a result, sketch-planning models may be appropriate for specifically targeted analyses, but cannot inform large-scale longer-term policy and investment decision-making (Ortúzar and Willumsen, 2011).

2.5.3 Travel demand modeling

Trip-based travel models have evolved over many decades ago. As their name suggests, trip-based models use the person trip as the fundamental unit of analysis. Trip-based models are widely used in practice to support regional, sub-regional, and project-level transportation analysis and decision making (Ortúzar and Willumsen, 2011). These models are typically simple and easy to implement, and often are implemented using common desktop software tools such as Trans CAD and geographic information systems. Depending on the scope of the study area, daily transport demand profiles, and peak periods is common training to model demand periods that are longer than the peak hour to capture the full demand associated with peak periods. The modeler will be utilized to describe the periods for which demand will be forecast and analyzed. Travel demand modeling is used in the decision-making process in transportation (Harrington et al., 2016). It supports the organizer and designers to expand better utilize current system limit, street arranges, comprehend unique effects (Tsitsi and Moyo, 2019). Demand is resolved from the requirement for the movement of individuals. People will be travel to reach different activities from their place of residence to their jobs, school, and shopping area. The four steps of the Urban Transport Travel Demand model are:

- Trip Generation
- Trip distribution
- Modal split
- Assignment

2.5.3.1 Trip generation

Trip generation is the initial step of four-step travel demand modeling and its goal is to acquire the number of trips/traffic generated (Oi) and attracted (Dj) from each TAZ within the study area (Hensher and Button, 2000). Trip generation is intended to address the question of how many trips of each type begin in each location with corresponding to the places where different activities occur according to socioeconomic data and land use (Ortúzar and Willumsen, 2011). Attractions and productions square measure calculable for every TAZ by trip purpose then balanced at the regional level so that total productions and attractions are equal. The ensuing productions and attractions by trip purpose and TAZ are subsequently utilized by the Trip distribution model to estimate zone-to-zone travel patterns. It is expected that all the trips originate in a certain transport zone, will show up in one of the zones within the investigation region.

2.5.3.2 Trip distribution

Trip distribution is the second step performed modeling. The trip distribution uses the TAZ productions and attractions output from trip generation and assigns each production to a destination and each attraction to an origin for all possible zones in the study area. In trip distribution, these two known sets of the trip end square measure connected along, while not specifying the particular route and typically while not relevancy travel mode, to create a visit matrix between origins and destinations Trip distribution requires informative factors that are identified with the cost (including time) of movement between zones, just as the measure of excursion making action in both the starting point zone and the objective zone (Hensher and Button, 2000).

Gravity model: Given an input matrix of zone-to-zone impedances and balanced trips of productions and attractions, the Gravity models estimate flows between all zones. Frequently used measures of impedance are travel time, travel distance, or cost. In our case, the impedance matrix is calculated as the shortest travel distance between all zones in the study area, (Hua and Porell, 2008). This model is mostly used when base year OD is not provided or important changes take place in the land use and road network. The model is mainly based on Newton’s Gravity Low and assumes trip-making behavior is influenced by external factors like total trip ends and distance traveled (Ortúzar and Willumsen, 2011). After many experiments and research, it was concluded that the effect of distance on trip making could be modeled better by decreasing function with the following equation.

$$\mathrm{Tij} = \mathrm{Pi}\,\frac{\mathrm{AjFijKij}}{(\sum \mathrm{AjFijKij})} \qquad (2.1)$$

where P_i and A_j are the numbers of the total trip ends in zone i and j respectively. F (ij) is the deterrence function or impedance function. This function decreases as travel cost or distance (time) increases.

2.5.3.3 Modal split

The modal split analysis is the third step in the conventional four-step transportation-forecasting model. The primary goal of mode choice analysis is to identify the travel mode that travelers utilize when traveling from one site to another. Travel between a specific origin zone and a specific destination zone is the choice in the travel demand model. Consequently, the trips that are distributed from every origin zone to every destination zone within the trip distribution model square measure more split into distinct travel modes. The input to the mode choice model is the total travel demand between each Origin-Destination pair and the commonly used approach to distributing the total travel demand for a given O-D pair over the available modes (Ortúzar and Willumsen, 2011).

2.5.3.4 Trip assignment

The way toward allocating a given arrangement of trips to the predefined transportation system is referred to as traffic assignment. The fundamental aim of the traffic assignment process is to show an example of vehicular developments (movements) in the transportation system. Therefore, the major aim of traffic assignment is to estimate the volume of traffic on the total distance covered by the vehicle, total system travel time, links of the network, to estimate travel costs, zone-to-zone travel costs (times), and to identify heavily congested links (Ortúzar and Willumsen, 2011).

2.6 Empirical reviews

2.6.1 Performance measurement

The goal of performance evaluation is to improve customer transportation services. Two essential emphases are contained within that short statement: the first is about enhancing services, and the second is about customers. (Wells and Raad, 1999).

2.6.2 Performance evaluation indicators were used for urban road networks

2.6.2.1 Evaluation of road network performance in Indonesia cities

An investigation was made in Indonesia to survey the street organization. In this examination, there is a dissimilarity of advancement accomplishment in the East Region of Indonesia, which has been abandoned from the Western Region. To arrive at a more ideal government assistance advancement upheld by Superior Street, a decent act of reasonable assessment is required. From 1999 to 2002, the study assesses the effectiveness of the road network in twelve provinces in Sumatra, Kalimantan, and the archipelago islands. Four indicators were employed in the study: road availability, road performance, road services, and traffic load. (Santosa, 2005). Every road indicator has a substantial difference between places, and the road index is simply an average of the four indicators in each province and year. The result reveals that each island has a distinct pattern of outputs (road index) and results (Gross Regional Domestic Product, GRDP). As expected, regions with better option implementation records produce higher output and outcomes. However, the analysis shows that some provinces with high road indices produce either low output or low outcomes (Minalu, 2014).

2.6.2.2 Performance measures for road networks: A case of Canadian cities

In Canada, most regions and regions utilize some sort of performance measures to evaluate their road networks. However, the methods of implementation and the types of performance indicators employed by different jurisdictions differ greatly. The project's main goal was to conduct a study of Canadian provincial and territorial governments on current methods for road network performance. The results of a survey on agency usage of performance indicators linked to six outcomes are documented in this report: mobility/accessibility, safety, cost-effectiveness, sustainability, environmental quality, reliability, and transportation system preservation. (Montufar, 2020).

2.6.2.3 Performance measures for road networks: A case of Ethiopian

In Ethiopia, for different Towns, researchers have conducted studies on the performance of evaluation road networks using remote sensing and GIS. Several researchers have conducted studies on the performance of evaluation road networks using GIS for Addis Ababa (Ayalneh, 2012; Minalu, 2014; Tesfahun, 2014; Tsegaye, 2020).

In the study area, there was no study carried out previously in this area concerning study the urban land-use patterns, assessing potential travel demand and current network, identifying inadequate infrastructure, evaluating road network performance using indicators, and developing a map that shows the network analysis, as well as recommendations for policymakers to improve performance of road network and to find better other options and methods of getting things done. All researchers in their study focused on evaluating transportation network structure by using Trans CAD and SPSS. In the analysis, there were a few investigations about a current network, identifying potential travel demand, and assessing the socio-economic impact of road traffic congestion by using SPSS. Furthermore, some studies used nearly the same criteria and approach. To assess road network performances primary consideration should be given to key issues and potential concerning road availability/road density, road serviceability, traffic load, road safety, and road connectivity.

The transportation facilities, industrialization, and infrastructure development of Burayu Town are seeing a quick change in the ongoing recent past and are expected to continue at a faster rate. These developments position a big challenge to the city administration to manage its facilities, especially in the transportation system. Using the following selected road network performance indicators, the research tries to check the performance of the road network. Selected performance indicators are road performance, road availability/road density, and road serviceability.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1 Description of the study area

Burayu Town is located in the western fringe of Addis Ababa, along the Addis Ababa-Ambo road at about 15 km from the center of Addis Ababa (Piazza) and nearly 27 km east of Holota Town, the capital of Wilmera District. Geographically bounded by latitude $9^{\circ}02'00''- 9^{\circ}02'30''$ N and longitude $38^{\circ}03'30''-38^{\circ}\ 41'30''$ E covering a total area of 90.57 km^2 (Fig 3.1.). Burayu was established as one of the kebeles in 1972 under Zone of West Shawa, Walmara district. Burayu was called Burayu Town Administration in 1996 under the zone of West Shawa and Burayu Town with its zone and administration established in 2006. Burayu Town has six kebeles; Burayu keta, Laku Keta, Geferse Burayu, Geferse Guje, Geferse Nono, and Melka Geferse. Burayu Town is located West of Finfinnee Town, East of Kolobo Town, and South of Sululta Town.

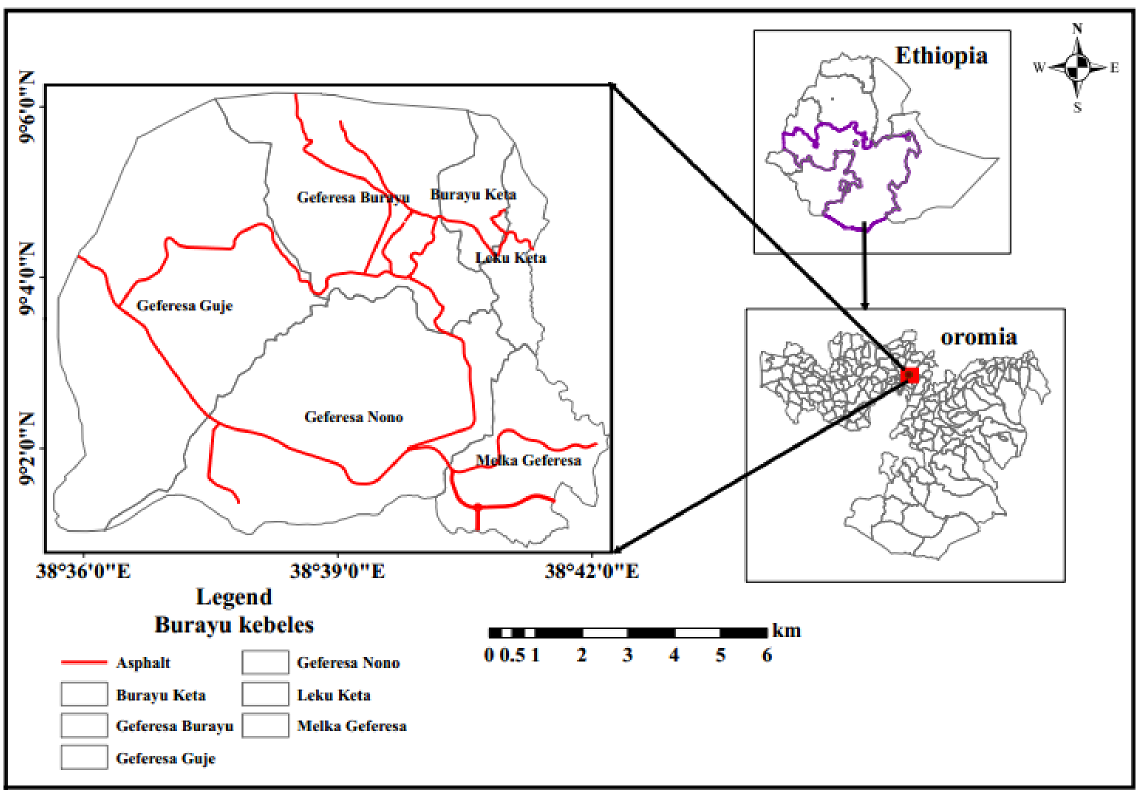

Fig 3.1 Location map of the study area

3.1.1 Geology

The present topographic setting of the world is the result of internal geologic processes (volcano-tectonic activity) external or surface processes like weathering and erosion by rivers or streams, and gully development. Burayu Town and its environments are made from volcanic rocks of the tertiary and quaternary ages. Localized recent alluvial deposits within the area are rarely observed and are only found along the Gafarsa stream above the junction with the seqo stream. Concerning volcanic rocks, basalts the thickness of which ranges from 0 to three meters are found exposed at many places within the study (Giovanni Merla, 2005).

3.1.2 Soil type

Soil development and therefore the nature of the soils within the area are mainly controlled by geology, topography, and hence drainage. In well-drained tableland areas, the predominant soil type is red and simply eroded. Whereas, in some areas like those found northwest of St Marry church and therefore the eastern tip of Tatek-Siga Meda, the soil is clayey. The occurrence of alluvial soils is extremely limited, which is merely found along narrow riverbanks or flood plains. The Town is specially covered with sepia salty clay soil (Thompson et al, 2012).

3.1.3 Population and socioeconomic characteristics of the study area

In a mobile society, social, economic status, and demographic characteristics are influential in the magnitude and pattern of their movement. Therefore, exploring people's demographic characteristics and socio-economic status helped to know the purpose of why peoples travel. Based on the 2007 census, the projected population of the Town in the year 2019 was estimated. Whereas as Burayu Town municipality counted it in the year 2018, the population size of the Town was around 375,349 in the (Table 3. 1.) Out of the total population of the Town, migrants constituted close to 65%. There were 59,171 housing units for households in Burayu Town; the ratio of the total number of households per 100 housing units becomes 1.0403. At the same period, the number of households who owned their residence is 11,376, and those who rent shared houses are 10, 855. The percentage of households with houses made of durable material is 14,633 in the Fig 3.2.

Table 3. 1 Burayu population by kebeles (Source: Burayu Town Municipality, 2021)

Kebeles	**Total Number of households**			**Total number of Population**			**Area**	
	Male	**Female**	**Total**	**Male**	**Female**	**Total**	**hectare**	**Density**
Laku Kata	6306	1604	7910	14847	17443	32290	285.25	11,290.21
Burayu kata	5476	878	6354	30285	26006	56291	1087.67	5,173.81
Gefersa	8609	3545	12154	50762	40552	91314	1391.175	6,550.50
Gefersa Guje	12453	2197	14650	48357	32685	81042	3170.87	2,544.49
Gefersa Nono	7385	3345	10730	34912	39846	74758	2215.54	3,358.40
Malka Gefersa	6329	1170	7499	19850	18804	39654	876.866	4,516.40
Total	46,558	12,375	59,297	199,013	176,336	375,349	9057.365	

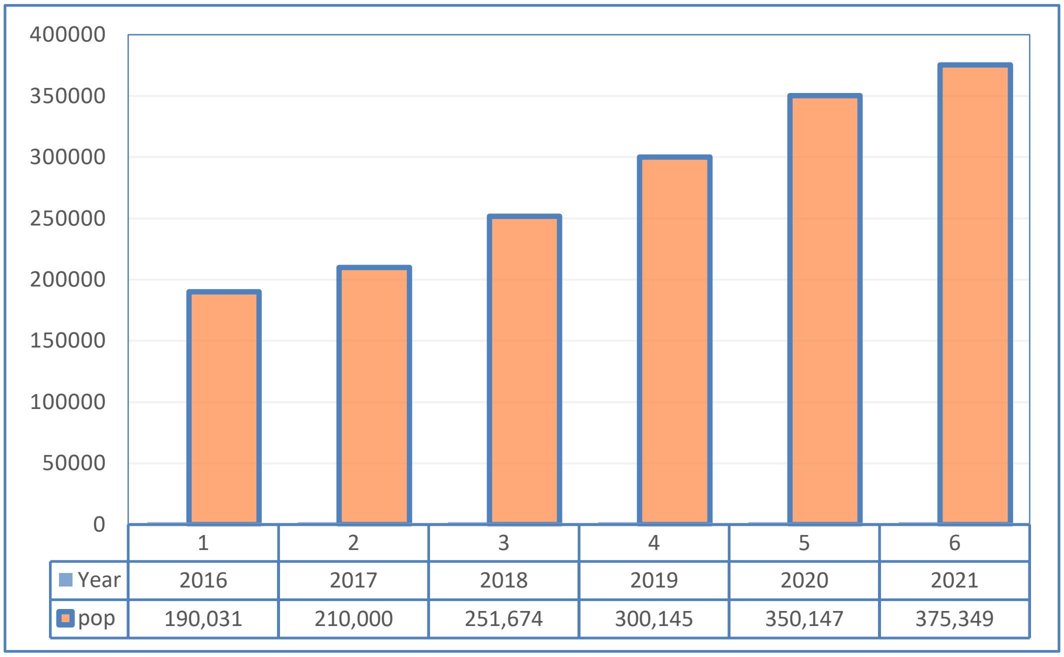

Fig 3.2 Population of Burayu Town

(Source: Burayu Town Municipality,2021)

3.1.4 Economy and income

The economic activities in Burayu Town are diverse. According to official statistics from the Burayu office, some people in the Town are engaged in trade, commerce, manufacturing, industry, and private producer of a different variety; in civil administration, in transport, communication, education, health, and social services in the hotel and agriculture. In Fig 3.3, The income levels are divided into three classes, high-income levels (>2500 birr), medium (between 1000 and 2500birr), and low-income groups (<1000 birr) per month (Micro Enterprises

Agency Office of Burayu Town, 2021). It can be observed that the central area has a higher population and the income level at these areas is medium to low.

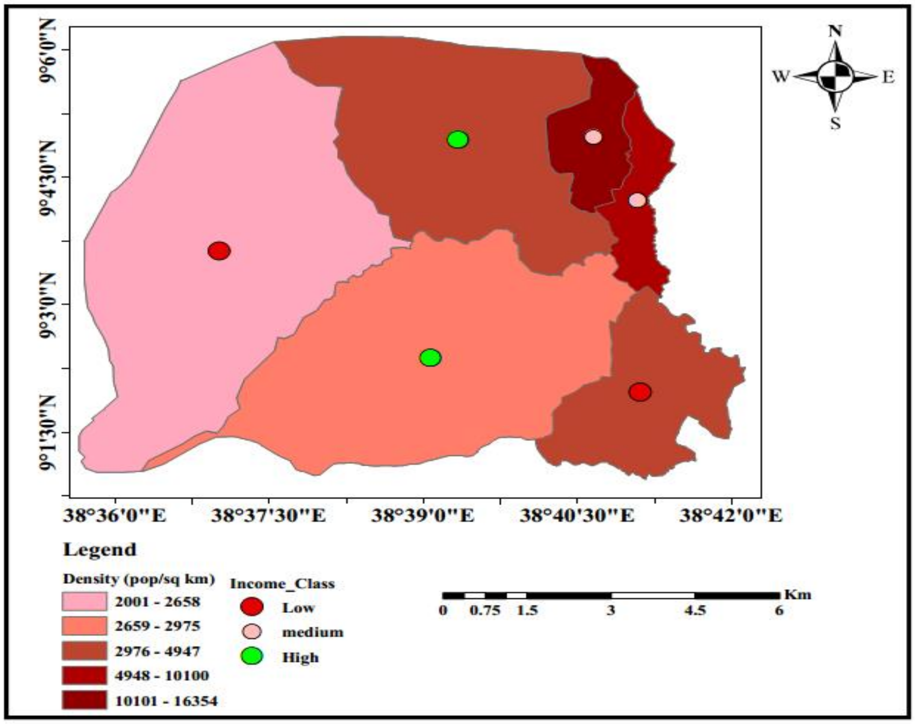

Fig 3.3 Population density and income class of Zone

(Source: Micro Enterprises Agency Office of Burayu Town, 2021)

3.1.5 Transport and road network

The main components of the Burayu transport system are the road network, taxis, minibuses, city buses, a small number of private vehicles, and large pedestrians. The road network provides the means for travel through the city. Public transport service within Burayu Town depends on motorized and non-motorized modes. Motorized mode depends on three modes namely rickshaw, mini bus, and few numbers of a city bus in their respective order as well as there is several public and private organization which gives transport service through entering and exit time especially Industrial, hospital and School, etc. Non-motorized mode is one of the modes of transport that do not rely on an engine or motor. It relatively gives short distances service, which shares trips in the Burayu Town and includes animal-drawn mode mainly of a horse-drawn cart. Based on data gained from the Transport and road development office of the Burayu Town administration the public transport fleet in the Town consists of about 820 or 465% rickshaws, 450 or 26% minibuses, 485 or 27%, carts, and 30 or 1% city buses. In Fig 3.4 the distribution of passenger traffic by Modes of Transport (percentage).

