PLANNING FOR SMART TRANSPORTATION SYSTEM IN URBAN KENYA

A CASE OF ELDORET MUNICIPALITY

BY

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DECLARATION

Declaration by the Candidate

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DEDICATION

I dedicate this thesis to my family and friends for supporting me throughout my academic life. This work could not have been possible without their continuous support and words of encouragement.

ABSTRACT

Transport Systems are essential for the development of economies of nations. Even so, transportation itself, and more so, the use of automobiles has negative environmental externalities that threaten the very existence of humanity such the generation of greenhouse gases. Other negative impacts of transportation include human safety issues through traffic accidents causing injury and even deaths. The main objective of this study was to develop an efficient urban mobility system for Eldoret Municipality. The study was guided by a series of specific objectives which were: to establish the origin and destination patterns of traffic within the Municipality, to establish the modal split, to determine infrastructure capacities for Smart Transport within Eldoret Municipality, to determine the relationship between urban mobility patterns and noise and emission levels in Eldoret Municipality and to determine the socio-economic effects associated with urban mobility systems within the Municipality. The study area covered the entire Eldoret Municipality in Uasin Gishu County with an area of approximately 148 km^2. The study adopted mixed methods research as the preferred research design involving the use of both qualitative and quantitative methods for both data collection and data analysis. Systematic random sampling was used to obtain respondents who were found within the identified four Gordon points where specific data was collected. Data from nine (9) modes of transport was also collected. The Data was collected by use of both primary and secondary methods which included the use of questionnaires, key informant interviews, observation, use of global positioning systems (GPS), photography and literature from various sources such as books and journals. Data was subjected to SPSS, Ms excel and Arc GIS 10.5. The data then underwent both qualitative and quantitative analysis where the findings were presented using graphs, charts, tables and statements. Findings illustrates that transportation in Eldoret municipality is unsustainable. There is heavy use of automobiles as compared to greener options such as cycling and walking. The infrastructural carrying capacity is overstretched with high number of automobiles leading to traffic congestion. The study concludes that in order to achieve a smart urban transportation system there is need for an integrated approach in the implementation of transportation policy. Provision of feasible and convenient alternatives to car use, provision of high-quality public transportation systems as well as secure and opportune walking and cycling facilities have been recommended as opportunities for making urban transport green in Eldoret Municipality.

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LIST OF ABBREVIATIONS

BRT	Bus Rapid Transport
GCEC	Global Commission on Economy and Climate
GIS	Geographic Information Systems
GoK	Government of Kenya
GPS	Geographical Positioning System
ICT	Information Communication Technology
INTP	Integrated National Transport Policy
ITDP	The Institute for Transportation and Development Policy
ITS	Intelligent Transport Service
KENHA	Kenya National Highways Authority
KNBS	Kenya National Bureau of Statistics
KRB	Kenya Roads Board
KURA	Kenya Urban Roads Authority
MT	Motorized Transport
NEMA	National Environment Management Authority

NGO	Non-Governmental Organization
NMT	Non-Motorized Transport
SPSS	Statistical Package for Social Sciences
UACA	Urban Areas and Cities Act
UCLG	United Cities Local Governments
UNFCC	United Nations Framework Convention on Climate Change
WCED	World Commission on Environment and Development
WHO	World Health Organization

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CHAPTER ONE

INTRODUCTION

1.1 Overview

This chapter presents the background to the study, statement of the problem, objectives of the study, research questions and justification for the study.

1.2 Background to the Study

Cities are engines of economic growth of countries around the world. This is because 80% of global economic output comes from cities (Marceau, 2008). In order to create economically dynamic and healthier cities, there is need to develop more compact and connected urban development. A compact, connected and coordinated city harnesses its growth potential by facilitating a central function and therefore, facilitating access for its people, to goods and services. Emerging cities can take lead in developing compact, connected and coordinated smart urban development model because of the fact that a substantive section of their infrastructure has not been constructed (The Global Commission on the Economy and Climate, 2014).

The 2030 Agenda for Sustainable Development, the Addis Ababa Action Agenda and the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCC) provide a supportive structure for addressing Urbanization. Goal number eleven on the 2030 Agenda intends to make cities and human settlements inclusive, safe and sustainable (Watson, 2016). In order to achieve this new urban agenda, emphasis should be put on the concept of smart cities (United Nations, 2016).

A smart city is defined as an urban setup that is creative, sustainable and provides friendlier environment for future economic development that that generally improves the quality of life (Jung et al., 2014).

There are six indicators of a smart city which include; smart economy, smart governance, smart citizen, smart living, smart environment and smart mobility/or transport (Winkowska et al., 2019). The growth of the economy of a city is attributed to its well designed and efficient transport system as a smart transportation system contributes to all aspects of a smart city.

Transportation and mobility is the most important aspect of a smart city due to its influence on all the other indicators (Joshi et al., 2018).

The Agenda 2063 is the blueprint and master plan for changing Africa into the global capital in the future. The agenda has a number of flagship projects with the major infrastructure project being an integrated high speed train network which will connect all African capitals and commercial centres and thus facilitate the movement of goods and people. The increased connectivity by rail will reduce transport costs and reduce congestion on the roads (Agenda 2063, 2015).

In Kenya, some of the major infrastructural projects include the Standard Gauge Railway, the Lamu Port South Sudan Ethiopia Transport (LAPSSET) Corridor among other projects. These projects are expected to have a significant positive impact in the transport sector.