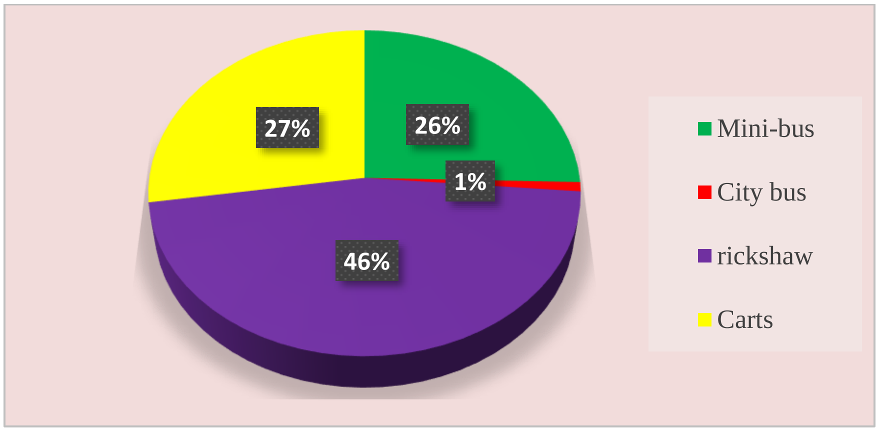

Fig 3.4: Pie chart of modes of transportation and percentage

(Source: Burayu Town Road Transport, 2021).

Table 3. 2 For the road category (source: Burayu Town road office, 2021)

NO	Type of Road	Total Length (km)	Total Length (%)
1	Asphalt	4.93	1.3%
2	Cobble Stone	124.28	25%
3	Gravel	237.4	46%
4	Red Ash	0.66	0.1%
5	Large Block Stone	6.28	1%
6	Earthen	197.17	27%
	Total	570.72	100

The road network type, as well as the road system of Burayu Town, are shown in Fig 3.6 and the in the (Table 3. 2.) current road in Burayu Town are asphalt, cobblestone, gravel, earthen, and red ash. The total length of the whole road in Burayu Town is about 570.33 km. From this, the total length of asphalt is 4.93 km, cobblestone 124.28 km, gravel 237.4 km, 197.17 km, and red ash 0.66 km as shown in Fig 3.5.

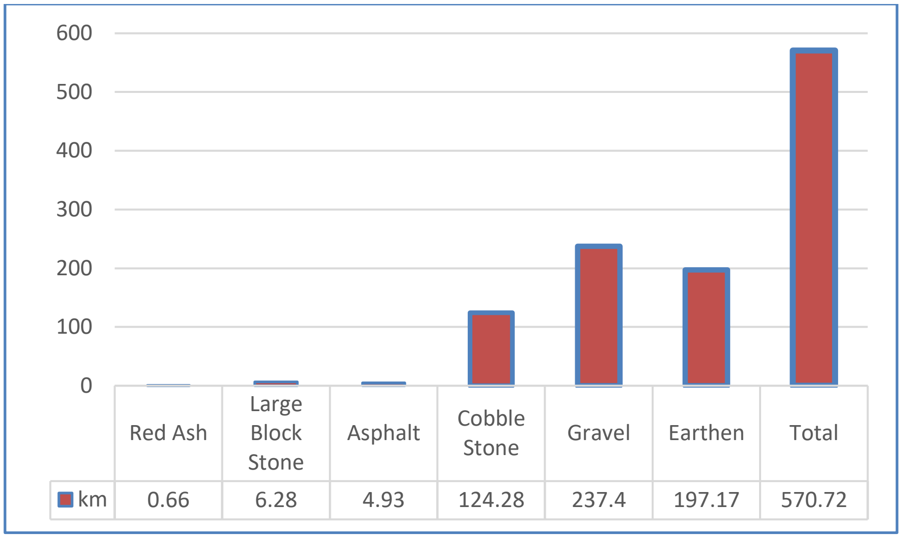

Fig 3.5 Existing road network in Burayu Town.

Source Burayu Town administration urban development and road office (2021)

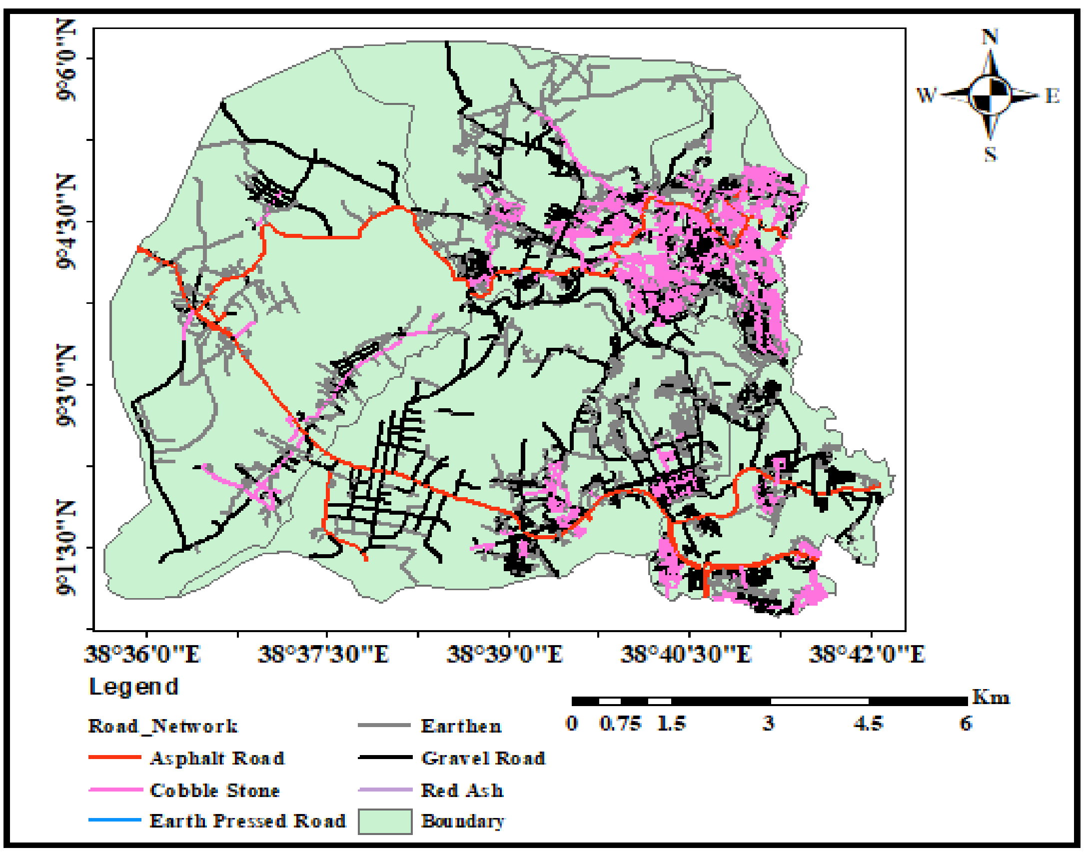

Fig 3.6 Existing road network in Burayu Town

Source: Burayu Town administration urban development and road office (2021).

3.2. Data

Before obtaining the data used in this research, the useful data, the type of data, and availability of data are evaluated before the fieldwork and secondary data tabulated in (Table 3. 3).

Table 3. 3 Secondary data

Data	Source	Format	Remark
Satellite images	https://earthexplorer.usgs.gov/	Images	For classification of LULC types
Socio-Economic Data	Burayu Town municipality office	Excel	To recognize how much and why people travel.
Demographic data	Burayu Town municipality office	Excel	To recognize how much and why people travel.
Land use map	Burayu land management office	Auto CAD	The map includes the master plan for the Town
Current road network	Burayu Road office	Shape file	The paved road and unpaved road are obtained in the Shape file.
Master Plan Road Network	Burayu Road office	Auto CAD	This map contains the roads according to the master plan.
Google Earth	Download	Images	Visualization, Feature collection (Infrastructure).

Table 3. 4 Landsat satellite imageries characteristic

Sensors	Satellite	Path	Row	Date of acquisition	Spatial Resolution (m)	Source
Landsat MSS	Landsat 8	168	54	20/01/2021	30	https://earthexplorer.usgs.gov/
Landsat TM	Landsat 5	168	54	1/ 09/ 2010	30	https://earthexplorer.usgs.gov/
Landsat ETM+	Landsat 7	168	54	02/05/2000	30	https://earthexplorer.usgs.gov/

There are different types of data collected from both primary and secondary data sources to succeed in the desired goal. Data from primary sources include GCP data. Secondary data such as socio-economic data, land-use map, current road network; shape files published research, journal, reports, etc. Land sat images can be download by using https://earthexplorer .usgs.gov/ shown (Table 3. 4). Are gathered from different organizations and websites. Landsat data types 1990, 2000, 2010 & 2021 acquired in the same season December and January, level of resolution (30m), Map projection is "UTM", Projection units is "meters", Datum and Ellipsoid is"WGS84" and UTM zone is 37. The False Color Composite (FCC) images are useful to distinguish between different cover types or ground objects like buildings, roads, and vegetation. The primary data collection method (field survey method) was used in this paper for quantitative data collection of the socio-economic characteristics and the trip details of the sample households through a questionnaire survey with interviews at the household level to estimate the number of trips that will begin or end in each zone within the study area. Field observation to understand the type and synchronization of vehicle fleets on the transportation system; and data collection on the road networks to understand the surface condition, road width, traffic sign, road damage area, bus station area, and visual observations on the road networks to understand service performance. Data related to the distribution of Auto rick show in the routes of the city obtained from the city transport bureau. Data related to the distribution of city buses and minibuses were obtained from the city transport bureau. In (Table 3. 5) software / equipment and Justification described bellows.

3.3. Software

Table 3. 5 Software / Equipment and Justification about the project requirement

Software / Equipment	The justification about the project requirement
Handheld GPS	-To collect ground control point
Computer, ArcGIS and ERDAS software	-Downloading and processing the data -Analysis images -Map preparation

3.4 Sampling method

The data sampling technique had been used because considering all populations in the research makes the research process difficult. There are different data sampling techniques among these techniques stratified random data sampling technique selected, to obtain appropriate information from the considered study area. The sample that was drawn from the household population was stratified over the kebele's level and that includes the total of 398 samples households over the study subject. Stratification indicated that, dividing the geographic locations of the study area into simple smaller TAZs. Then, the samples were selected from each of the kebeles with the respected sample size.

3.4.1 Determination of sample size

To determine a representative sample size from the target population, different strategies can be used according to the necessity of the research work (Umulisa, 2012). Different scientific kinds of literature stated different sample size determination strategies. However, unfortunately, there are no straightforward and one objective answers to the question of the calculation of sample size. Substantially larger sample size may signify a data collecting and analysis method that is excessively costly given the study's goal and required level of precision. A too-small sample, on the other hand, may imply outcomes with an unacceptably high degree of variability, lowering the overall value of the exercise. So, somewhere between these two extremes lies the most efficient (in cost terms) sample size for the given study objective (Ortúzar and Willumsen, 2011). By using (Umulisa, 2012) Method to determine sample size A random sampling technique was used to draw samples from the population. For a given population (N) and confidence level (α), the number of samples (n) can be determined (Umulisa, 2012) using equation 3.1

$$n = \frac{N}{1+N(\alpha)2} \qquad 3.1$$

Assume 95% confidence level, then alpha (α) = 1- 0.95 = 0.05

$$\text{So, } N = \frac{Po}{HHav} \qquad 3.2$$

where n is the number of samples

N is the number of households in the study subject.

Po is the population in the study subject.

HHav is average people per house hold and taken it as 6.33

N= 375,349/6.33 = 59,297 HHs in the study subject

$$n = \frac{59{,}297}{1+59{,}297(0.05)^2} \qquad n = 398 \text{ household samples}$$

Therefore, 398 samples were further distributed in the study area (Burayu Town) as shown in Table 3. 6 In Burayu Town there are six kebeles and the type of sample selection was stratified sampling and random selection from Burayu Town from each kebeles based on whether the kebeles were highly populated or not. The following table describes sample selection from the six kebeles from Burayu Town. (Table 3. 6) describes sample size selection from the six kebeles in Burayu Town.

Table 3. 6 Sample selection in Burayu Town.

TAZs	Population	Sample size
Laku Kata	32,290	32
Burayu kata	56,291	53
Gefersa Burayu	91,314	116
Gefersa Guje	81,042	95
Gefersa Nono	74,758	64
Malka Gefersa	39,654	38
Total	375,349	398

3.5. Method of data analysis

After the collection of the research data, the analysis of the data and its interpretation was performed as follows. The analyses of the collected information from the different sources are organized into their representative categories to come up with logical results. In dealing with the qualitative analysis based on the evidence collected from the different sources, an effort was made to carefully understand and interpret the information to use it together with the quantitative data. After collecting the necessary information, data analysis was done using a geographic information system and remote sensing software to present the result in descriptive methods. The methods of the research are composed of two phases the first phase is a classification of land-use land-cover and accuracy assessment. The second phase is travel demand modeling.

3.5.1 Digital image processing

Most of the common digital image processing is categorized into the following four categories. Pre-processing operations, also known as picture restoration and rectification, are used to correct for data distortions caused by sensor platform-specific radiometric and geometric errors. Image enhancement, on the other hand, is the process of making an image more interpretable for a certain application. The most common are radiometric enhancement used for adjusting the brightness values of the image. Spatial enhancement is used for adjusting the quality of the image and deriving new information using spatial operation. Spectral enhancement is used for image transformation techniques working with multispectral images. The third is Pan sharpening (resolution merge) used for increasing the resolution of colors image using the higher-resolution panchromatic image. Principal components analysis is a technique for reducing data redundancy and correlation between bands using image modification techniques (Lencho, 2019).

3.5.2 Data extraction

The layer stack is used to stack multiple (usually single band) images as bands/layers into a single output multi-band image file. Since downloaded land sat has separately in multiple bands selecting the bands Landsat 1990, 2000, 2010, and Landsat 2021 has 7, 9,7,11 separate band respectively, those separately exist band combined into a single multiband for each land satellite.

Clip/Extract using a mask used to create a new feature class called a study area or area of interest that contains a geographic subset of the features in another, larger feature class by cutting out a chunk of one feature class using one or more features from another feature class. Layer stack image covers a large area of 3,111,000 hectares (170km * 183km) but in the case of this study, the area is 9057 hectares. As a result, utilizing the Burayu Town boundaries, clip/extract the region of study or windowing as a rectangle using a mask. GeoTIFF format was used for Landsat imagery. GeoTIFF is a public-domain metadata standard for embedding geo-referencing information in TIFF (image) files (GeoTIFF).

3.5.3 Image classification and accuracy assessment

Supervised classification is a method for identifying spectrally similar areas on an image by locating "training" locations of known targets and extrapolating their spectral fingerprints to unknown target areas (Rahman and Saha, 2008). When there are few classes, training sites are confirmed using ground truth data, or homogeneous regions that represent each class, supervised classification is usually the best option. There are different algorithms for supervised classification; the classic classifiers are maximum likelihood minimum distance and parallel pipelined methods. The maximum likelihood algorithm uses a maximum likelihood procedure derived from Bayesian probability theory to determine the probability of the cell to be belonging to a particular class defined in training sites. The maximum likelihood classifier computes the class probabilities and classifies the cell where the probability is higher (Rahman and Saha, 2008). Most accurate of the classifiers (if the input samples/clusters have a normal distribution). Maximum likelihood is parametric, which means it relies significantly on the data in each input band having a normal distribution. Burayu Town classified land-use land-cover change using supervised classification method, maximum likely hood algorithm, finally making accuracy assessment for each year classified land-use land-cover maps.

a). **Errors of omission** refer to reference data that were left out (or omitted) from the correct class in the classified map. Omission errors are calculated by reviewing the reference data for incorrect classifications in columns for each class adding together the incorrect classifications and dividing them by the total number of reference data for each class (Prisley and Smith, 2009).

$$\text{Omission error} = \frac{\text{CI}}{\text{Ct}} * 100 \qquad 3.3$$

where CI is incorrectly classified sample locations of the reference data or column and Ct is total number of sample locations of the column.

b). **Producer's accuracy** is the map accuracy from the point of view of the mapmaker (the producer) (Rahman and Saha, 2008).

$$\text{Producer's accuracy} = \frac{Ci}{Ct} * 100 \qquad 3.4$$

where Ci is correctly classified sample locations of the reference data or column and Ct is total number of sample locations of the column.

c). **Commission errors** are calculated by reviewing the classified data for incorrect classifications by going across the rows for each class Adding together the incorrect classifications and dividing them by the total number of classified data for each class (Prisley and Smith, 2009).

$$\text{Commission error} = \frac{Ri}{Rt} * 100 \qquad 3.5$$

where *Ri* is incorrectly classified samples in the row and *Rt* is total number of samples in row

d). **User's accuracy** is the accuracy from the point of view of a map user, not the mapmaker.

$$\text{user's accuracy} = \frac{Ri}{Rt} * 100 \qquad 3.6$$

where *Ri* is correctly classified samples in the row and *Rt* is total number of samples in the row.

e). **Overall accuracy** is essentially told us out of all of the reference sites what proportions were mapped correctly. The overall accuracy is usually expressed as a percent, with 100% accuracy being a perfect classification where all reference sites were classified correctly. The diagonal elements represent the areas that were correctly classified (Rahman and Saha, 2008).

$$\text{Overall accuracy (PCC)} = \frac{Sd}{n} * 100 \qquad 3.7$$

where *Sd* is sum of values along diagonal and *n* is total number of samples. Overall Accuracy also known as Percent Correctly Classified (PCC)

f). **Kappa coefficient** is generated to evaluate the accuracy of a classification performed as compared to just randomly assigning values. The kappa coefficient can range from -1 to 1. A value of 0 indicated that the classification is no better than a random classification. A negative number indicates the classification is significantly worse than random. A value close to1 indicates that the classification is significantly better than random (Landis and Koch, 2007).

$$K = \frac{P(A)-P(E)Rl}{1-(E)RL} \qquad 3.8$$

where P (E) RL is Random Location conditional to the observed distribution in both maps.

3.5.4 Travel demand modeling analysis

Burayu Town is one of the fastest-growing Towns regarding building infrastructure as well as population size in the country. Because of this, there is a fast growth of public transport users to travel from home to other places or from other places to home within the city to achieve their activities or needs. Travel demand is the number of persons or vehicles expected to travel between a particular origin and destination via a particular route and mode of travel over a given period. For travel demand modeling as is mentioned in the literature review part, it is basic to use some parts of four-stage urban travel demand modeling (FSUTDM) for this research. By using the same procedure as FSUTDM, trip generation and trip distribution parts are computed. In modeling travel demand the most appropriate transport travel demand modeling for the determination of travel demand is the four-stage travel demand modeling. The steps that were followed for transportation demand analysis in the research are (Ortúzar and Williamson, 2011).

- Trip generation
- Trip distribution

- Modal split and
- Traffic assignment

3.5.4.1 Trip generation

The conventional four-step transportation planning method begins with trip generation, which is the process of calculating the number of trips that will begin or terminate in each zone within the study region using regressions equation in (Table 3. 7). Based on socioeconomic and household statistics, the number of trips created by each zone (O) and attracted to each zone (D) is predicted. It has two parts namely trip production and trip attraction in the determination of the number of trips produced and attracted for each zone. Trip generation (associated with trips attracted to non-residential end). and, Trip Production (associated with trips generated at the residential end) within this research, the trip generation model is adopted from the (Urban Transport Study, 2018). The available demographic and socioeconomic data are aggregated at the zone level. The study area is divided into 6 Traffic analysis zones. Trip attraction and production are computed for each TAZ using the multiple regression model based on household survey and depending on trip purpose.