Eldoret Town is one of the fastest growing towns in Kenya. It functions as agricultural, transportation and commercial hub within the North Rift Region (NOREB).). The population

of Eldoret was found to be 475,716 as per the 2019 Kenya National Population and Housing Census (2019). The Kenya National Bureau of Statistics however projected the population of Eldoret Municipality to over 1,335,242 people by the year 2050 . There is therefore the need to develop a smart transport system to match the demand of the increasing population.

It is estimated that there are approximately 1.42 billion cars in the world as at 2019 and is expected to double in the next decade (World Economic Forum, 2016). The major problem facing transportation is the high rates of pollution because of the high number of cars on the roads. The City of China in Asia is among the most polluted with approximately 280 vehicles per kilometre making it among the most crowded in the World.

In the majority of urban centres across the globe, the expansion in the use of motor vehicle and the high travel demand has rendered urban transport one of the major contributors to urban island effects, local air pollution and greenhouse gas emissions. In upcoming economies the situation is dire, with growing metropolitan regions experiencing some of the world's acute levels of pollution (Li et al., 2020). Measures and policies have been put in place to manage transportation sector to mitigate both the high demand on transport as a result of economic growth as well as a safety measure towards the environment and human health. Nonetheless, to a large extent, these measures and policies have had preposterously different results, with some ironically leading to increase in pollution that they seek to solve. Air pollution and climate change are the major threats to human health that arise from the high demand and growth of transport sector. In the year 2016, the World Health Organization (WHO) reported about seven million deaths from numerous life-shortening diseases including heart diseases, lung cancer and stroke. This challenges mostly experienced in

rapidly developing nations as a result of exponential increase in the combustion of fossil fuels to meet demand and supply forces, inadequate clean technologies and poor enforcement of environmental regulations. Due to the rapid increase in private vehicle ownership and travel demands, poor fuel efficiency in developing countries, the transportation sector is significant in addressing local air quality.

Some policies have been employed across the world to solve the transportation challenge. Policies to promote modal shifts include: the expansion of public transport. This is the first defence line for most local governments. In Beijing for instance, more than sixty-seven million dollars was invested in transportation infrastructure between the year 2007 and 2015, expanding public transit networks, adding fourteen new subway lines and more than two hundred bus routes and 3,300 new buses. Similar adjustments are in progress in India, Mexico and other developing nations. The stimulation of economic activities and trade has been noted to be one major benefit of this mode of tackling transportation challenges (Redding & Turner, 2015). Restriction on driving and vehicle purchases is the second policy used to promote modal shifts. This refers to the governments' influence on the demand-side policies to incentivize travellers to change their travel behaviour such as driving less during congestions and using public transport rather than private vehicles. These are commonly referred to as command and control approaches. For instance, Germany, cities have enforced low emission zone policies, which restrict high-polluting vehicles form moving in certain areas (Wolff, 2014). Congestion pricing is also another form of command and control. It is a market-based policy tool to affect travel behaviours such as travel time, distance, frequency and modes.

Nevertheless, the implementation of congestion pricing is yet to be implemented in developing nations (Li et al., 2020).

Policies to promote alternative fuel vehicles technologies have started gaining momentum world over. These are guidelines that have come about amid the concern on energy security and transportation-based air pollution and greenhouse gas emissions. Alternative fuel automobile includes flexible fuel vehicle, hybrid rechargeable vehicles, battery-operated electric vehicle, plug-in hybrid electric vehicles, fuel cell vehicles and natural gas vehicles(Jacobsen & Van Benthem, 2015). Alternative fuel vehicle offers alternative solutions to mitigate and potential to do away with environmental externalities that come with petroleum usage. Policies to support the use of alternative fuel vehicles include subsidies for adoption of alternative fuel vehicles. This include the use tax credits and rebates (Jacobsen & Van Benthem, 2015). Besides subsidies for alternative fuel vehicles, governments also need to offer subsidies on the construction of alternative fuel vehicle fuelling stations.

Fuel standards and emission regulations can be subjected upon vehicle producers to lower pollution. Fuel-Economy Standards among the main policies that has been used to improve fleet-wide fuel efficiency by requiring vehicle manufactures to manufacture fuel efficient vehicles. Nine countries, that is, United State of America, the European Union, Japan and China have put in place fuel economy and greenhouse gas emission standards for public service vehicles, where automaker have to meet these standards in their vehicle production. Vehicle manufactures who fail to meet these standards are required to either pay a penalty or purchase regulatory credits from the market under the credit-trading regime (Busse et al., 2013; Grigolon et al., 2018). Fuel-content Regulations and a Tail pipe Emission Standards

have also been implemented in these countries to restrict the chemical composition of the fuel as way of lowering the toxic pollutants from fuel combustion. An example is the European Union's Fuel Quality Directive that mandates sulphur levels of less than 10 ppm for both gasoline and disease vehicles.

1.3 Statement of the problem

Cities in the 21st century face major challenges which include rapid urbanism, transportation congestion, wasteful consumption of resources and environmental degradation. Traffic congestion is among the major transport challenges with most people preferring private cars as opposed to the use of public transport making our cities unsustainable (Hussein, 2013).