Table 3. 7 Regressions equation. Source: (Urban Transport Study, 2018)

Trip production	Equation	Symbols
Work trip	1.46*w	W=number of workers
Educational trip	1.68*St	St=number of student
Other trip	0.199*Pop	Pop=population
Non home based trip	0.023*Pop	Pop=population
Trip Attraction		
Total work trip	1.57*E	E=Employment
Total educational trip	1.67*St	St=Number of student
Total other purpose trips	0.86*E	E=Employment
Total non-home based trips	0.069*E	E=Employment

The Total production and attraction of trips from each zone are computed using these equations. Since the total trips produced by all zones should, in principle, be equal to the total trips attracted to all zones, matching the two values would be necessary. Assuming the production is more reliable, the attraction was matched to it using the following balancing factor (Ortúzar and Willumsen, 2011).

$$\text{Balancing factor} = \frac{\sum Oi}{\sum Dj} \qquad 3.9$$

$\sum O_i$: The sum of trips produced by all zones, i

$\sum D_j$: The sum of trips attracted by all zones, j

3.5.4.2 Trip production

The term trip production is used for trips generated in each traffic zone associated with residential areas. The trips were classified according to trip purposes; home-based work trips, home-based education trips, home-based other trips, or none home-based trips. The main purpose of this step is to develop a procedure that creates trip linkages between traffic zones.

Different models can be used to model trip distribution. From these models, a common method in most studies is used in the urban transport study (2018), which is the doubly constrained gravity model. The gravity model is based on newton's gravity law. The basic principle is that the number of trips between two zones i and j are directly proportional to the number of trips produced in zone i, the number of trips attracted to zone j, and inversely proportional to some function of the spatial separation of the two zones (Ortúzar and Williamson, 2011).

Mathematically, the gravity model often takes the form:

$$\text{Tij} = \text{Pi}\frac{\text{AjFijKij}}{\sum \text{AjFijKij}} \qquad 3.10$$

where Tij= Trips between origin and destination

Pi = Trips Produced in zone i

Aj= trips Attracted to zone j

Fij = Friction factor a measure of impedance from i to j or distance decay factor.

Kij = Balancing factor (Ortúzar and Williamson, 2011).

For the real network, the distance between centers of the 6 TAZs is computed using network analysis OD cost matrix. This gives the network distance between every TAZ as an attribute to the desire line. After this, the desired lines are exported to a shapefile which added an attribute shape-length (the euclidian distance between TAZ). To make computation easier, the database file was saved in excel format.

3.5.4.3 Trips through each zone

In the preparation for the spatial mismatch assessment trips that pass through each zone are computed. Here, two methods were used; euclidean network-based assignment, which assigns both euclidian and network-based trips on the reference network, and network-based assignment which assigns the network-based trips on the real network. The two methods are discussed in the following sections.

Euclidean network-based assignment: Following the method applied by (Ayalneh, 2012) the reference network is intersected with TAZ in ArcGIS. Since the reference network has 36 lines.

Real network-based assignment: the same analysis is done for the reference network assigning the euclidean-based flow. After joining the output of the trip assignment to the real network layer, this layer is intersected with the TAZ layer.

3.6. Methodological flow chart

Fig 3.7 shows the procedural steps in carrying out the research. The analyses at different levels were carried out. The existing situation analysis was done to assess the performance of the existing system, which led to studying the urban land use patterns and assessing potential travel demand and current network to identify an efficient urban land transport system. Based on the analysis result conclusion and recommendations for the future were drawn.

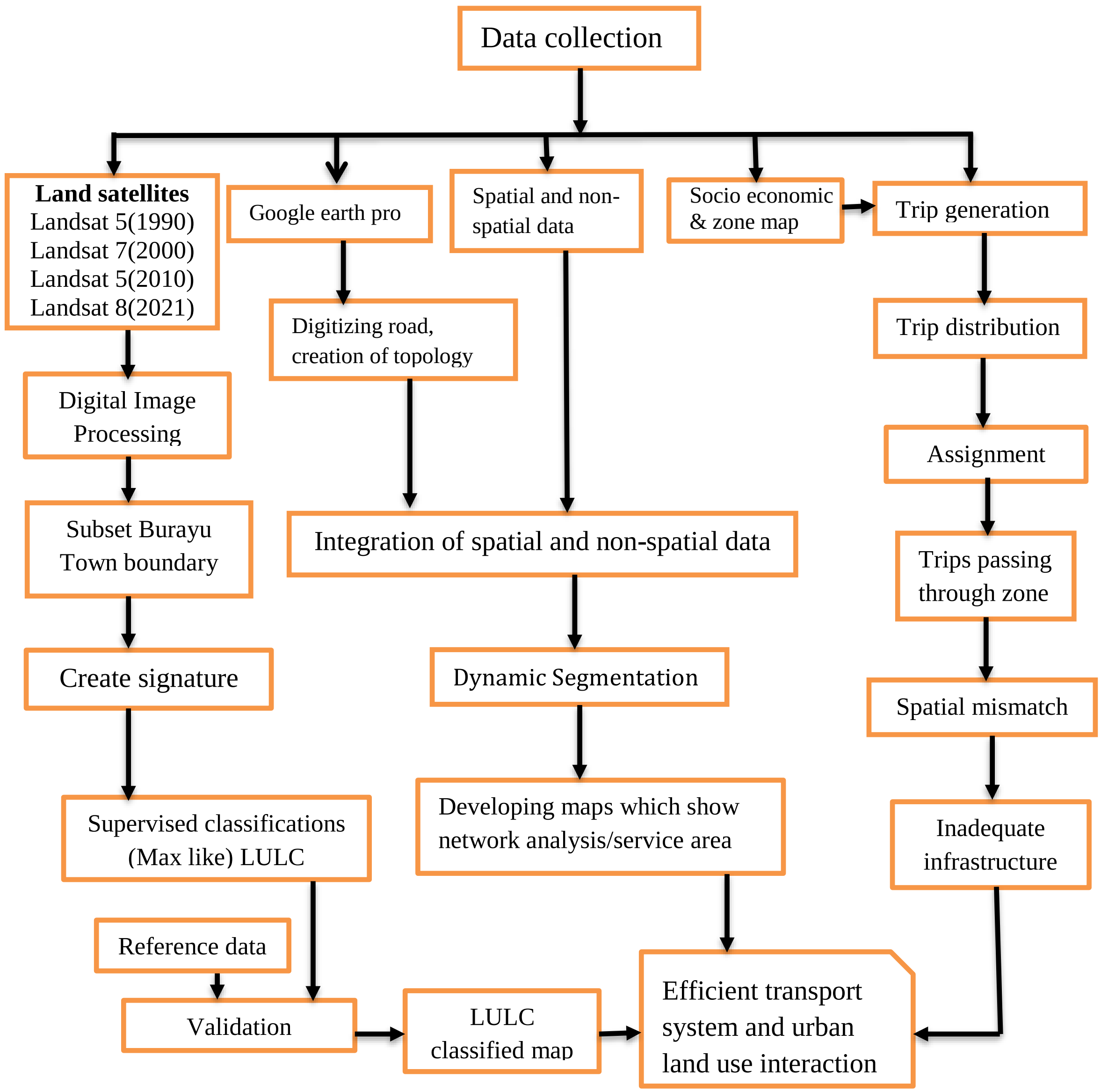

Fig 3.7 Methodology follow chart

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1 Land-use and land-cover status

Training sites are the areas defined for each land-cover type within the image and create the spectral signature for each type of land-use land-cover. This is done by analyzing the pixels of the training sites (Václavík and Rogan, 2009). The classification of these land sat images are pixel-based classification category, supervised classification method with maximum likely hood algorithm for all Burayu Town land-use land-cover classes of 1990, 2000,2010, and 2021 in the Fig 3.1 .

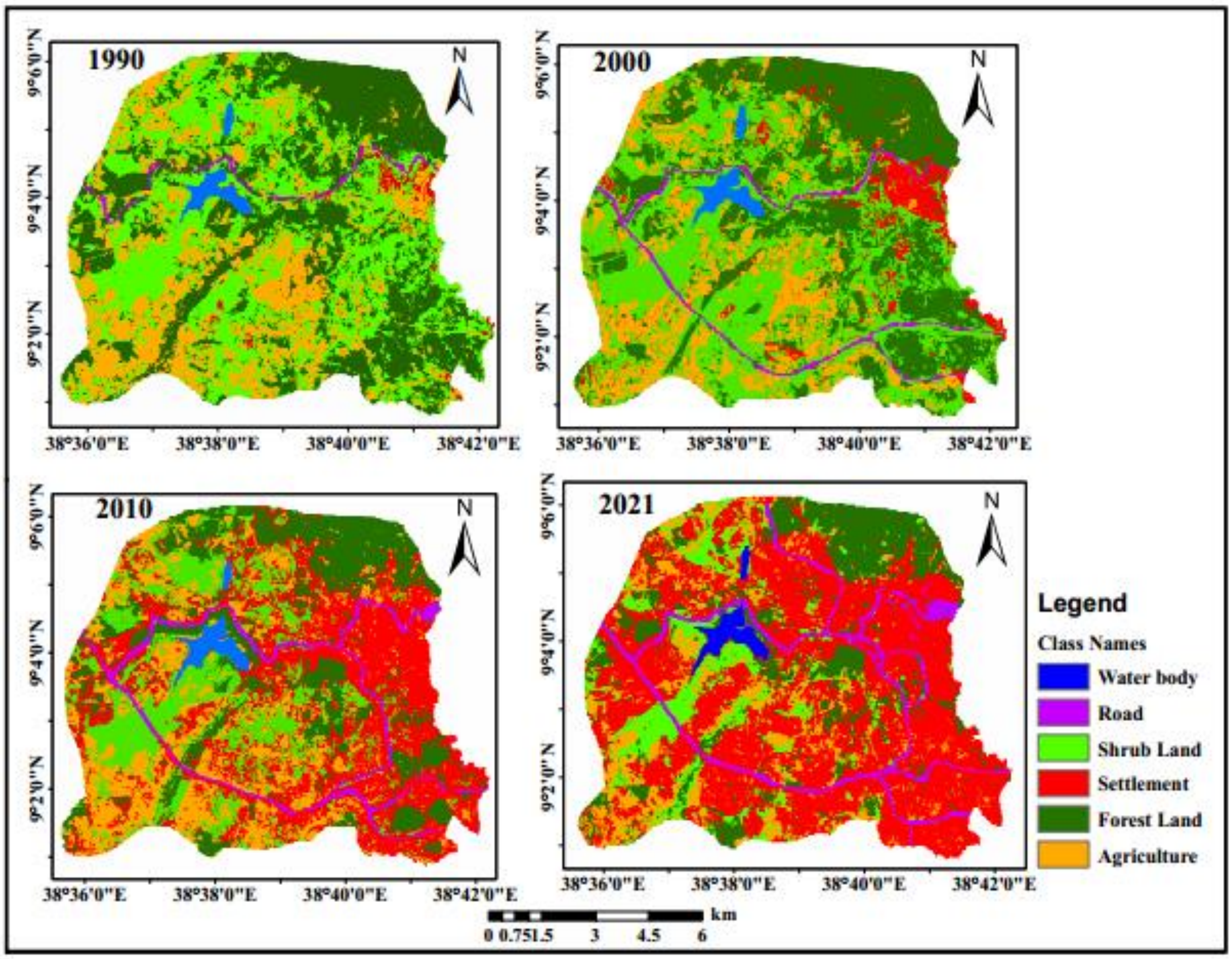

Fig 4.1 Land-use land-cover

4.1.1 Accuracy assessment

The ground control points were collected from a known real study area, google earth (2021). For each land-use land-cover classification map, 300 reference points are collected. The error matrix tables, including total classification accuracy, percentage of producer and user accuracy, and kappa coefficient, generate many statistical measures of thematic accuracy are shown in Table 4. 1. Based on this equation classified land-use land-cover map of Burayu Town in 1990 has 89.33% overall accuracy and 0.88 kappa coefficient, similarly, the 2000 land-use land-cover map has 91.66% overall accuracy and 0.901 kappa coefficient, for 2010 land-use land-cover map has 93 % overall accuracy and 0.92 kappa coefficient. Finally, the 2021 land-use land-cover map has a 97.33% and 0.96 kappa coefficient. Based on strength of agreement for kappa statistics (Landis and Koch, 2007) all classified overall kappa and kappa statistics fall in almost perfectly classification.

Table 4. 1 Error matrix of land-use land-cover classes in 2021

	Land-use classes	REFERENCE DATA (2021)							
		Settlement	Forest Land	Water	Agriculture	Road	Shrub Land	Total Points	U.A (100%)
CLASSIFIED DATA (2021)	Settlement	49	1	0	0	0	1	51	96.07
	Forest Land	0	48	0	1	1	0	50	96
	Water body	0	0	50	0	0	0	50	100.00
	Agriculture	1		0	48	0	0	49	94.11
	Road	0	0	0	0	49	0	49	97.56
	Shrub Land	1	1	0	1	0	48	47	95.74
	Total Points	51	50	50	50	50	49	300	
	P.A (100%)	96.07	96	100	96.00	98	97.82		
	Overall Accuracy = 97.33%								
	Kappa Coefficient (K) = 0.96								

4.1.2 Land-use and land-cover change

The change analysis is used for the rapid assessment of changes such as gains and losses, net change, persistence, and specific transitions in both the map and graphical form. The change between 1990-2000, 2000-2010, 2010-2021, and 1990-2021 is calculated using image difference (later- earlier) of classified land-use land-cover Burayu Town of four different years in the Table 4. 2 and Fig 4.2.

Table 4. 2 Land-use land-cover changes (1990-2021)

land-use land-cover	1990		2000		2010		2021	
	Area(ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
Water body	134.36	1.34	134.36	1.34	134.36	1.34	134.36	1.34
Road	90.71	1.00	217.95	2.40	320.42	3.57	497.23	5.26
Forest Land	3115.77	34.45	2902.30	32.08	1903.32	20.96	1447.29	15.98
Shrub Land	3571.89	39.51	3479.07	38.48	1808.16	19.62	1070.18	11.83
Settlement	200.72	2.22	625.45	6.98	3068.73	34.18	4869.33	53.83
Agriculture	1943.56	21.49	1697.87	18.72	1822.01	20.33	1038.62	11.76
Total (ha)	9057.00	100.00	9057.000	100.00	9057.000	100.00	9057.000	100.00

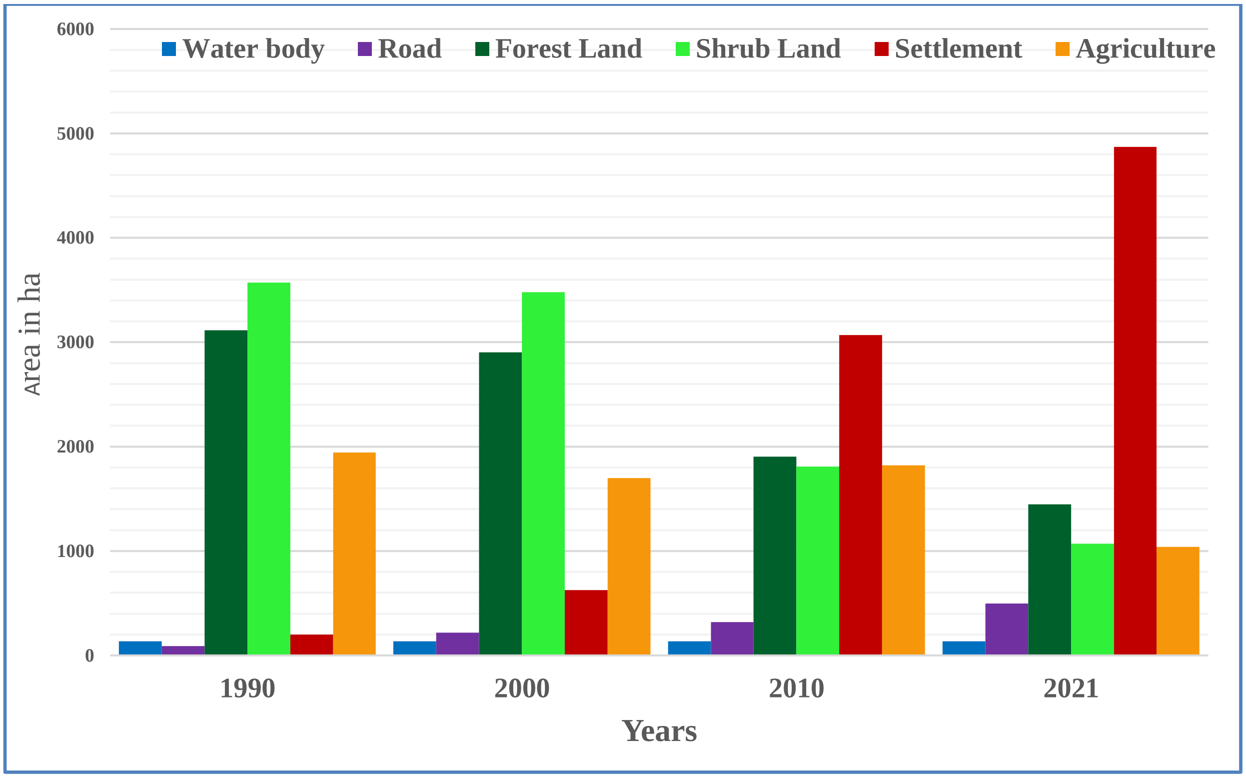

Fig 4.2 Land-use land-cover changes (1990-2021).

In 1990, about 200.72 hectares of land, or 2.22 % of the total area of Burayu Town was occupied by settlement. In 2021, the land occupied by settlement has increased to about 4869.33 hectares, which was 53.83% of the total area of the Town. Between these two years, the settlement has increased by about 4668.60 hectares of land or by 51.61%. Again settlement in 2000 increased by 424.73 hectares from its 1990 coverage (Table 4. 3 and Table 4. 3). Settlement covers 3068.73 hectares in 2010 and 4869.33 hectares in 2021 (Table 4. 2 and Fig 4.2) and increased by 1800.60 hectares (Table 4. 3 and Fig 4.3).