In Africa, some of the challenges facing transport systems within the urban areas include poor resource allocation, lack of regulatory frameworks, institutional weaknesses, inefficient public transport systems, poor allocation of spaces for transport infrastructure and inadequate traffic management systems. The major challenge in Kenyan cities in regards to urban mobility is the lack of balance between the provision of traffic infrastructure for both motorized (MT) and Non-Motorized (NMT) transport. (Angira, 2013).

Eldoret Town is the fifth largest town in Kenya and one of the fastest growing urban centres and is currently awaiting city status. Over the last few years, the town has been experiencing high rates of traffic congestions especially on the major arteries that connect to the Central Business District (Komollo, 2010). This congestion has led to increased rates of pollution and thus temperature increases. The pollution due to traffic congestion has ramifications on the health of the residents. The congestion has led to the waste of money, time and man hours

and thus negatively affecting the economy. From the population of 475,716 people as per the 2019 Kenya National Population and Housing Census (2019) the municipality is projected to have over 1,335,242 people by the year 2050 as indicated by the Kenya National Bureau of Statistics. With this boom in population the demand on transportation infrastructure may be unmanageable in the near future if the status quo is maintained.

With a referral hospital, an airport, several major universities and college campuses, Eldoret is famed home of athletics champions. It is also famed to be one of the country's food baskets. In Eldoret residents have had to contend with heavy traffic jams snarl ups. Immobile vehicles in long queues have become a common phenomenon. Senseless hooting, arrogance by touts and obstructions by impatient matatu drivers are the norm, culminating in loss of thousands of working hours every week. The north rift town's steep growth over the recent years has not been matched with proportionate expansion of road space. The ever-busy Uganda road passes through the town in an agonizingly single lane and roads that lead into the town are insufficient too. The Eldoret Kapsabet road is as busy as Uganda road as it leads to the densely populated Langas estate, and cuts through to Eldoret airport which adds to the population especially in the morning and late in the evenings when flights arrive and take off. The age of devolution too has led to traffic congestions. There has been a phenomenal upsurge of people who have come into the town in search of opportunities. Both the formal and informal sectors are growing at a pace with the demand for services that the current road infrastructure is not able to match. Cargo trucks, buses and vehicles travelling through the town yet these motorists have no business in town. Since there is no by-pass, they end up adding to the snarl-ups. Careless driving and bodaboda operators add to Eldoret town traffic

menace as the matatu drivers pick and drop passengers at any point. The availability of pedestrian walkways and cyclist lanes is inadequate. Arguably, the ever-increasing number of private motor vehicle owners has overstretched the town's capacity to accommodate vehicles within this area.

Despite being annoyance traffic congestion has got a lot of negative consequences which include reducing regional economic wealth since it wastes time resulting in delays and hence late arrivals for employment, meetings and education. The inability to forecast travel time accurately leads to drivers allocating more time on travel and less time on productive activities. Wasting of fuel and air pollution due to idling, acceleration and braking are among the salient negative impacts of traffic congestion. Stressed and frustrated motorists lead to road rage and reduced health of motorists. Blocked traffic interferes with the passage of emergency vehicles travelling to their destinations where they are urgently needed. The stagnation of vehicles in one geographical location creates a heat island effect hence adversely pollutes the environment creating unhealthy conditions in the vicinity. The spill over effect from congested main arteries to secondary roads and side streets as alternative routes are attempted hence affecting neighbourhood's amenity and real estate prices. Last but not least traffic congestion leads to a higher chance of collisions due to tight spacing and constant stopping-and-going.

1.4 Objectives of the study

The general objective of the study was to develop an efficient urban mobility system for Eldoret Municipality

1.4.1 Specific objectives

i. To establish the origin and destination patterns of traffic within the Municipality

ii. To establish the modal split in Eldoret Municipality

iii. To determine infrastructure capacities for smart transport within Eldoret Municipality

iv. To determine the relationship between urban mobility patterns and environmental effects of transport systems on noise and emission levels in Eldoret Municipality

v. To determine the socio- economic effects of urban mobility systems within the municipality

1.5 Research questions

i. How can the transportation system in Eldoret be made smart?

ii. What is the composition of traffic along the various roads within Eldoret Municipality?

iii. How adequate are parking spaces in Eldoret Town?

iv. What is the level of pollution from the transport sector?

v. What are the socio-economic effects of urban mobility in Eldoret town?

1.6 Justification of the study

The designing and development of sustainable transportation system is considered one of the most urgent issues in developing countries. Given the rapid urban population and sprawling

of developments into low density downtown, most urban dwellers heavily rely on the use of automobile which have negative environmental consequences. It is unclear which is the best way to attain a sustainable future given the multitude of stakeholders involved, the complexity of urban ecosystems and the split bdecision-making nature in most urban regions. This study was intended to develop a smart transportation plan for Eldoret Municipality to ensure that there is less congestion, less pollution and no accidents through an approach that promotes a smart transport system for a smart city. It is vital to ensure that the flow of traffic is sustainable such that it is efficient and safe.

A smart transportation system will be of utmost importance in realization of the “Big Four Agenda” as it will act as a link between the various sectors such as agriculture, health, housing and manufacturing and therefore measures need to be put in place to ensure its provision and thus a major enabler to the ‘’Big Four Agenda’’ (Government of Kenya, 2018). A smart transport system ensures that there is link between agricultural farms and the market, promotes the health sector by ensuring that lives are saved in the access to health services, links the industries to markets thus promoting manufacturing as well as promoting the sector will be incomplete without the provision of a smart transport system.

This was to be achieved through the promotion of smart mobility options such as mass transit systems as well as individual mobility systems in order to achieve efficiency. Some of the mass transit systems for an efficient public transport system include the use of bus rapid transit system and the metro rail system as it provides cities with affordable solutions to ensure that their transit systems keep pace with the ever-increasing urban population. This was to ensure that public needs are put over private needs (United Nations, 2016). The study

also intended to develop a transportation plan for the Municipality to ensure that there is less congestion, less pollution and no accidents through an approach that promotes smart transport systems.

Making the Kenyan urban transportation system green calls for policies that promote a change in travel behaviour. Whereas it might be more challenging to achieve than enhanced technology, travel behaviour change has proven to be of greater and lasting sustainability gains in Germany. In the transport sector to achieve sustainability means, first, promoting the use less energy demanding and environment friendly modes of transport for shorter trips. Second, promote economic development, improving transport safety, achieving equal access to destination for all members of the society and better quality of life.

It is however important to note that different cities have different needs. It is therefore imperative for cities to consider their urban problems in a holistic manner so as to choose the best option that suits them. This means that there is need to localize their solution to the problems facing them. This is because some technologies may be too expensive especially for developing countries (United Nations, 2016). The study therefore considered this approach by localizing the solution to the problems facing Eldoret Municipality to ensure its sustainability.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

This chapter presents a review of literature on various aspects of urban development. The chapter is divided into various subheadings which include: the concept of smart cities, smart transport systems, urban transportation challenges, urban mobility planning strategies, examples of best practices of smart transportation systems globally, urban mobility systems, policy legal and institutional frameworks of urban transport in Kenya, theories of urban transport and the conceptual framework of the study.

2.2 Urban transportation challenges

Greenhouse gas emissions from the transport sector are the main causes of air pollution. Statistics show that that there are three million deaths each year in cities worldwide as a result of air pollution. Emissions from the transport sector have been increasing in the recent years. With the increase in the traffic volumes over the years, it is expected that cities would adopt sustainable modes but that is not the case. Instead, there is little use of sustainable transport modes and technologies in order to ensure healthy and friendlier cities.

Most cities lack an integrated plan to guide development. This leads to uncontrolled development and therefore management of such a city is difficult. The development of an efficient public transport system is therefore not possible in such a case.

Another major urban transportation problem is tall rate of road traffic accidents. World Health Organization (WHO) estimates that 1.25 million individuals die from road accidents

each year with the most affected being the pedestrians and cyclists. This therefore makes road traffic accidents the leading cause of unnatural deaths in most cities.

2.3 Solutions to Urban transportation problems

There are a number of innovative solutions to solve the current urban transportation problems.

2.3.1 Transport telematics

One way is by enhancing collective passenger transport by making public transportation more attractive through the use of modern technology. In order to achieve this goal, it is important to promote a more sustainable approach to mobility planning within urban areas. This calls for collaborations between operators in the public transport sector and those from the public sector where policies are made.

In order to make urban transportation more attractive and efficient, it is essential that cities use modern transport telematics systems which promote the use of modern technology to control traffic movement. This is achieved through the use cameras installed at strategic locations, use of Geographical Positioning Systems (GPS), satellite-based applications and automated traffic counting devices. The use of technology will also enhance other activities such as facilitation of ticketing and giving real time information to both the drivers and passengers and therefore enable them to make proper decisions. The use of these modern technologies ensures that public transportation is given a priority to make it attractive as well as ensuring that there is efficient flow of traffic and proper management of parking. Therefore the use of technology is encouraged because information collected will be used by decision-makers to make decisions (Boschetti et al., 2014).

2.3.2 Safety measures

In a bid to ensure safety of all transport users, there are numerous measures put in place. They include ensuring authorities' responsible ensure road users comply with traffic rules, that road infrastructure is safe, use of safer vehicles, and the promotion of the use of modern technology for efficiency. The road safety improvement measures should be implemented through cycling, walking, public transport (Boschetti et al., 2014)

2.3.3 Alternative strategies to car ownership

One of the most innovative ways to avoid the increase in the number of private cars is to promote strategies such as car sharing, the promotion of non-motorized modes such as cycling and walking and also ensuring that there is better infrastructure.

2.3.4 Use of clean fuels and vehicles

One of the measures to ensure that the environment is not polluted is by use of cleaner vehicles and fuels. This reduces the detrimental effects that result from emissions and thus protect human life particularly those that reside within the urban areas. In order to realize the implementation of this practice, some cities especially in Europe offer special parking tariffs for those cars with low emission as well as financial rewards (Boschetti et al., 2014).

2.4 Understanding the Concept of Smart Cities and Smart Transportation system

Cities are the centres for human and economic activity. Cities are hubs that avail a lot of opportunities to their inhabitants given their great potential to create synergies. Nonetheless, cities can also create problems that multiply in size and complexity. Inequalities in cities tend to be on the extreme and without proper mediation, the negative effects of cities can easily

overwhelm the positive impacts. There is need for urban areas to manage their development to promote economic competitiveness at the same time enhancing social cohesion, environmental sustainability and an increased quality of its residents (Monzon, 2015). With recent global technological development in more so in information communication technology, the “Smart City” concept emerged as a strategy to achieve more efficient sustainable cities. Since its inception, the smart urban concept has been transformed and its application on specific projects to the execution of international measures to solve urban challenges.