Table 4. 3 Land-use land-cover from 1990 to 2021

land-use land-cover	Change from 1990 to 2000 (ha)	Change area (%)	Change from 2000 to 2010 (ha)	Change area (%)	Change from 2010 to 2021 (ha)	Change area (%)	Change from 1990 to 2021(ha)	Change area(%)
Water	0.00	0%	0.00	0%	0.00	0%	0.00	0%
Road	127.24	1.40%	102.48	1.17%	176.80	1.69%	406.52	4.26%
Forest	-213.46	-2.37%	-998.99	-11.12%	-456.03	-4.99%	-1668.48	-18.47%
Shrub	-92.82	-1.03%	-1670.91	-18.86%	-737.99	-7.78%	-2501.71	-27.68%
Settlement	424.73	4.76%	2443.28	27.20%	1800.60	19.65%	4668.60	51.61%
Agriculture	-245.69	-2.77%	124.14	1.61%	-783.38	-8.57%	-904.93	-9.72%

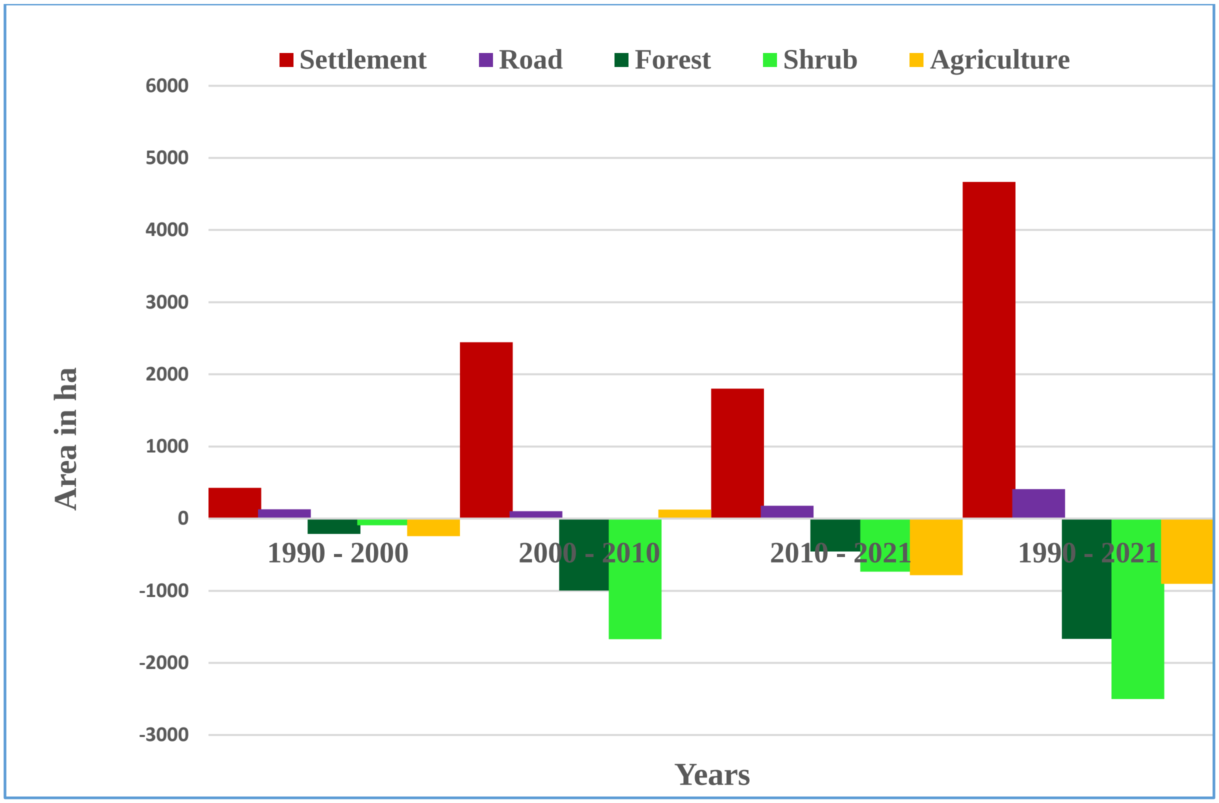

Fig 4.3 Land-use land-cover change during 1990-2021

4.2. Urban land-use and transportation interaction

Both transportation and land-uses are two interconnected systems, where the changes that occurred on one inexorably affect the other land use and transportation because both are two sides of the same coin (Magnus, 2016). Transportation and land use interactions mostly consider the retroactive relationships between activities, which are land use related, and accessibility, which is transportation-related. People settled in areas that were amenable to access by the modes of transportation available at that time (Magnus, 2016). This study results show settlement area land-use land-cover type is increasing at an alarming rate over the years, but the road area land-use land-cover type is increasing insignificant rate over the year. The intention is to understand the extent of urban expansion, which was observed and has a direct influence on transportation service. As settlements in Burayu Town are mainly established along with the road network, the road length per unit person in the central areas is observed to be not high. Urban traffic faces many challenges, which are mainly caused by urban expansion and an increase in car ownership, which then influence the flow of traffic, accessibility, and mobility. Accelerated population growth puts pressure on land use and increases the risk of urban expansion inadequately connected to public transport capacity. Urban expansion without inclusive policies can put societies at risk where new residential expansion areas become the scene of new phenomena of social exclusion and mobility poverty. Guaranteeing sustainable and inclusive urban development implies, among other things, fair access to the public transport network and the main opportunities/activities being reached through it for all individuals/groups in the whole society (Magnus, 2016). Therefore, coordinating or integrating land-use and transportation planning and sustainable development should be better to monitor abrupt urban expansions of the Burayu Town.

4.3. Urban transportation supply

The transportation supply helps to assess public transport demand data, which shows existing facilities both in the movable and fixed facility and in this research transportation supply, which concerned is mainly public transport supply and urban road supply.

4.3.1. Urban road infrastructure

Burayu Town transport infrastructures are structures and services that act as a basis for the economy and quality of life of a Town. Burayu needs a large road network with high standards, quality, and safety conditions. Burayu Town municipality is responsible for the expansion of the road network in Burayu Town. The total area according to the structure plan boundary of the city had an area of 90.57 km^2 of which the total area reserved for the road network was 4.93 km.

The current conditions of the road in Burayu Town are asphalt, cobblestone, and gravel (earth pressed and rad ash), and its area coverage is described in (Fig 4.4). From the total area of existing road network coverage in Burayu Town asphalt covers, about 1.3% gravel covers about 46% of total road network area coverage, and cobblestone cover about 25%. The rest 27.7% is covered by the earth pressed and red ash in Burayu Town. The area coverage of the whole roads in Burayu Town is 570.72 km. From this, area coverage of asphalt is 4.93 km, cobblestone is 124.28 km, and area coverage of gravel is 237.4 km the rest are earth pressed and red Ash.

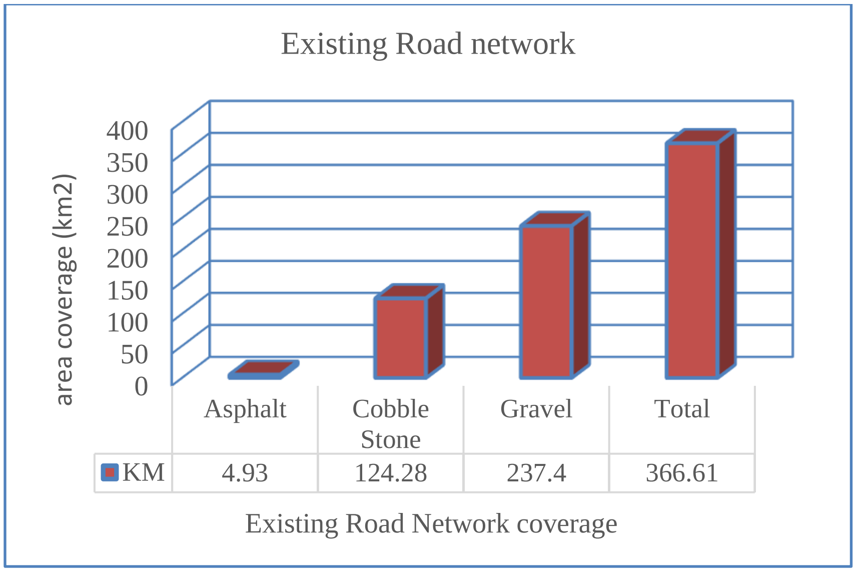

Fig 4.4 Existing road network in Burayu Town.

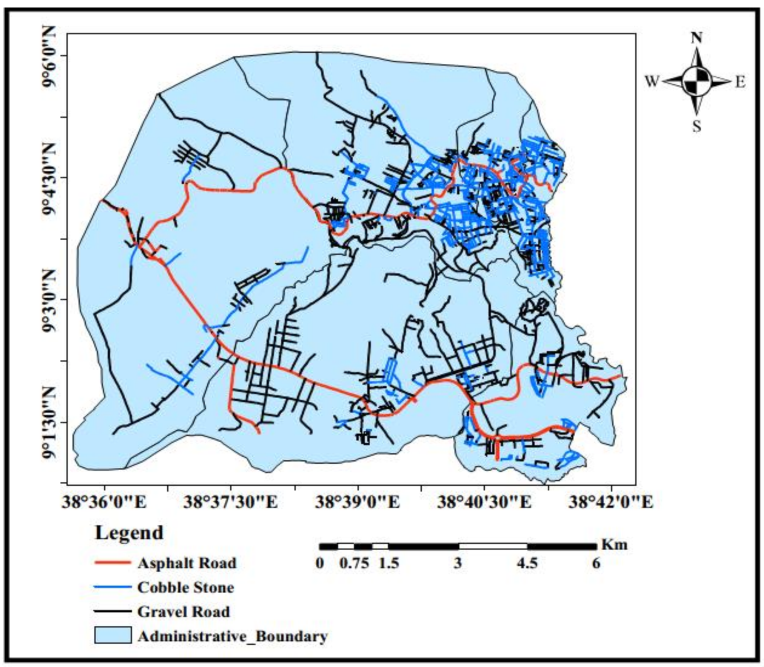

Fig 4.5 Existing road network in Burayu Town

From Fig 4.5, the area coverage of the whole roads in Burayu Town is 570.72 km. From this, area coverage of asphalt is 4.93 km, cobblestone is 124.28 km, and area coverage of gravel is 237.4 km.

4.3.2 Public transport supply in Burayu Town

The public transport supply of Burayu Town depends on auto-rickshaws, minibuses, and city buses. Based on data gained from the transport and road development office of the Burayu Town administration the public transport fleet in the Town consists of about 820 rickshaws, 450 minibuses, carts 485, and 30 city buses shows in Fig 4.6. The public transport supply of Burayu Town depends on auto-rickshaw, minibuses, and city buses. This does not include public vehicles, which give staff transport service by private, non-governmental, and governmental organizations. However, some private and governmental institutions avail of transport service at the entry and exit time for their employees. Mini-buses operate on long-distance routes and they have no specific route distribution as well as transport service without the limitation of route allocation. However, auto-rickshaw has been operating on a short distance and limited corridors of the city there is road corridor prohibited for them. In the case of city buses, public transport operators serve mainly on all routes and every driveway on demand. Concerning Burayu Town, the trip-making characteristics of the passengers are more of education and work purpose trips, in which more of the travelers move from their peripheral residential places to the major school and central business district. The trips are made towards the center in the morning and vice versa in the evening. From the study, it was observed that, as there was no balance between origins and destinations. When passenger transport system is considered, the residents are more interested to make trips by using the mode of city bus than the other mode. From the result, the number of vehicles per link does not satisfy the required one. Therefore, an additional number of vehicles is needed. In general, the public transport demand in Burayu Town was not balanced concerning the number of vehicles, which is served the existing travel demand of the Town.

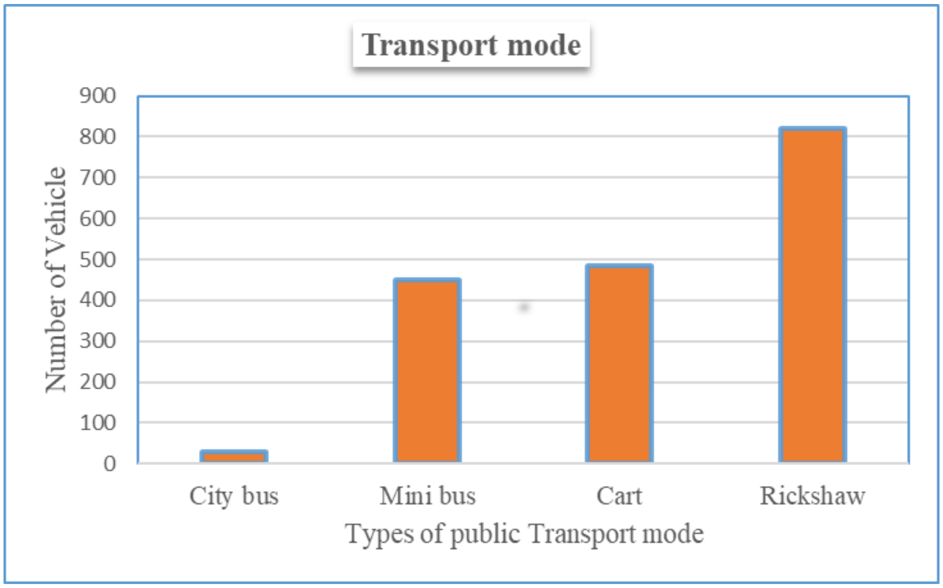

Fig 4.6 Type and number of public transport mode

(Source: Burayu Town road and transport)

In Burayu Town at this time bus, the operation did not fully satisfy the transport need of the Town. There is no marked city bus waiting for the station, clear route, clear origin, and destination point and there is no starting and arrival time, which is important information that helps the passenger to load and unload.

4.4 Transport demand modeling

4.4.1 Trip generation

Trip generation is the first step in the four-step transportation forecasting process, which is used for forecasting travel demands. Depending on land use, characteristics of zones, and socio-economic properties exhibited at the household level, the intensity of travel demand and trip ends are estimated. This step classifies each 'trip-making potential' of the TAZ into attraction and production levels using multiple regressions models. So using the regression models, trip production and attraction for each zone are calculated. The trips are stratified into four based on trip purposes. These are work trips, education trips, other purpose trips, and non-home-based trips. As shown in Table 4. 4, the work trips share the highest percentage of trips, with about 41% and 40% in both the production and attraction category respectively while the non-home based trips only account for 2 % of total production and attraction levels.

Table 4. 4 Trips share by purpose

Trip Purpose	Production	Percentage Production	Attraction	Percentage Attraction
Work Trip	163,927	41	157,428	40
Education Trip	162,108	38	156,121	37
Other Trip	74,694	19	85,112	21
Non-Home Based	8,633	2	6,878	2
Total	409,362	100	405,539	100

The share of the trip for each zone by purpose is shown in Table 4. 5 from the total trips attracted, Gefersa Burayu being the CBD, takes the higher share. Laku Kata and Malka Gefersa, which include most of the peripheral areas of the city, take the lowest values for both attraction and production. Gefersa Burayu kebele takes the higher values for work and education trip productions.

Table 4. 5 Trip shares of kebele in Burayu Town

Kebele	**Production**				**Attraction**			
	Work (%)	Education (%)	Other (%)	Non-home (%)	Work (%)	Education (%)	Other (%)	Non-home (%)
Laku Kata	11	13	9	9	14	14	13	13
Burayu Kata	15	19	15	15	16	18	17	17
Gefersa Burayu	22	21	24	24	22	22	22	22
Gefersa Guje	18	17	20	21	18	16	16	16
Gefersa nono	21	18	22	20	16	17	18	18
Malka Gefersa	13	14	10	11	14	13	14	14
Total	100	100	100	100	100	100	100	100

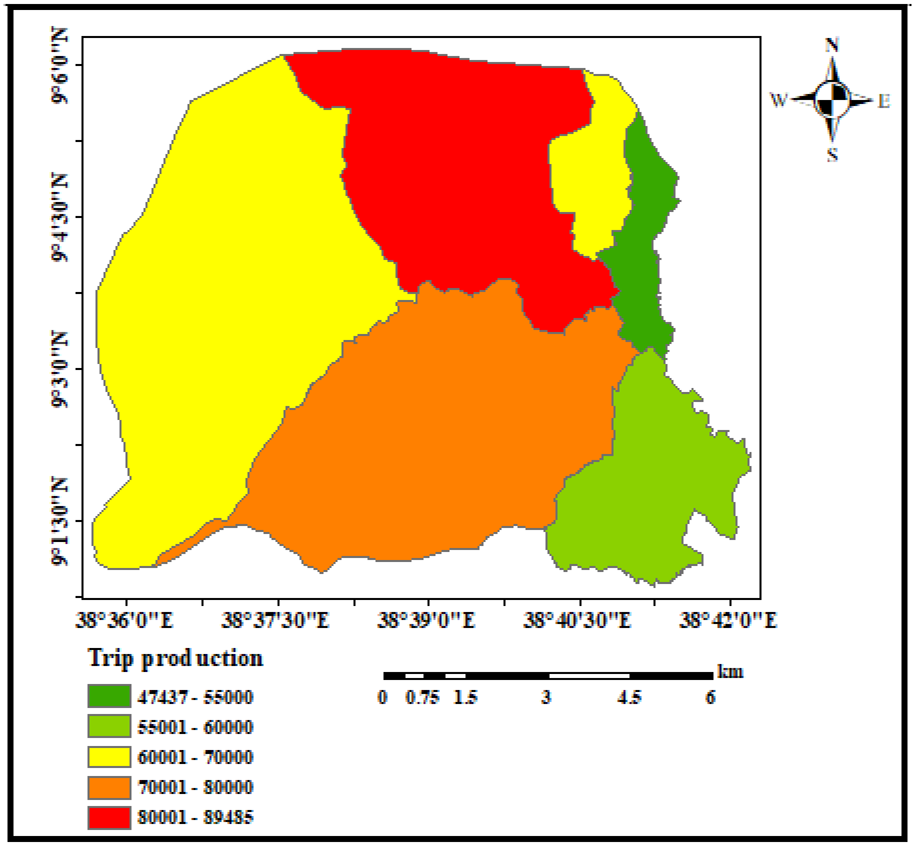

Fig 4.7 Trip production

From Fig 4.7, it can be observed that total trip production ranges from 47,437 in kebele 1 to 89,485 in kebele 3 (locally known as Laku Kata and Gefersa Burayu respectively). As already observed the majority of the trip had been produced from Gefersa Burayu (3). This happened due to kebeles covering the largest population being concentrated in these kebeles.

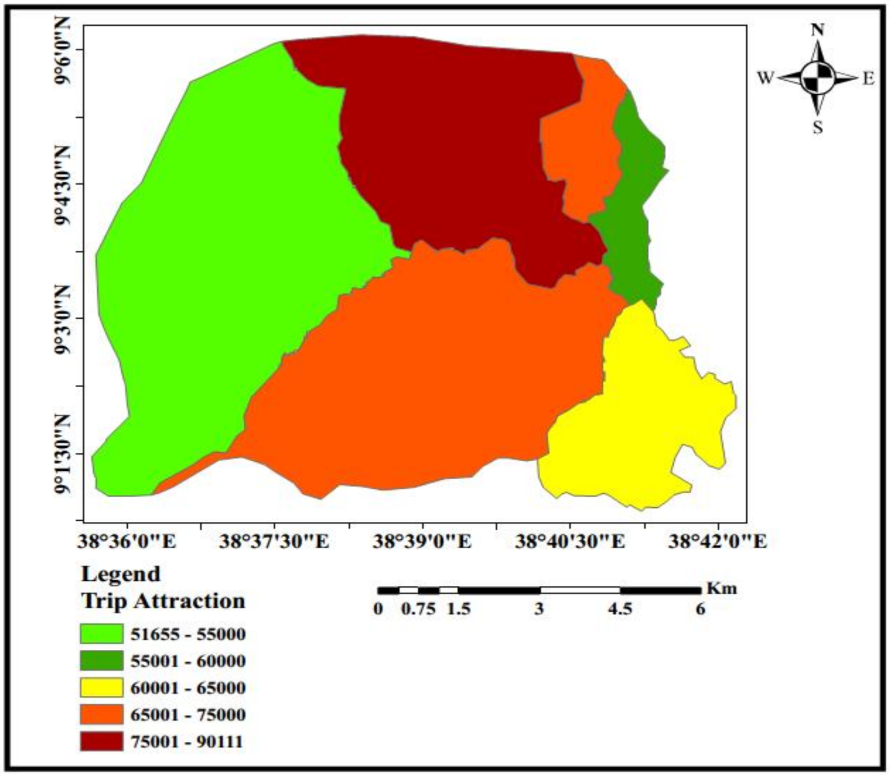

Fig 4.8 Total trip Attraction

From Fig 4.8 Trip attraction level ranges from 51,655 in kebele (4) to 90,111 in kebele (3). Kebele (3) and (5) (locally known as Gefersa Burayu and Gefersa Nono) have high trip attraction values as they are the main business centers of the city. The range of trip attraction values is much larger than production. This shows that activities responsible for attraction levels; mainly jobs, schools, and shopping centers are located in the central business district around the center of the city and its vicinity.

4.4.2 Trip distribution

Trip distribution is the second component in the traditional four-step transportation planning or forecasting model. This phase matches the origins and destinations of the trip maker to create a trip table matrix that shows the number of journeys between each origin and destination. The trip distribution stage decides where a zone's travels are going, as well as the percentage of journeys that end up in other zones. The gravity model is used to compute the proportion of trips from and to each zone where the impedance factor used is distance.