2.4.1 Smart Cities

The ASCIMER Project (Assessing Smart Cities in the Mediterranean Region) defined a smart city as an integrated system in which human and social capital interact using technology-based solutions. It is aimed at resilient and sustainable development, high quality of life on the multi-stakeholder basis and municipality-based partnership. The common ground in defining smart cities has been that they should embody innovation in city management, services and infrastructure. Many authors emphasize on the interconnection of all urban aspects while defining smart cities. This thus points at infrastructure as the focal point and technology as the enabler of combination, connection and integration of all systems to make a city smart (Monzon, 2015; Nam & Pardo, 2011). This thus demonstrates that the smart city concept implies a comprehensive approach to city management and development. There must be a balance of the technological, economic and the social aspects in an urban setup for it to be referred to as smart. It echoes a holistic approach to urban misfortunes maximising the use of new technologies so as to redefine urban model and relationships

among stakeholders (Batty et al., 2012). The major innovations that arise from the Smart City concept are the rise of user-friendly approach that puts into consideration urban issues from the perspective of the citizen's needs, the participation of citizens in the city functioning. There are various dimensions towards the smart city concept as follows:

i. Smart living

Smart living refers to the ability of a smart city to be free from slum proliferation by combating urban sprawl and providing affordable housing to the most vulnerable population of the urban setup. It also includes putting in place mechanisms for emergency management. For smart living to be achieved cities should be free from urban violence and insecurity. This also includes safety and security from health problems and cyber-crimes. The urban population should be free to have a cultural identity free from threats.

ii. **Smart People**

Smart people is another dimension of smart cities that aims at eradicating low education levels among the urban population, reduction and or complete eradication of urban poverty. It also emphasises on the reduction of the gap between the government and the governed. This aspect also sheds light on the needs of the ageing population, promoting social cohesion and social diversity as a source of innovation.

iii. Smart Governance

Smart Governance focuses on how to deal with low urban institutional capacity that is formal and informal government, instability in governance, urban youth problems such as

unemployment, shortage in access to technology and unbalanced geographical development. Dealing with these challenges in smart cities leads to territorial cohesion and flexibility in governance.

iv. Smart Economy

Smart economy dimension of the smart city concept is about dealing with economy weakness and lack of competitiveness that is mono-sector economy, limited urban based industries and high infrastructure deficit in smart cities. In so doing smart economy seeks to deal with challenges of infrastructure deficit, economic decline and promoting sustainable local economies.

v. Smart Environment

Smart environment is a dimension of the smart city concept that aims to deal with topics of scarcity of resources through a holistic approach to environmental issues, climate change and effects of climate change, water scarcity, rapid growth and pollution. This factor puts the urban ecosystem under pressure as such smart environment seeks to deal with these issues by proposing among others energy saving alternatives.

vi. Smart Transport/ Smart Mobility

The concept of Smart transport emerged after a long-time use of the traditional transportation systems where the different transportation modes such as road transport, rail transport and air transport operated independently causing inefficiency in the transport sector.

The smart transportation system which is also referred to as Intelligent Transport Systems enables the use of Information Communication and Technology (ICT) to facilitate interaction between the various transport modes for proper functioning of the entire transport system. It is through the use of smart transportation system that there are concepts such as global airway hubs, intercity railway networks, intelligent road networks, protected cycle routes, protected pedestrian paths and integrated public transport for a safe, rapid, cost effective and reliable transportation (Mohanty et al., 2016). Smart transport or smart mobility seeks to tackle issues of lack of public transport by introducing new alternatives such as inclusive mobility, non-car mobility, multimodal public transport system and dealing with challenges of traffic congestion.

Smart transport systems connect mixed-use, employment housing and commercial clusters. Some of the examples of smart transport systems include Rapid Bus Transit (BRT), bicycle "superhighways", car and bicycle-sharing, smarter traffic information systems and the use of electric vehicles with charging point networks using renewable sources of energy such as solar energy. It should however be noted that for effectiveness of smart transport systems, other smart urban utilities should be promoted such as the use efficient energy, street lighting technology and smarter, more efficient buildings (The Global Commission on the Economy and Climate, 2014).

The concept of smart cities is an emerging concept with the aim of solving the high number of urban issues through the use of technology. This is because of the fact that there is rapid urbanization in world and therefore cities face emerging challenges (Allam, 2018).

A smart city is an instrumented, interconnected and intelligent city. It has the following characteristics; smart energy, smart data, smart transport, smart infrastructure, connected devices and connected mobility (Haleem, 2018).

One of the objectives of a smart city is to offer perfect mobility among other services which include access to city services such as health, education, employment opportunities and affordable housing. The use of Information Communication and Technology (ICT) is a prerequisite of smart cities with the support of energy efficiency and sustainability. For proper functioning of smart cities, it is incumbent for local authorities to be accountable, transparent and to be empowered. Smart cities are intended to take care of the needs of both the current and the future generations (Çelikyay, 2017)

According to United Cities Local Governments (UCLG, 2012), smart as a new city model are more liveable, functional, competitive, use new technologies, innovative and manageable cities (Çelikyay, 2017).

2.5 Smart Cities Planning Concepts

Over time, cities have witnessed the emergence of numerous planning concepts which include modern, sustainable, resilient, eco, low carbon and knowledge cities. The concept of smart cities is seen as a new way of solving emerging urban challenges and therefore addresses human needs and thus achieving sustainability. It should however be noted that this concept should be implemented through an inclusive and holistic approach to overcome emerging global urbanization pitfalls such as city fragmentation (Allam, 2018).

In order to achieve productivity within urban areas, cities need to adopt a compact, connected and coordinated approach to urban development. A compact approach will enable cities manage their expansion and thereby facilitate high density development which is complemented by green spaces to achieve liveability. Connected infrastructure encompasses the use of innovation and technology in urban infrastructure with more focus shifting towards smart transport systems. A coordinated form of governance ensures that institutions both at the National and the local level are empowered to facilitate proper planning and implementation across both the public and private sectors. Areas of interest under coordinated governance include land use change and transport (The Global Commission on the Economy and Climate, 2014).

2.6 Best practices of Smart Transportation systems

A number of countries world over have made momentous improvement in their transport systems to ensure they are smart. This sections is a review of some of the best transport systems globally.

2.6.1 Barcelona, Spain

Barcelona is one of the cities in the globe with a smart transport system for smart mobility. Trains and buses are used for public transportation with internet connectivity to be fully accessed by the passengers. Information about the time for the arrival of buses is displayed at the city bus stops so that passengers don't waste their time. There is also the use of sensors and GIS technology to facilitate parking for commuters with the usage of a smart mobile. The use of bicycles to link different transportation places has also been a great success in Barcelona.

For efficiency in the parking system, the City of Barcelona uses a smart parking system which includes the use of wireless parking sensors placed at parking bays which senses the occupancy of each space thus sending information to a central management unit. This technology aims at reducing congestion while at the similar time reducing carbon-dioxide emissions (Madakam & Ramachandran, 2015).

2.6.2 Singapore

In order to avoid traffic congestion, Singapore has implemented the use of a sophisticated Intelligent Transport system. There is cooperation between the intelligent transport services and other transport services such as free public transportation, quota system, congestion charge and the public transport system.

This system is also used to alert motorists to traffic accidents and other occurrences on the road therefore providing real-time traffic information to the public.

The use of this technology has propelled Singapore to be one of the least congested major cities with its ever increasing population (*Smart Mobility 2030 Its Strategic Plan for Singapore,* 2014).

2.6.3 Amsterdam, Netherlands

Amsterdam is one of the Europe's most sustainable cities in as far as transportation is concerned. The city offers convenient, safe and alternatives that are accepted by people. The city has been referred to as the cycling capital of Europe because of its preference on the use of bicycles as compared to the dependence of cars. In the year 2008, cycling accounted for thirty eight percent of all transport modes making it the leading transport mode. Cycling has

many advantages including the fact that it has no air or noise pollution, economical and equitable. The city restricts access of cars to the city centre with many streets reserved for pedestrians. There is also provision of bike parking facilities especially at the train stations (Buehler & Pucher, 2010).

2.7 Urban Mobility systems

Urban mobility refers to the movement of people or freight in urban areas and consists of all urban transportation systems. There are three broad categories of urban mobility. They include collective, individual and freight transportation. Collective transportation is also referred to as public transit and aims at ensuring that the public can access mobility within a town or a city and includes modes such as buses, trams and trains. Individual transportation is determined by a person and includes modes such as walking and cycling. Freight transportation encompasses the transportation of goods between various parts within an urban area (Rodrigue, 2017).

One of the ways of achieving an efficient urban mobility is to promote the use of smart mobility. Smart mobility refers to an approach that aims at congestion reduction thus promoting faster, cheaper and greener transportation options. In order for efficiency in smart mobility systems, data is collected from a variety of sources to provide information about mobility patterns. Some of the smart mobility options include mass transit systems such as bus rapid transport and the metro rail system. Other individual mobility systems include bicycle sharing, ride sharing, vehicle sharing and more recently on-demand transportation (United Nations, 2016).

One way to make cities more attractive and facilitate economic growth is the promotion of the use of sustainable mobility. This is because a city or a town with an attractive transport system is a liveable city.

According to Urban Mobility Strategies for Liveable Cities, (2016), there are three principles of an integrated and an environmentally-friendly urban mobility. One is the principle of avoiding transport by promoting a compact, mixed-use development. This ensures that several functions are carried out within a designated area thus minimal transport is involved. The second principle is by shifting transport. This is an approach where traditional methods of transport use are not used and instead shifting to attractive and the use of non-motorized means of transport. The third approach is improving transport by making it safe and efficient by ways such as reduction in speed limits Policy, Legal and Institutional Frameworks of Urban Transport in Kenya

The following are the laws, policies and institutions governing transportation in Kenya.

2.7.1 Vision 2030

The Kenya Vision 2030 is the nation's long –term growth plan which aims to create a universally competitive and prosperous nation offering a high superior of life for all its citizens. It aspires to change Kenya into a newly industrializing, middle-income country by 2030. It is based on three pillars; economic, social and political. Infrastructural development is addressed under the economic pillar where the country is to be connected through a network of roads, railways, ports, airports and telecommunications (Government of Kenya, 2007).

2.7.2 Integrated National Transport Policy

The theme of the policy paper on Integrated National Transport Policy for Kenya is '*Moving a Working Nation'*. The policy paper identifies challenges besetting the transport sector in Kenya all of which are experienced in Eldoret Town and its vision of achieving a world class integrated transport system intends to address the challenges (Government of Kenya, 2009).