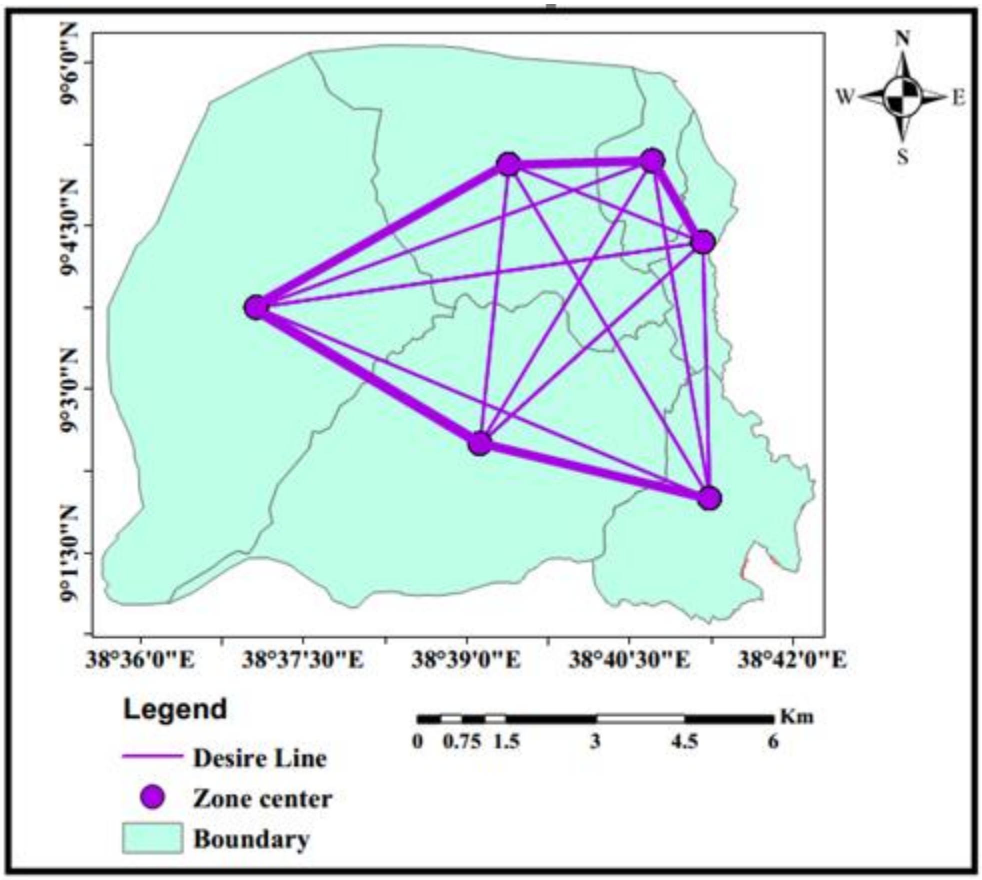

Fig 4.9 Desire connective different zone lines

Another way to show the pattern of trips is by using desire lines. These lines represent graphically the number of trips between O-D pairs. Graphically, the higher the number is, the wider will the corresponding map (Fig 4.9 desire lines by O-D pairs). It is a good visual aid to estimate roughly the pattern of movements. In this phase of transport modeling, the spatial pattern of trips in terms of potential travel demand between origin and destination is predicted.

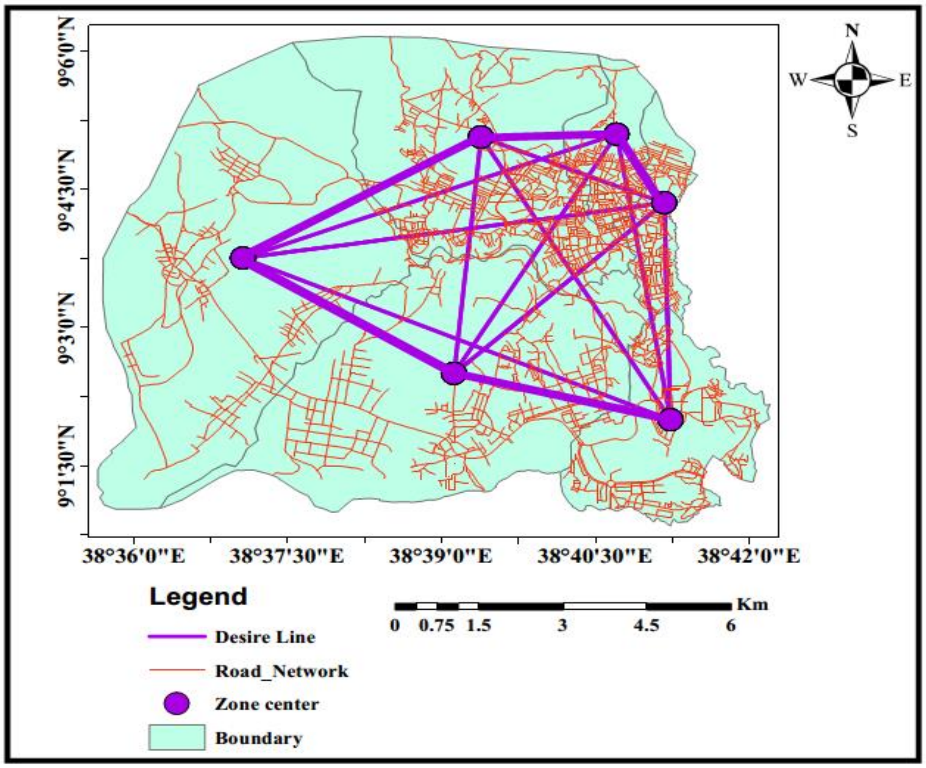

Fig 4.10 Desire connective lines and real road network

By overlaying the existing network onto the desire lines for travel demand and visualizing the spatial pattern of the desire lines and real network, it can be seen that some zones are disconnected or people have to travel a long way to reach their destination using the real network especially, the peripheral zones of Town. From Fig 4.10 understand that the mismatch between the desired lines and the existing network only shows those areas that are disconnected without actually considering the magnitude of travel demand quantitatively in these areas. Considering only the distance people travel to reach their destination, the researcher notes some large differences based on the desired lines and the real network.

4.4.3 Road density

Network density (road density) can be measured as the ratio of the total road network in an area to the land area or to the total population in that area. Given a similar network topology, in different zones, higher road density (road per area) implies a higher availability of alternative routes (Jenelius, 2009). The road density investigates the network structure only considering the supply side whereas the road density per unit of population measures the availability of network distance per person. Fig 4.11 shows maps of the road density in the study area. The road density per unit of the population shows there are some areas without a road; especially, in areas that are situated at the periphery of the city. Even though the population is low in these zones, there is some demand as can be seen from the density per population plots. The road per area shows higher values in the central business district but this is not true for the road density per population due to the high population in the central business district.

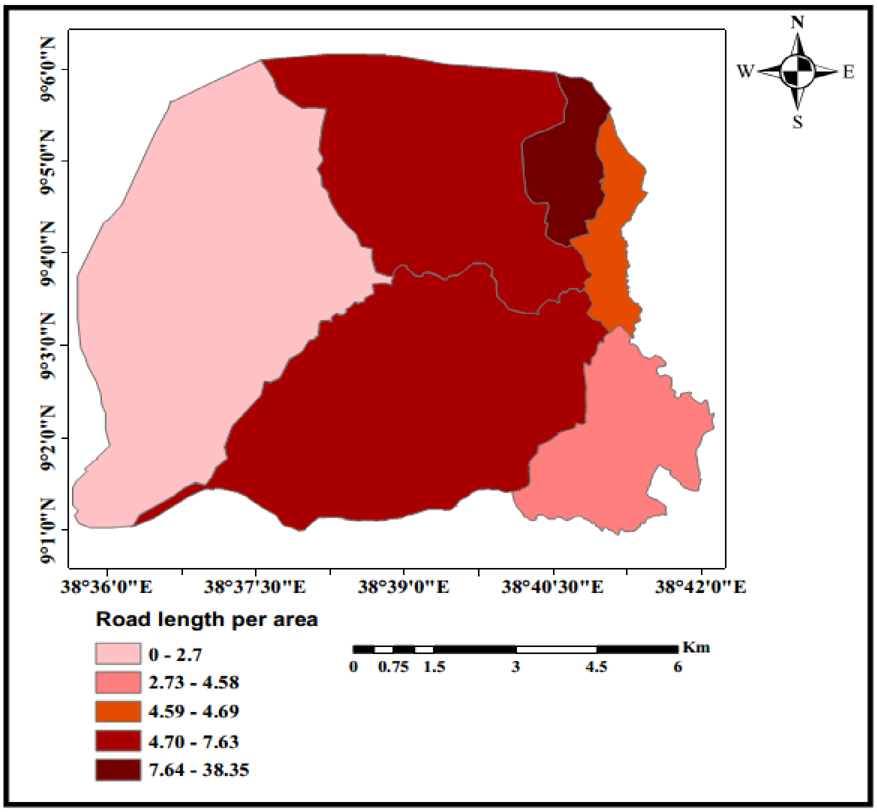

Fig 4.11 Road length per area.

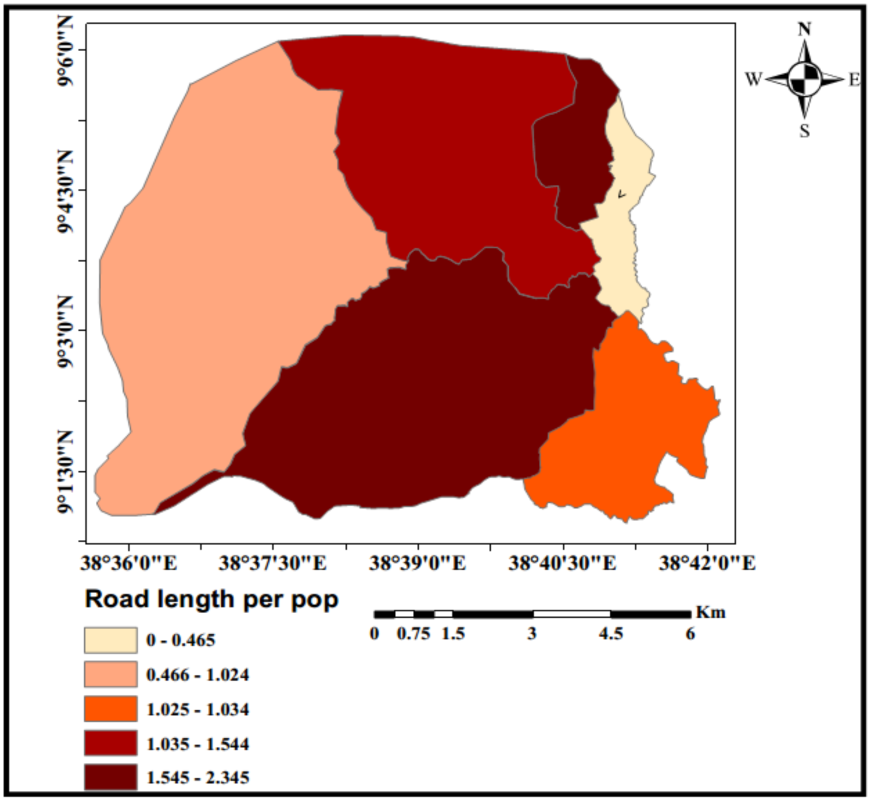

Fig 4.12 Road density, road length per population

There is a high value of road per population in Kebele (2) and kebele (5), an area locally known as Burayu kata and Gefersa Nono, which is fast developing. From Fig 4.12, the researcher concludes that the kebele 1, 4, and 6 locally known as Laku kata, Gefersa Guje, and Malka Gefersa have low road infrastructure availability both concerning road density per population and per unit area. Most of the peripheral zones have low infrastructure availability.

4.4.4 Proximity to the road network

The use of GIS gives a possibility to delineate areas for which public transport demand is covered, and how best to represent potential demand spatially using different technics as buffering operations (Grubesic et al., 2007). One of the parameters that show the availability of transport infrastructure is its proximity to the end-users. Proximity measures how many people can access the infrastructure within a certain distance. Considering a uniform distribution of the population over the area of each zone, the population density of the zones is computed. A simple buffer analysis is used to measure the proximity of the population from the infrastructure. As shown in Fig 4.13 and Fig 4.14 the availability of road networks in some areas is very poor. For example, for kebele (2) Burayu Kata, kebele (3) Gefersa Burayu, and Kebele (4) Gefersa Guje more than half of the population in this kebele can access any kind of road network only if they traveled more than 1000 m distance. (Grubesic et al, 2007) suggested that the walking distance to these facilities should not be greater than 500 m. From this, the researcher can conclude that these zones have a very low level of road infrastructure availability.

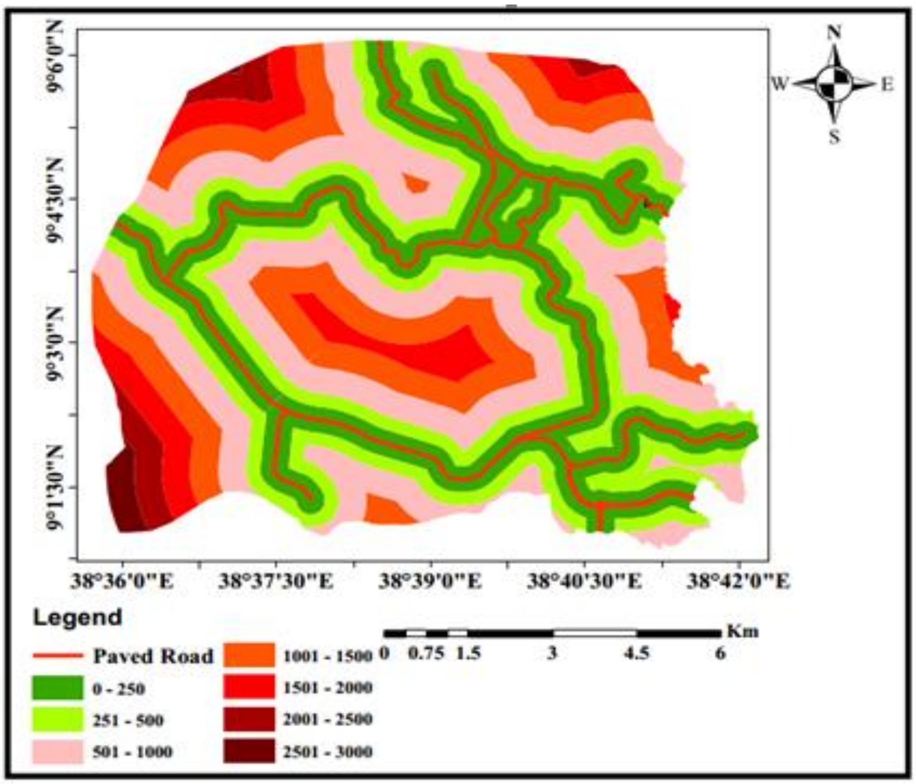

Fig 4.13 Proximity to paved roads

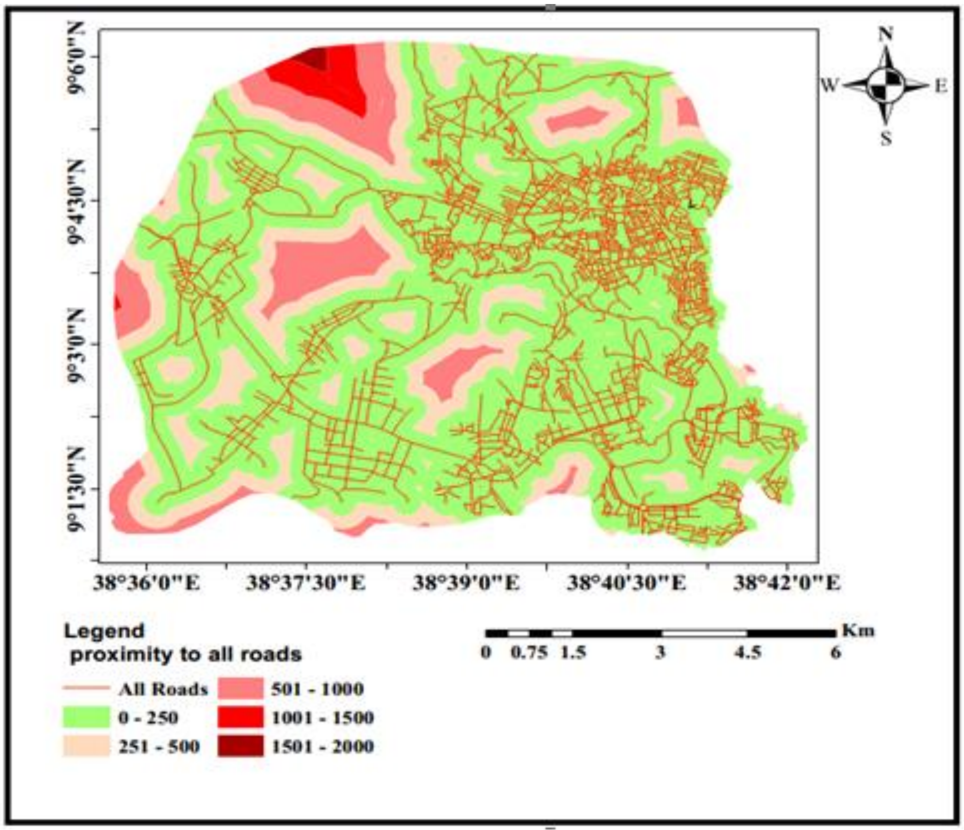

Fig 4.14 Proximity to all roads

4.5 Spatial mismatch

4.5.1 Real network-based assignment

In this method, total network-based trips passing through each zone are computed. The trips through each zone can be computed by intersecting the network layer with the TAZ layer. Assigning network-based trips on the zone, total trips passing through each zone are plotted as can be seen in Fig 4.15, For the network-based trips zone, 3 and 5 (locally known as Gefersa Burayu and Gefersa nono) have values greater than 75,000 trips.

The trips that pass through each zone range from 48,300 to 90,000 for Euclidian-based and 41,095 to 80,000 for network-based trips. As shown in Fig 4.15 and Fig 4.16, in both cases higher values can be observed in the central areas. Due to their remoteness and low demand, these values decrease as one move to the peripheral areas. For the Euclidian-based trips and the network-based trips, zone 3 (locally known as Gefersa Burayu) has the highest value. This zone is the main business district of the city with high population and employment opportunities. The second-highest value network-based trips, zone 5 (locally known as Gefersa nono) has the highest value.

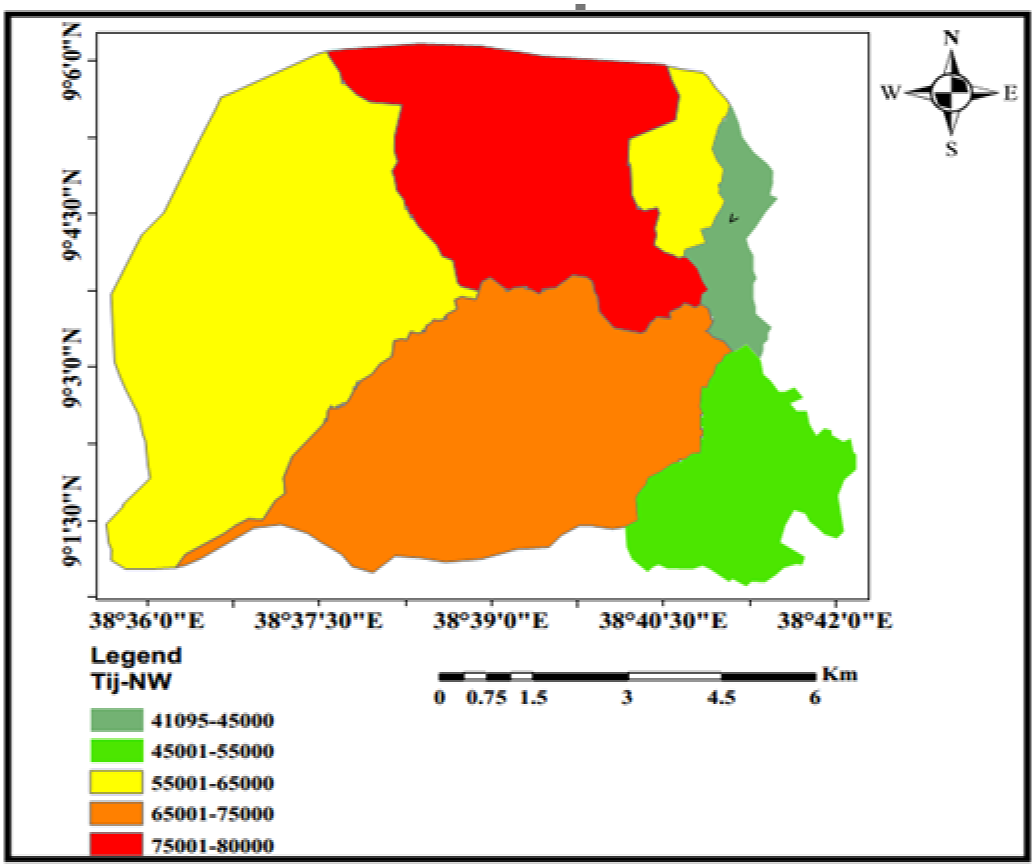

Fig 4.15 Trips passing through each zone by real networks.