2.7.3 Urban Areas and Cities Act, 2011

Section (9) of the Urban Areas and Cities Act, 2011 provides for elevation of a town to the rank of a Municipality. The Act defines a Municipality as an area whose population is at least two hundred and fifty thousand residents as at the time of the last populace and housing census and has an integrated development plan for other requirements. Based on these requirements, Eldoret Town qualifies to be a municipality (*Urban Areas and Cities Act, No. 13 of 2011*, 2011)

In accordance with this Act, each city and municipality is expected to operate within the context of an integrated development planning. That plan will provide the basis for the provision of infrastructural services such as transport. In Kenya, the institution mandated to carry out census is the Kenya National Bureau of Statistics (KNBS).

The management of a city or a municipality shall be vested in the County Government and administered on its behalf by a board constituted inline with section 13 or 14 of the Urban Areas and Cities Act, 2011. The functions of the board includes; overseeing the activities of the city or municipality, developing and adopting policies, plans, strategies and programmes, articulate and implement an cohesive development plan, control land use, land sub-division,

land development and zoning by civic and private sectors for any purpose including transportation (*Urban Areas and Cities Act, No. 13 of 2011*, 2011). In this case, the County Government in charge of the administration of Eldoret Town which is the town under consideration is the County Government of Uasin Gishu.

2.7.4 County Government Act, 2012

The Act gives effect to Chapter Eleven of the Constitution; to provide for County Governments' authorities, roles and responsibilities to deliver services and for connected purposes. It identifies the County Governments as corporate bodies with perpetual succession and shall have all the powers of cooperate bodies. Part XI of the County Government Act, 2012 is devoted to County Planning.

2.7.5 The Physical and Land Use Planning Act No. 13, 2019

It is an Act of parliament that was passed in 2017. The Act regulates all physical planning and land use activities in Kenya. It establishes two levels of planning; National and County levels. Section 14(1) establishes the County Physical and Land use Planning Consultative Forum. The functions of the forum include providing a platform for consultation on County and Inter-County Physical and Land Use Development Plans, promotion of effective coordination and integration of Physical and land use development and sector plans.

Section 36(1) states that once in every ten years, a County Government shall prepare a County Physical and Land Use development Plan for that County. Section 37 (c) is to provide for a basis for infrastructure and services delivery. Section (g) provides transport and communication networks and linkages.

2.7.6 Key Institutions

The institutional theory of organization portrays institutions as the domain of analysis of organizations at the core of the analysis of organizations design and conduct (Meyer, 2017). As such, organizations are local instantiations of wider institutions. Institutions are defined as beliefs, rules and norms that shape the creation and spreading of organizational forms, design features, and practices (Berthod, 2016). Complying with institutionalized practices and standards is considered a means to legitimacy, decrease in uncertainty, and increase in intelligibility of organization's actions and activities. Organizations are not sovereign, they must operate with a number of external influences such as differences in culture, legal provisions, conventions, norms and demands raised by a diversity of culture for instance NGOs, regulatory agencies etc. The outcome beliefs, rules, and persisting expectations explain choices in formal structures and organizational practices (e.g., ISO norms, information technologies, CSR standards, or the divisional form).

Institutions, broadly speaking, are those beliefs, rules, roles, and symbolic elements capable of affecting organizational forms independent of resource flows and technical requirements. These beliefs, rules, roles and symbolic elements could be of different nature for instance regulative, those that are required or enforced by the rule of law, normative, those that are enforced by a common sense of the right thing to do, for instance it is expected that elected leaders represent the interests of the constituents. Otherwise, we have cognitive, that is those that are not serious us such, that is mental models of how work should be conducted, more so in instances of routine behaviour in organizations.

i. Ministry of Transport, Infrastructure, Housing and Urban Development

This is the Ministry in charge of transport at the National level. It is in charge of policy formulation and also large-scale infrastructural projects. Its vision is to be a global leader in the provision of transport infrastructure, maritime economy, the built environment and sustainable urban development.

The Ministry consists of the following five State departments; the state department for transport, the state department for infrastructure, the state department for housing and urban development, the state department for maritime and shipping affairs and the state department for public works. Some of the institutions under the Ministry include the Kenya Roads Board, the Kenya National Highways Authority, The Kenya Urban Roads Authority and the Kenya Rural Roads Authority (Government of Kenya, 2016).

ii. The County Government

County Governments are devolved units formed under Article 176 of the Constitution of Kenya 2010 and comprise of both the County Assembly and the County Executive (*Constitution of Kenya*, 2010).

County Governments' powers, functions and responsibilities to deliver services and for connected purposes are provided for in the County Government's Act, 2012. Section 105(1) of the County Government Act provides for the formation of a county planning unit. The designated planning authority in the county is required to appropriately organize for the effective implementation of the planning function within the county- Section 105(2). According to Section 107 (1) to guide, harmonize and facilitate the development within each

county there shall be the following plans; County integrated development plan, county sectoral plans, county spatial plan, Urban areas and cities plans as provided for under the Urban Areas and Cities Act, 2011 (G.O.K, 2012).

2.8 Theories of Urban Transport

This study used the theoretical work of sustainability from the Brundtland report titled "Our Common Future" and the Nested model on sustainability. The World Commission on Environment and Development (WCED), 1987 focused on sustainable development with three main pillars; environment, social and economic pillars.