4.5.2 Euclidean network-based assignment

The spatial mismatch index shows the difference between the Euclidian-based and network-based trips passing through each zone (Åslund et al., 2010) by intersecting the link flows with the zone the trips that pass through each zone using the reference network and real network are computed. Assigning Euclidian-based trips on the zone total trips passing through each zone are plotted as can be seen in Fig 4.16.

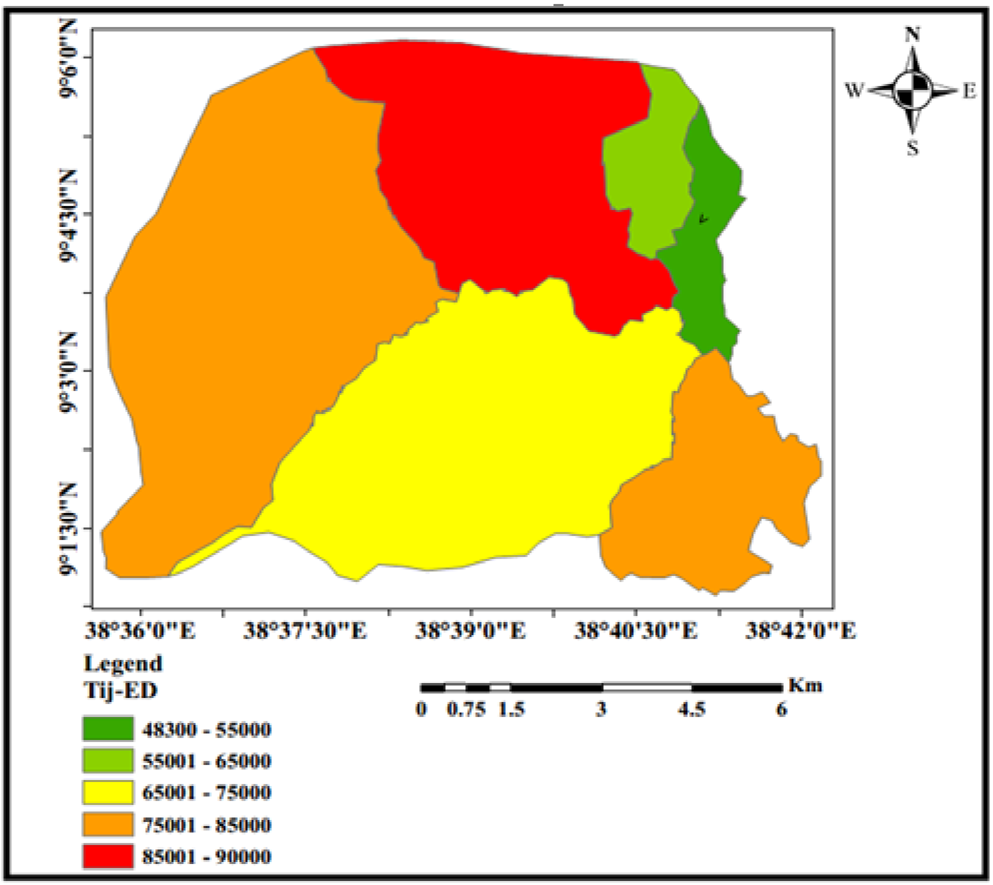

Fig 4.16 Trips passing through each zone by Euclidian-based trips

As shown in Fig 4.16, higher values can be observed in the central areas. Due to their remoteness and low demand, these values decrease as one move to the peripheral areas. For the Euclidian-based trips, zone 3 (locally known as Gefersa Burayu) has the highest value.

From these indicators, the researcher can conclude that:-

A. Areas with very low values show that the networks in these areas carry more demand than it has the capacity and need some kind of improvement. The improvement can be manifested in the form of diverting the traffic by constructing new connections, traffic management, or even by providing more public transport.

B. Areas with high values show there is a considerable amount of demand but the road infrastructure either need significant capacity improvement.

Spatial mismatch 1

The results of SMIs are shown in Fig 4.17, the values for SMI 1 range from 1.07 to 1.65, and the map is prepared by dividing these values quantitatively. The output shows lower mismatch values around the CBD city. Higher values correspond to higher mismatch and lower values show lower mismatch. Higher values can be observed in the periphery areas, especially in zone 4 and 6.

The zones with SMI 1 lower values follow a corridor showing a specific pattern in the network. In extreme zones 4 and 6 (locally known as Gefersa Guje and Malka Gefersa) even though these zones have higher demand, the existing network is very small to support it. Higher mismatch values can be observed mostly in peripheral zones, and some central areas.

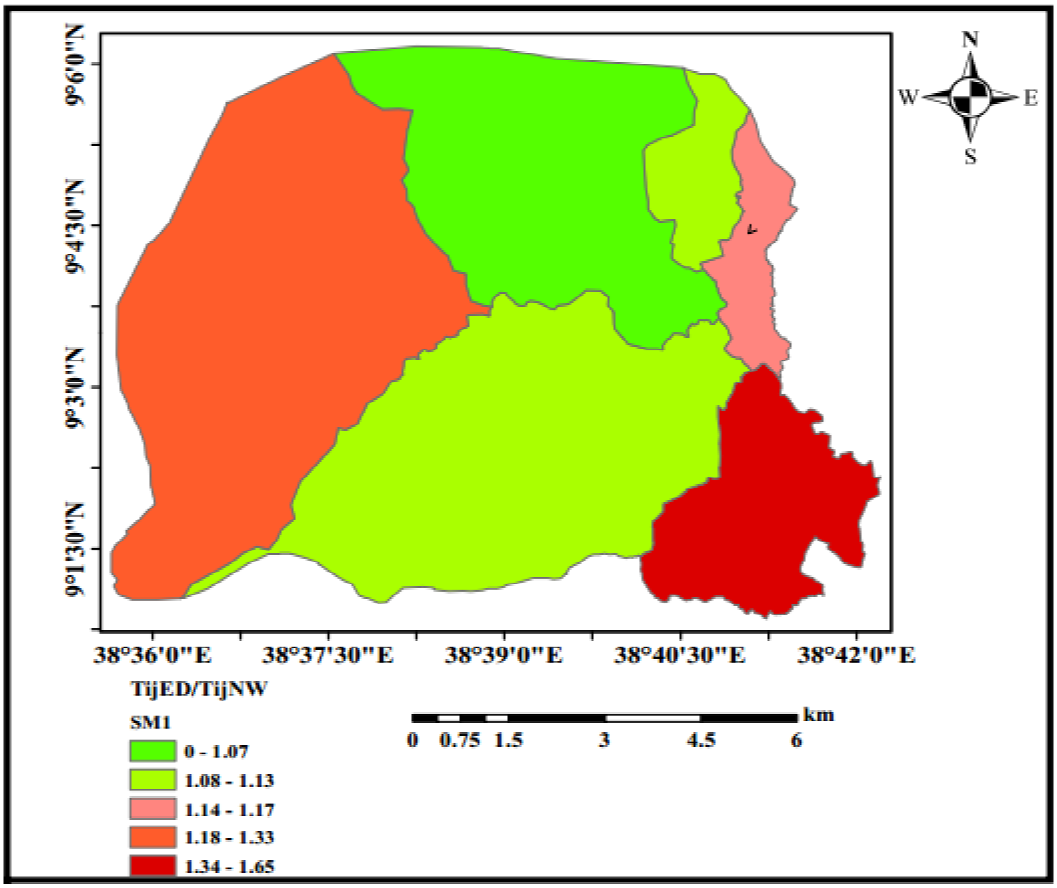

Fig 4.17 Spatial mismatch indices using the reference network and real network

Spatial mismatch 2

SMI 2, on the contrary, computes the difference between the Euclidian-based and network-based trips and had values ranging from 5,000 to 30,304. Higher values indicate high mismatch areas. Higher values can be observed in peripheral areas. Zone 4 and 6 (locally known as Gefersa Guje and Malka Gefersa) have the highest value Fig 4.18.

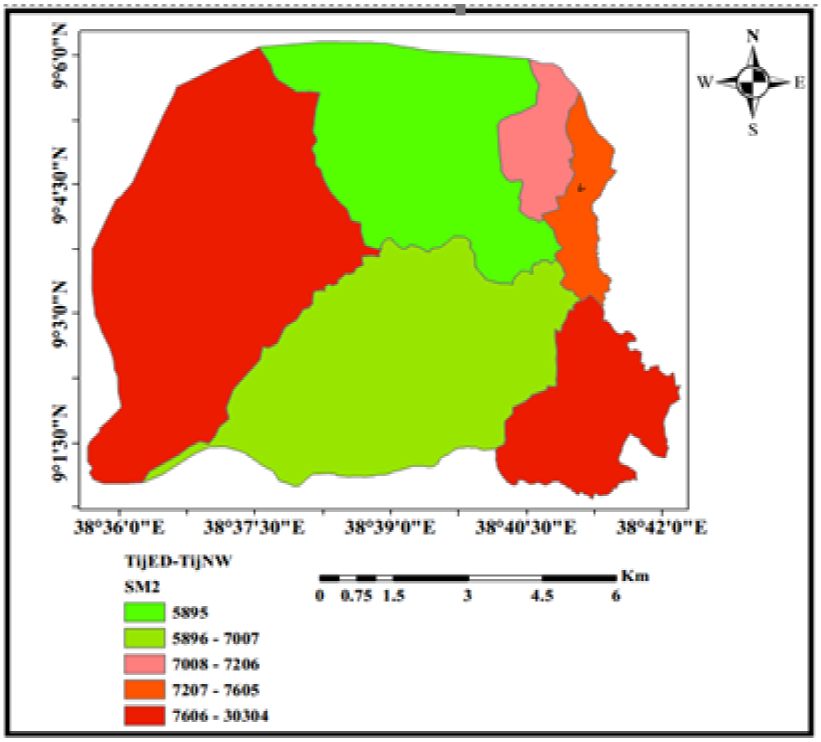

Fig 4.18 Spatial mismatch indices using the reference network and real network

From these indicators, the researcher can conclude that some of the periphery zones especially zone 4 and 6 lack road infrastructure. Areas with higher values show that the networks in these areas carry more demand than it has the capacity and need some kind of improvement. The improvement can be manifested in the form of diverting the traffic by constructing new connections, traffic management, or even by providing more public transport.

4.6. Linear referencing

The approach of recording geographic locations using relative positions and a measurable linear characteristic is known as linear referencing. To locate occurrences along the line, distance measurements are employed. The method of using a linear referencing measurement system to compute the map positions of events stored and controlled in an event table and show them on a map is known as dynamic segmentation.

4.6.1 Creating make route event layer (dynamic segmentation)

Once creating a route for the entire road one can say that it is ready for making the route event layer. A route feature class is a line feature class that has a defined measurement system. These measurement values can be used to locate events, and conditions along with their set of linear features. To speed up and facilitate the linear referencing process as well as finding the road width, lane number, traffic sign on the dynamically segmented road, known places of the study area (major places).

4.6.1.1 Dynamic segmentation by road width

Figure 4.19 illustrates that the roads are segmented through a defined criterion (road width in this case). For the case of Burayu Town, the road has seven different sizes of width (6, 7,8,9,10,14 and 16) meters. For each road, a given road width is assigned according to its width size. Furthermore, they are defined by different colors to distinguish various types of sizes of road width. Therefore, the segmented road along with the change point of the road width is seen clearly.

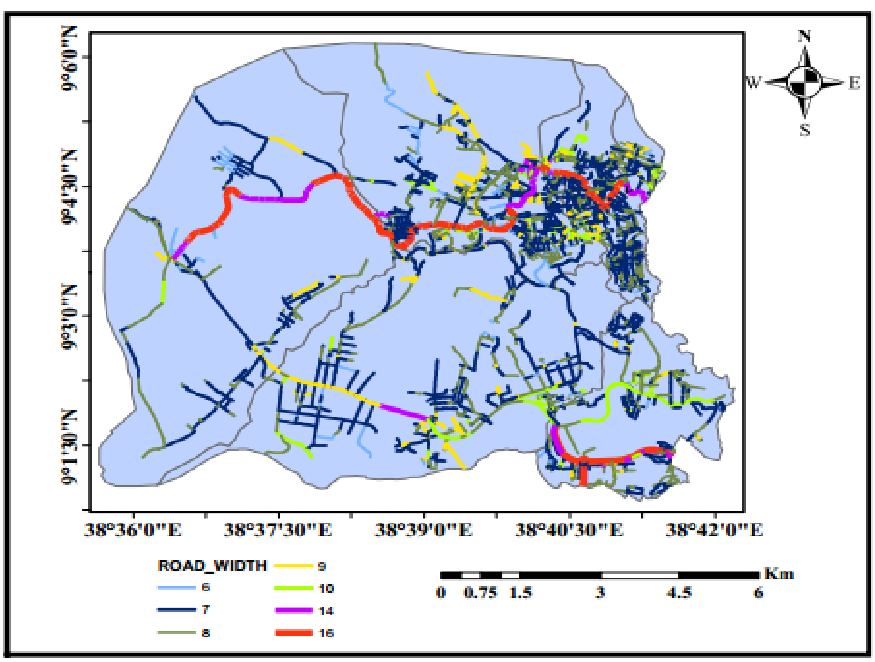

Fig 4.19: Dynamic segmentation taking road width as criteria.

4.6.1.2 Dynamic segmentation by lane number

The other criterion used for dynamic segmentation of the road other than road width is that of lane number of the road (the number of cars passes through the given road at a time or the number of lines on the given road that a car passes through). There are two types of lane numbers in the study area; a road with one lane, and a road with two lanes in the Fig 4.20.

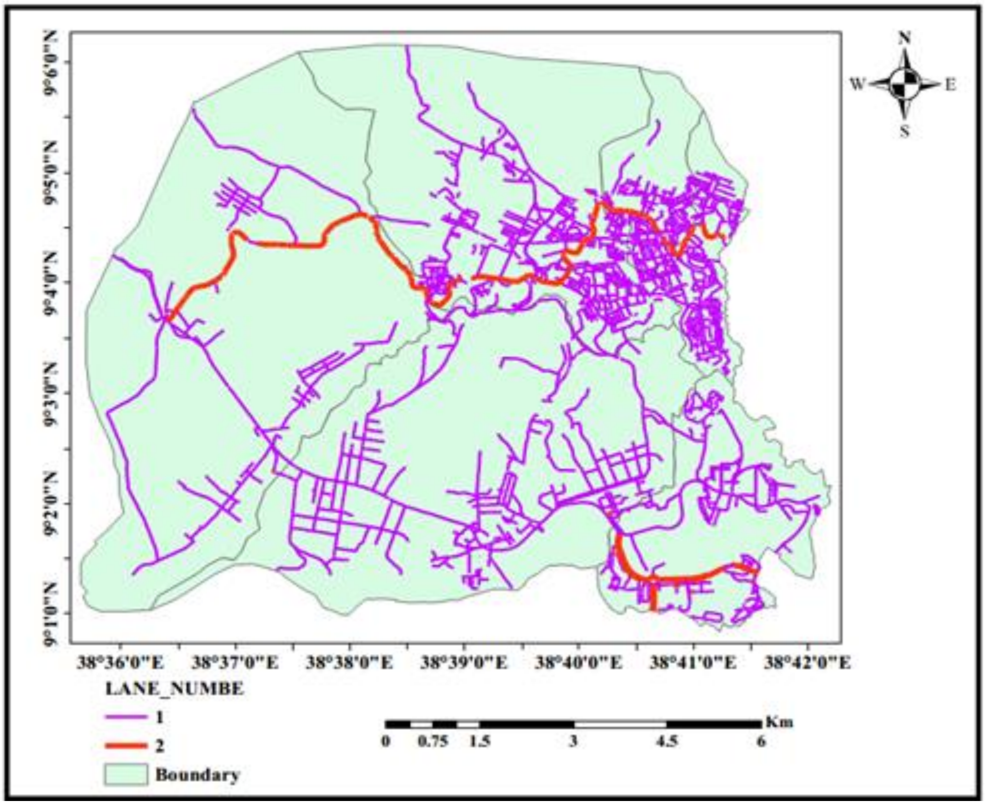

Fig 4.20: Dynamic segmentation taking lane number as a criteria

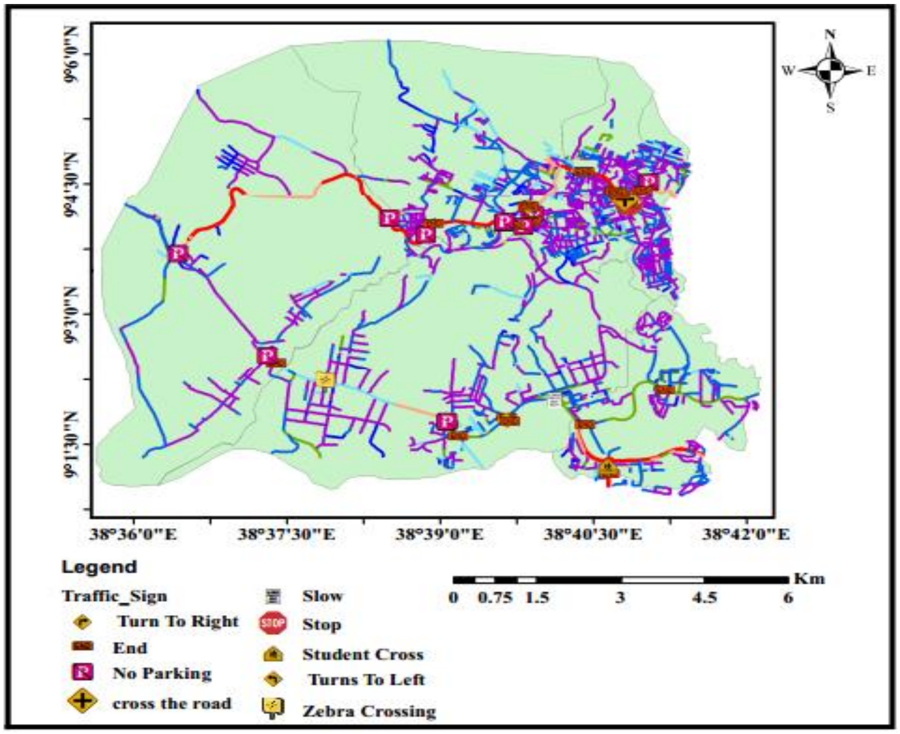

Fig 4.21: Map of traffic sign on the dynamically segmented road

Fig 4.21 shows the distribution of traffic signs throughout the Town, the type of traffic sign, which types of signs were found in which area. The traffic sign found in the study area is generally categorized into seven types; namely, No parking, END, DO NOT TURN, SLOW STOP, STUDENT CROSS THE ROAD, and zebra crossing, and for each of the signs a symbol is assigned.

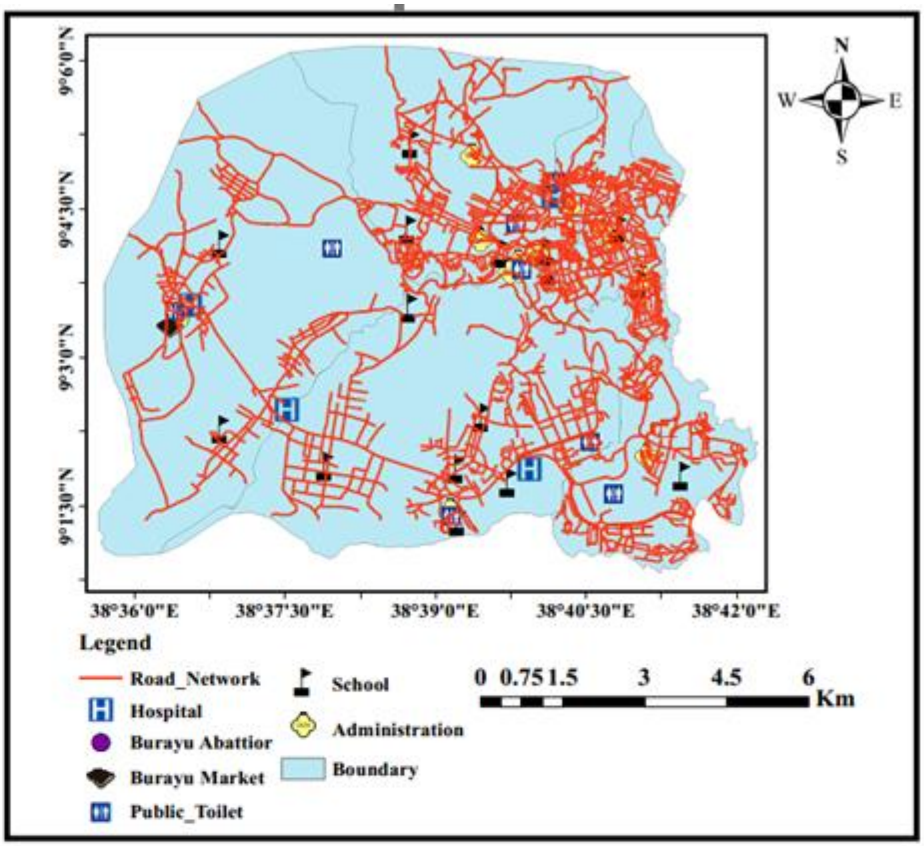

Fig 4.22: Known places of the study area

Fig 4.22 shows linear referencing and dynamic segmentation is the process of displaying linearly referenced features on a map furthermore which known place is found in which road name, at what distance from the given reference a given known place is found and identified in a good manner.

4.7 Network analysis

Using the network analyst one can perform types of network analyses like that of finding service area.

4.7.1 Finding service area

A network analyst can locate service regions near any network location. The service areas demonstrate how impedance affects accessibility. A network service area is a geographic area that includes all roadways that are accessible (that is, streets that are within specified impedance). Network analysts' service regions can also be used to assess accessibility. The term "accessibility" refers to how simple it is to access a site. Travel time, distance, or any other network impedance can all be used to determine accessibility. It might assist you in making other marketing decisions by identifying what is near an existing business. A buffer distance around a point is a simple approach to assess accessibility. ArcGIS network analyzers can study service networks computed by ArcGIS.

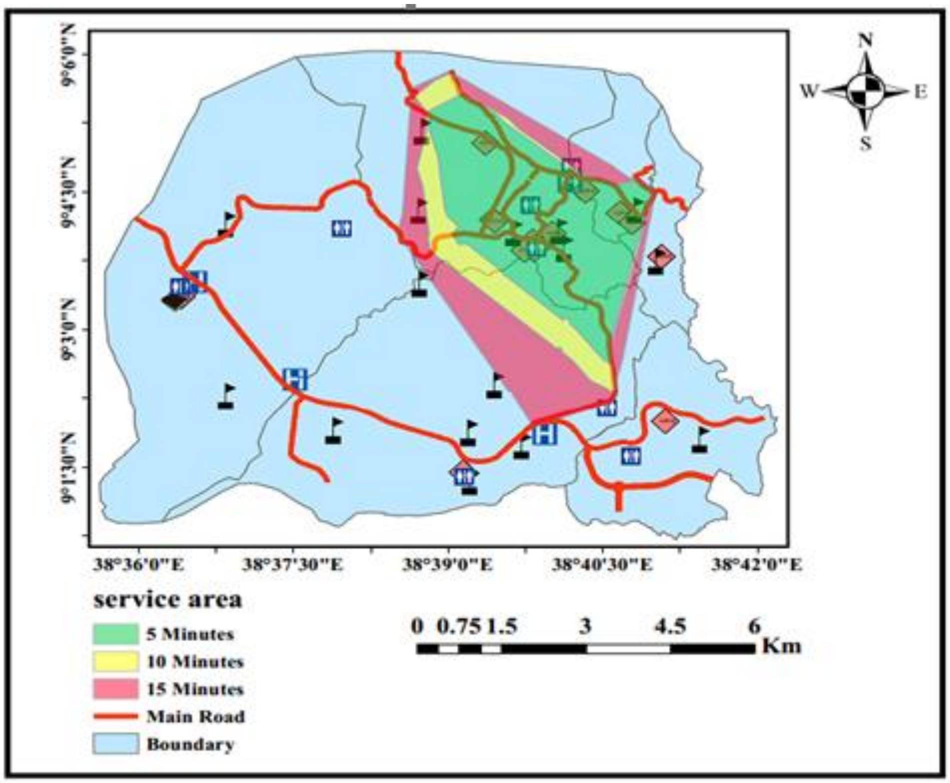

Fig 4.23 Service area coverage for a facility

Fig 4.23 illustrates, the analysis is done using the impedance drive time for a given facility. In this case, the analysis is done using the impedance drive time for specific facilities namely administration using three different default breaks; five minutes, ten minutes, and fifteen minutes impedances. Thus, it (the polygon) illustrates that administration serves that much of area within five-minute drive time, which is designated by green polygon, which means a person at administration, can have such a kind of services within five-minute drive time. The other one is that ten minutes' drive time, which means these facilities, can serve areas within this polygon, or a person at the areas (facilities) can get service within the polygon designated by yellow within ten minutes. The last one is within fifteen minutes drive time (impedance), which means these facilities can service within the polygon designated by red within fifteen minutes drive time.

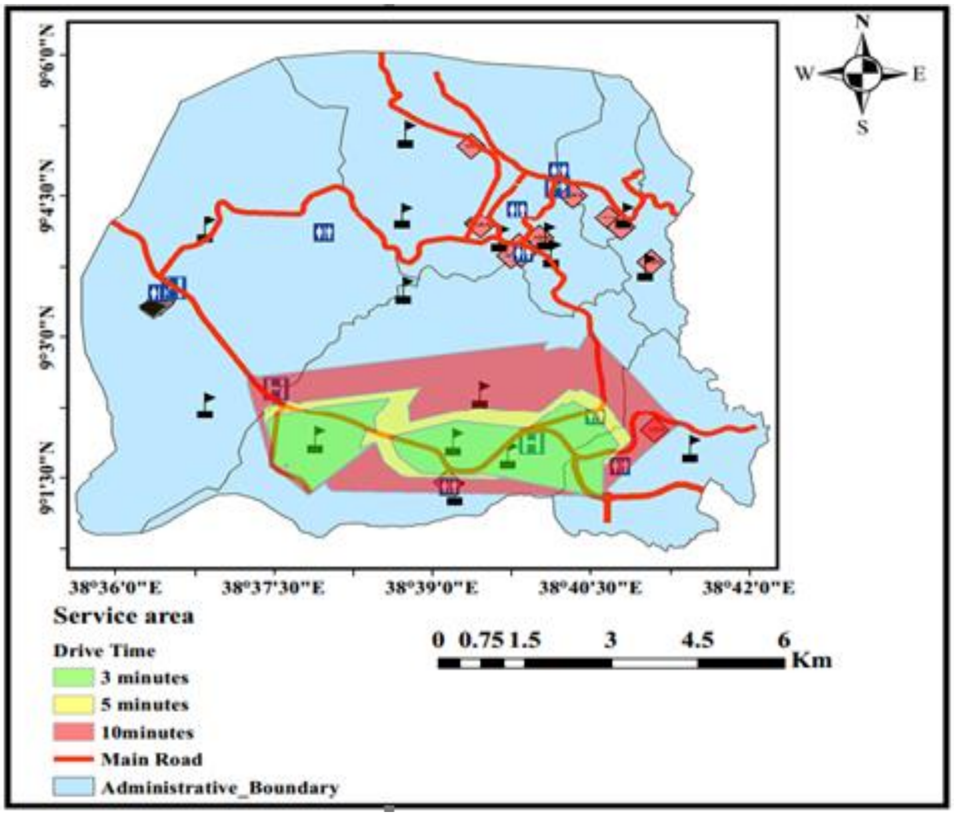

Fig 4.24 Service area coverage for a facility

In the Fig 4.24, the analysis is done using the impedance drive time for two specific facilities namely hospital and school using three different default breaks; three minutes, five minutes, and ten minutes impedances. Thus, it (the polygon) illustrates that both facilities (hospital and school) serve that much of area within three-minute drive time, which is designated by green polygon or a person at hospital and school, can have such a kind of services within three minutes' drive time. The other one is that five minutes' drive time, which means these five facilities, can serve areas within this polygon, or a person at the two areas (facilities) can get service within the polygon designated by yellow within five minutes. The last one is within ten minutes' drive time (impedance), which means these facilities can service within the polygon designated by red within ten minutes' drive time. The purpose of this study is to assess the road network's performance in Burayu Town. The road network's performance will be evaluated using several indicators such as road availability, road performance, and road serviceability.

A. Determination of the road density

To calculate the road density first we have to know the total road length and the total area the total area of Burayu Town is 90.57 $km^{2,}$ and the total road length constructed until 2021 G.C includes asphalt, gravel, and cobblestone. Resolve of the road density using total road length in km/90.57 km^2 (Ethiopian Road Authority, 2016).

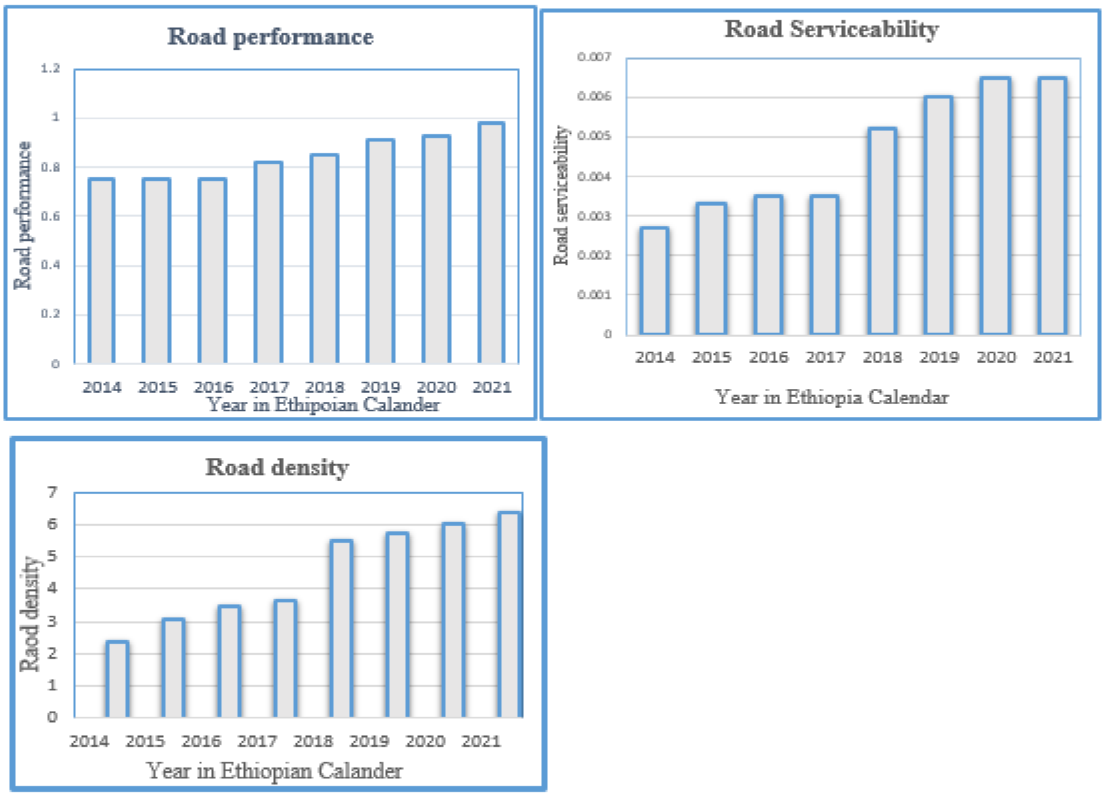

Fig 4.25 Trends of road network performance in the study area.

From the Fig 4.25 result, the trend in change of road density from 2014 G.C up to 2021 G.C Therefore, this result means the proportion of the area covered with the road in the Town is increasing which in other words enhancing mobility and accessibility in the Town. Given the number of elements involved in building the transportation network, their intricate relationships among factors, and their changing significance over time, understanding variation in road density is no easy feat. Therefore, from the above result, the trend in change of road density from 2014 G.C up to 2021 G.C is increasing insignificant. Therefore, this result means the ratio of the area covered with the road in the Town is insignificant increasing which in other words little enhances mobility and accessibility.

B. Determination of road performance

To calculate the road performance we have to know the total road length in stable condition and this is determined by deducting total gravel road length and total asphalt road with maintenance from the total road length because these types of road are not comfortable to ride (Ethiopian Road Authority, 2016).

The road performance in the Town has many effects like it increases in road maintenance cost because gravel roads have greater maintenance cost than paved roads also it increases the user operating cost due to poor quality of roads. Additionally, as we observe from the above results the trend in road performance is constant in some years like from 2014 to 2016, and then gradually increase starting from 2018. Therefore based on the evaluation indicator of road performance, increasing the total length of paved roads will increase road performance then the road network performance will be good.

C. Determination of road serviceability

The road serviceability is a ratio between the total lengths of the road with several populations in that area. The unit of this index is km/people using the equation we can calculate this as Total road length/population (Ethiopian Road Authority, 2016).

As Towns have grown, both in terms of their population size and functions, the relative advantage of locations and accessibility or serviceability within them has changed through time because of the development of new roads in response to the current pressure for development. Inevitably, these developments provide a different level of accessibility/serviceability to new locations. As a result, it will be easier to move between locations or cut travel costs, opening up new options and contributing to the economic life of certain business and social activities as well as residential areas. The ease with which people can get to their destinations is measured by accessibility. The higher the travel cost, the lower the accessibility. It also measures the value of destinations: the more activities there are at the destination, the more valuable it is for the people. as it is observed from the result, road serviceability in the Town is increasing gradually from 2018 up to 2021 but the rate of change is very low which means the construction of new roads is not much reachable by the peoples and to increase the accessibility/serviceability of roads in the Town we have to work hard in developing good road network in which it increases peoples benefit and development of the Town.

4.8 Discussion

Land-use land-cover changes have a wide range of consequences at all spatial and temporal scales. Because of these effects and influences, it has become one of the major problems for environmental change as well as influence the flow of traffic, accessibility, and mobility. Urban traffic faces many challenges, which are mainly caused by urban expansion and an increase in car ownership, which then influence both the flow of traffic and the environment.

According to Lencho (2019) model spatial-temporal urban land-use land-cover changes of Burayu Town using Landsat 1990, 2000, 2010, and 2019. The study results show urban land use land cover for the last three decades, the built-up area is increased by (44%) and the forestland (22%), agriculture land (5%), and shrub land (14%) are decreased. (Bedessa, 2014) Analyze urban expansion and modeling of land-use/land-cover changes in Adama city using Landsat 1973, 2000, and 2010. According to his results expansion of built-up increased from 2%in 1973, 10% in 2000, and 23% in 2010. (Gashu and Gebre-Egziabher, 2018) analyze of urban land-use and land-cover changes a case of Bahir Dar city. His results showed that there was an increased expansion of built-up areas in the last 25 years from 1.5% in 1986 to 4.1 % in 2001 and 9.4% in 2010. Similarly, in this study Burayu Town 2021 classified Land-use land-cover classes are increasing at an alarming rate over the years. Burayu Town land-use land-cover classes changes from (1990-2021) settlement is increased by 4,668.60ha (51.61%), the road is increased in small amounts by 406.52ha (4.26%). Generally, in 1990, about 200.72 hectares of land, or 2.22 % of the total area of Burayu Town was occupied by settlement. In 2021, the land occupied by settlement has increased to about 4869.33 hectares, which was 53.83% of the total area of the Town. Between these two years, the settlement has increased by about 4668.60 hectares of land or by 51.61%.

In 1990, about 90.71 hectares of land or 1% of the total area of Burayu Town was occupied by road. In 2021, the land occupied by road has increasing insignificant to about 497.23 hectares, which was 5.26% of the total area of the Town. Between these two years, the road has increased by about 406.52 hectares of land or by 4.26%. In 1990, about 1943.56 hectares of land, or 21.49 % of the total area of Burayu Town was occupied by agriculture. In 2021, the land occupied by agriculture has decreased to about 1038.62 hectares, which was 11.76% of the total area of the Town. Between these two years, agriculture has decreased by about 904.93 hectares of land or by 9.72%. In 1990, about 3115.77 hectares of land, or 34.45 % of the total area of Burayu Town was occupied by forest. In 2021, the land occupied by forest has decreased to about 1447.29 hectares, which was 15.98% of the total area of the Town. Between these two years, the forest has decreased by about 1668.48 hectares of land or by 18.47%. In 1990, shrubs occupied about 3571.89 hectares of land or 39.51 % of the total area of Burayu Town. In 2021, the land occupied by shrubs has decreased to about 1070.18 hectares, which was 11.83% of the total area of the Town. Between these two years, the shrub has decreased by about 2501.71 hectares of land or by 27.68%. According to (Lencho, 2019) the overall accuracy of classified Burayu Town land-use for 1990, 2000, 2010, and 2019 is 88%, 92%, 93.6%, and 97.6% respectively. The kappa coefficient agreement of classes and overall classification for the study periods were 0.85, 0.902, 0.92, and 0.97, respectively. (Balew et al., 2019) overall accuracy for 1987, 2002, and 2017 land-use and land-cover maps were 85.71%, 86.61%, and 92%, respectively. The kappa coefficient agreement of classes and overall classification for the study periods were 0.854, 0.864, and 0.92, respectively.

For this study ground, control points were collected from a known real study area. The total number of reference points 300 collected for the land-use land-cover classified map. Using the supervised classification method, maximum likely hood algorithm, the overall accuracy of classified Burayu Town land-use for 1990, 2000, 2010, and 2021 is 89.33%, 91.66%, 93%, and 97.33 respectively. The kappa coefficient agreement of classes and overall classification for the study periods were 0.88, 0.901, 0.92, and 0.96, respectively and it is acceptable.

In this particular project, the researcher had modeled the transport system to estimate the land-use transport interaction to ultimately determine the level of infrastructure that is required to support the economic activity in the study area. This can be used as an effort to develop a comprehensive transport plan for the city. By synthesizing various geographic, socioeconomic, infrastructure, and land-use planning aspects with current travel patterns as observed in the city. Based on the case study for Burayu Town, it is observed that had higher trip production and attraction is exhibited in the central area. These areas are characterized by high population and important socio-economic activities of the Town including employment centers and schools. In some zones within the CBD, the attraction potential is much higher than the production level, corresponding to the nature of the Town where economic activities are concentrated at one location. The road density per unit of the population shows there are some areas without a road;

especially, in areas that are situated at the periphery of the city. Proximity measures how many people can access the infrastructure within a certain distance. Considering a uniform distribution of the population over the area of each zone, the population density of the zones is computed. Proximity to the roads within the central areas is less than 500m, allowing more people to access these roads. However, in the peripheries, people have to travel more than 1km to access the existing road infrastructure, indicating the inadequacy of the system. Using a network analyst, one can find service areas around any location on a network. Service areas show how accessibility varies with impedance. In this case, the analysis is done using the impedance drive time for specific facilities namely administration using three different default breaks; five minutes, ten minutes, and fifteen minutes impedances.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Based on the five specific objectives the following conclusions were drawn.

Land-use land-cover changes have a wide range of consequences at all spatial and temporal scales. Because of these effects and influences, it has become one of the major problems for traffic congestion, pollution, road accidents, and environmental change. Identifying the interaction between changes and time is important to set decision-making mechanisms and construct alternative scenarios. The objectives of this study were first to analyze the urban land-use patterns using RS imageries. Secondly, assess potential travel demand in the study area. This study result shows Burayu Town land-use land-cover change is increasing at an alarming rate over the years. Burayu Town land-use land-cover classes changes from (1990-2021) are: settlement is increased by 4,668.60 ha (51.61%), the road is increased by 406.52 ha (4.26%), forestland is decreased by 1668.48 ha (18.47%), agricultural land is decreased by 904.93 ha (9.72%), shrub land is decreased by 2501.71ha (27.68%), and waterbody is neither increased nor decreased. The settlements in Burayu Town are mainly established along with the road network. In recent years, the economic and environmental implications of traffic congestion have been linked to the lack of coordination between transportation planning and land use. Urban traffic faces many challenges, which are mainly caused by urban expansion and an increase in car ownership, which then influence both the flow of traffic and road accidents. The main challenges are traffic congestion, pollution, and road accidents (Ewing et al., 2018). The total length of the whole existing roads of Burayu Town is 570.33 km from this, the total length of asphalt is 4.93 km, cobblestone is 124.28 km, and total length of gravel is 237.4 km the rest are earth pressed and red ash.

In this particular study, the researcher had modeled the transport system to estimate the land use transport interaction to ultimately determine the level of infrastructure that is essential to support the economic activity in the study area. This can be used as an effort to develop a comprehensive transport plan for the Town. Concerning the study for Burayu Town, it is observed that had higher trip production and attraction is exhibited in the central area. These areas are characterized by high population and important socio-economic activities of the Town including shopping, employment centers, and schools. In some zones within the central business district, the attraction potential is much higher than the production level, corresponding to the nature of the Town where economic activities are concentrated at one location. The road density, expressed as length per area, is found to be high in the central areas. Proximity to the roads within the central areas is less than 500m, allowing more people to access these roads. However, in the outskirts, people have to travel more than 1km to access the existing road infrastructure, indicating the inadequacy of the system This study focused on calculating the service area for a specific facility using travel time as an impedance to demonstrate the application of network analysis. The overall conclusion obtained from the indicators shows that there is less road infrastructure in the peripheral regions of the Town and the central area had a capacity limitation. In general, the number of public transport demand in Burayu Town was not balanced concerning several vehicles, which are served the existing travel demand of the Town.

5.2. Recommendations

Based on the findings of the study and conclusions, the following recommendations were drawn.

- More attention is given to diverting the traffic flow from the central areas to the peripheral areas by constructing new links or upgrading the existing roads. This eases the traffic load in the central areas but since the peripheral areas have long distances, the network is not efficient in respect to cost (considering distance as cost).
- This study results can be used as base information for the urban planner, land administration and management office, environmental protection office, to investigate impacts of land-use land-cover change and urban expansion to transport natural resources, and land resources management in the future.
- The use of high-resolution imageries such as IKONOS, Quick Bird, and SPOT is important in generating good quality land-use land-cover maps. Because it is difficult to map small parcels of land-use land-cover like urban areas in 1990 study periods and high-resolution imagery provides better information by mapping these areas. Therefore, for future studies, it is better to use high-resolution images to fill such kinds of gaps.
- From the master plan development of Burayu Town shows, the peripheral areas are reserved for further extension of industrial and residential land use, but in these areas, the road network is not well developed, which created obstacles to the mobility of people. Even though road network development was planned in these areas, it is not implemented due to unknown reasons.
- Rapid settlement increase has played a major role affecting land-use land-cover change and there should be strategic planning to monitor abrupt urban expansions of the Town from concerned governmental and non-governmental bodies (offices).

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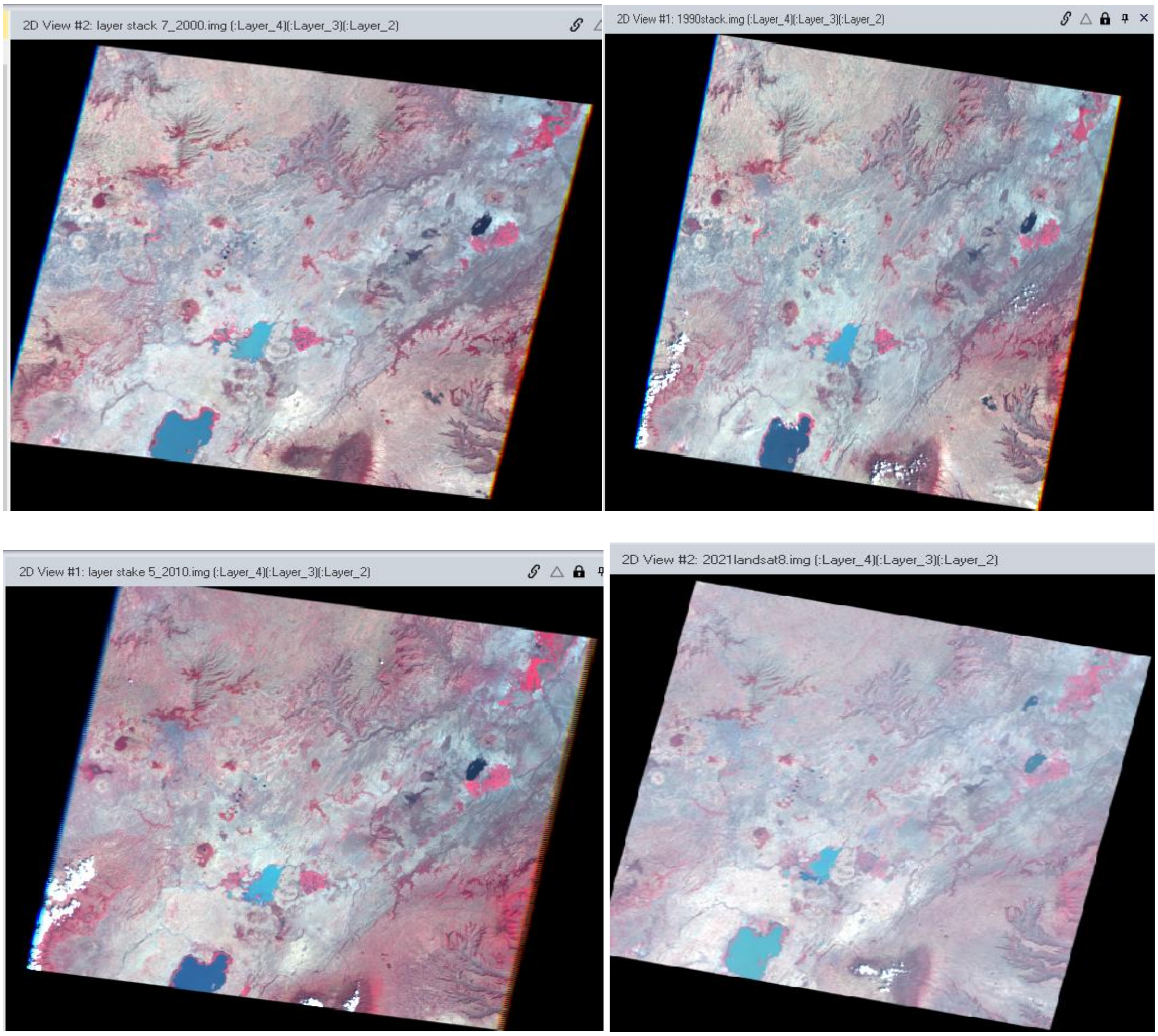
Appendix

Appendix 'A' Layer stack (Composites) land satellite image



Appendix 'B' Reference/ GCP Points

Table

Reference points

FID	Shape *	Classified	GrndTruth	Easting	Northing
1	Point	1	1	458730	1004730
2	Point	1	1	464130	998610
3	Point	1	1	465150	1004910
4	Point	1	1	460920	1003200
5	Point	1	1	463590	1005150
6	Point	1	1	461190	1005630
7	Point	1	1	460260	999210
8	Point	1	1	467040	998880
9	Point	1	1	458280	1001490
10	Point	1	1	459870	1005810
11	Point	1	1	459180	1003170
12	Point	1	1	461670	1003320
13	Point	1	1	459060	1005570
14	Point	1	1	462570	1001400
15	Point	1	1	456870	1002000
16	Point	1	1	461880	1005030
17	Point	1	1	466560	998700
18	Point	1	1	458970	1000830
19	Point	1	1	464400	1003560
20	Point	1	1	462690	1002420
21	Point	1	1	465720	1002330
22	Point	1	1	459660	996930
23	Point	1	1	463920	1001910
24	Point	1	1	463740	999420
25	Point	1	1	459840	1003980
27	Point	1	1	457950	1003830

1 (0 out of 305 Selected)

Reference points

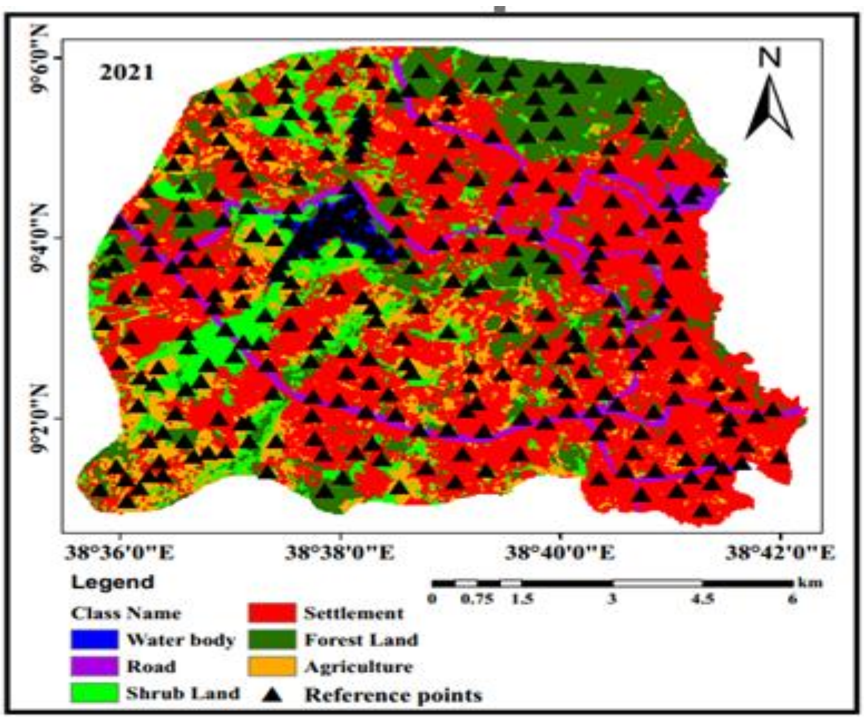


Table: Error matrix of Burayu Town LULC Classes in 1990

		REFERENCE DATA (1990)							
		Settlement	Forest Land	Water	Agriculture	Road	Shrub Land	Total Points	U.A (100%)
CLASSIFIED DATA (1990)	Settlement	43	0	2	1	2	0	48	89.58
	Forest Land	3	46	2	0	1	1	53	86.79
	Water body	0	0	41	2	0	2	45	91.11
	Agriculture	2	3	0	45	0	1	51	88.23
	Road	0	1	0	1	46	0	48	95.83
	Shrub Land	1	2	0	4	1	47	55	85.45
	Total Points	49	52	45	53	50	51	300	
	P.A (100%)	87.75	88.46	91.11	84.90	92	92.15		
	Overall Accuracy = 89.33%								
	Kappa Coefficient (K) = 0.88								

Table: Error matrix of Burayu Town LULC Classes in 2000

		REFERENCE DATA (2000)							
		Settlement	Forest Land	Water	Agriculture	Road	Shrub Land	Total Points	U.A (100%)
CLASSIFIED DATA (2000)	Settlement	46	0	1	1	0	0	48	95.83
	Forest Land	0	43	1	2	1	0	50	86.00
	Water body	1	2	45	0	0	0	48	93.75
	Agriculture	1	2	0	48	2	2	55	87.27
	Road	0	1	0	1	46	1	49	93.87
	Shrub Land	2	3	0	0	1	47	53	88.67
	Total Points	50	51	47	52	50	50	300	
	P.A (100%)	92.00	84.31	95.74	92.30	92.00	94.00		
	Overall Accuracy = 91.66%								
	Kappa Coefficient (K) = 0.901								

Table: Error matrix of Burayu Town LULC Classes in 2010

		REFERENCE DATA (2010)							
		Settlement	Forest Land	Water	Agriculture	Road	Shrub Land	Total Points	U.A (100%)
CLASSIFIED DATA (2010)	Settlement	48	1	1	0	0	1	51	92.16
	Forest Land	1	46	0	2	1	2	52	92
	Water body	0	0	45	1	0	0	46	97.67
	Agriculture	2	1	1	45		1	50	86
	Road	0	0	0	1	48	0	49	95.23
	Shrub Land	1	2	0	1	1	47	52	88.63
	Total Points	52	50	47	50	50	51	300	
	P.A (100%)	95.91	92	97.67	87.75	88.88	88.63		
	Overall Accuracy = 93%								
	Kappa Coefficient (K) = 0.91								

Appendix ‘C’: Socioeconomic data

No	kebeles	Total Number of households			Total number of Population			Area
		Male	Female	Total	Male	Female	Total	hectare
	Laku Kata	6306	1604	7910	14847	17443	32290	285.25
2	Burayu kata	5476	878	6354	30285	26006	56291	1087.67
3	Gefersa Burayu	8609	3545	12154	50762	40552	91314	1391.175
4	Gefersa Guje	12453	2197	14650	48357	32685	81042	3170.87
5	Gefersa Nono	7385	3345	10730	34912	39846	74758	2215.54
6	Malka Gefersa	6329	1170	7499	19850	18804	39654	876.866
	Total	46,558	12,375	59,297	199,013	176,336	375,349	9057.365

Table: Burayu Town Road Density Trend and Road Serviceability (2014 -2021)

Year	Road density
2013/2014 G.C	2.38
2014/2015 G.C	3.09
2015/2016 G.C	3.47
2016/2017 G.C	3.62
2017/2018 G.C	5.53
2018/2019 G.C	5.75
2019/2020 G.C	6.05
2020/2021 G.C	6.37

Year	Road Serviceability
2013/2014 G.C	0.0027
2014/2015 G.C	0.0033
2015/2016 G.C	0.0035
2016/2017 G.C	0.0035
2017/2018 G.C	0.0052
2018/2019 G.C	0.0052
2019/2020 G.C	0.0053
2020/2021 G.C	0.0053

Table: Road performance Trend (2014 -2021)

Year	Road performance
2006 E.C or 2013/2014 G.C	0.75
2007 E.C or 2014/2015 G.C	0.75
2008 E.C or 2015/2016 G.C	0.78
2009 E.C or 2016/2017 G.C	0.82
2010 E.C or 2017/2018 G.C	0.85
2011 E.C or 2018/2019 G.C	0.91
2012 E.C or 2019/2020 G.C	0.93
2013 E.C or 2020/2021 G.C	0.98

Appendix ‘D’: Regressions equation for trip attraction and production

Trip production	Equation	Symbols
Work trip	1.46*w	W=number of workers
Educational trip	1.68*St	St=number of student
Other trip	0.199*Pop	Pop=population
Non home based trip	0.023*Pop	Pop=population
Trip Attraction		
Total work trip	1.57*E	E=Employment
Total educational trip	1.67*St	St=Number of student
Total other purpose trips	0.86*E	E=Employment
Total non-home based trips	0.069*E	E=Employment

Source: Urban Transport Study (2018)

Appendix 'E': Interview Questionnaire

ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY (AAIT)

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

MSc in Geodesy and Geomatics Program (Specialization: Geomatics)

Interview Questionnaire

Dear Head of Household

Subject: Questionnaire about public transport demand users in Burayu Town.

This questionnaire aims to collect social and economic data related to households. These data will be used to study their effect on the number of trips (i.e. work trips, educational trips, shopping trips, and recreational trips) using public transport such as Rick show, minibus, city bus or others that household makes and to develop a trip generation model for Burayu Town.

General Information about the (sample) respondents

The questionnaires and interview guides are aimed to collect data for the research on the topic: Performance Assessment of Road Transport Network and Urban Land Use Interaction: The Case of Burayu Town Using GIS and Remote Sensing, Ethiopia.

Instruction: Circle the letter of your choice or fill the blank spaces

1. What mode of transport do you use most frequently for the purpose of?

A) Work: 1) walking 2) public transport 3) Private automobile 4) vehicles supplied by employee 5) motor bicycle

If your answer is public transport, which type of mode do you use?

1) Auto rickshaw 2) mini bus 3) public bus

B) Education: 1) 1) walking 2) public transport 3) Private Automobile 4) vehicles supplied by the employee (service) 5) motor bicycle

If your answer is public transport, which type of mode you use?

1) Auto rickshaw 2) mini bus 3) public bus

C) Shopping: 1) walking 2) public transport 3) Private Automobile 4) vehicles Supplied by employee 5) motor bicycle

If your answer is public transport, which type of mode you use?

1) Auto rickshaw 2) mini bus 3) public bus

D) Recreation: 1) walking 2) public transport 3) Private Automobile 4) vehicles Supplied by employee 5) motor bicycle

If your answer is public transport, which type of mode you use?

1) Auto rickshaw 2) mini bus 3) public bus

2. If you use public city bus transport for any of the above purpose on average how much time is lost to:

1) Waiting for bus at stops 1) 1-5min 2) 5-10min 3) 10-15min 4) above 20min

2) Arrive to your destination stops 1) 1-5min 2) 5-10min 3) 10-15min 4) above 20min

3. If you use mini bus for any of the above purpose on average how much time is lost to:

1) Waiting for mini bus at stops 1) 1-5min 2) 5-10min 3) 10-15min 4) above 20min

2) Arrive to your destination stops 1) 1-5min 2) 5-10min 3) 10-15min 4) above 20min

4. If you use Auto rickshaw for at list one of the above purpose on average how much time is lost to:

1) Waiting for Bajaj at stops 1.) 1-5min 2.) 5-10min 3.) 10-15min 4.) Above 20min

2) Arrive to your destination stops 1.) 1-5min 2.) 5-10min 3.) 10-15min 4.) Above 20min

5. Which zone is your most often trip destination locations for the purpose of?

1) Work ________________

2) Education________________

3) Shopping________________

4) Recreation _______________

6. The reason for selection of the above mode of transport (question number 1) is

1 No other option 2 Best in terms of cost 3 best in terms of comfort

4 if any other________________

7. Have you ever participated in transportation planning program at any Administration level of the Town government?

1/ Not at all 2/ yes sometimes 3/ Yes always

Stakeholder participation

8. Is the land use transport integration well considered in the transport planning and forecasting of future demand?

9. How do you decide to construct a new road or upgrade the existing road? What is the criterion (such as accessibility and connectivity) used for the selection of the projects for intervention?

10. Which part of Burayu Town is not well served by the network? Are there already identified areas suffering from inadequate infrastructure?

11. Is the land use transport integration well considered in the transport planning and forecasting of future demand?