The three pillars aim at achieving a sustainable transport system to enhance an efficient urban mobility. Therefore, in a bid to achieve sustainability, it is important to address the above-mentioned pillars. The major limitation of these three dimensions to sustainability is that it lacks a way to prioritize between the conflicting and prioritizing factors (Pryn et al., 2014).

2.8.1 The Nested Model on Sustainability

The Nested model was developed by ecological economists Dala and Costanza. The model was developed in order to address the challenges of the Brundtland report, the major challenge being the lack of prioritization between the three pillars of sustainability. The model is therefore proposed as an alternative approach to the intersected model.

This model showed three pillars of sustainability in which the economic circle is nested with the social circle to come up with socio-economic circle which is in turn nested with the environmental circle. This is thus an improvement of the model depicted in the Brundtland report as this nested model shows that the environmental pillar is of paramount importance

as it supports the other two pillars. This model therefore places a hierarchy among the three pillars of sustainability.

In this regard, in order to ensure improvement in the transport sector, there is need to promote more sustainable transportation systems that would prioritize the environmental pillar. These sustainable transportation options include the use of light rail, use of mass transit systems and the use of cycling to minimize the release of carbon-dioxide (Pryn et al., 2014).

2.9 Conceptual Framework

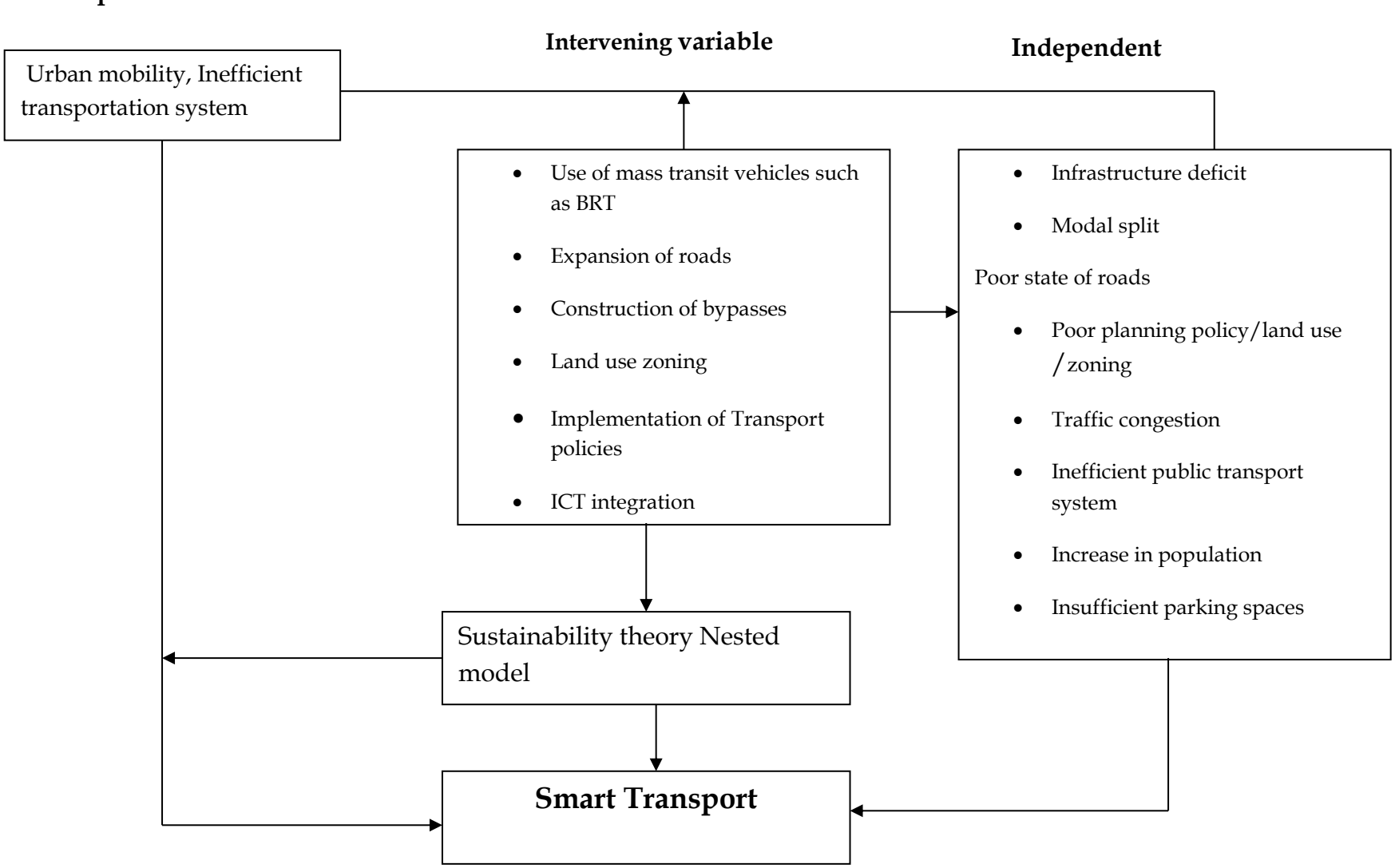

Figure 2.1 Conceptual Framework

Source: Author, 2023

2.10 Theory of Change (Toc)

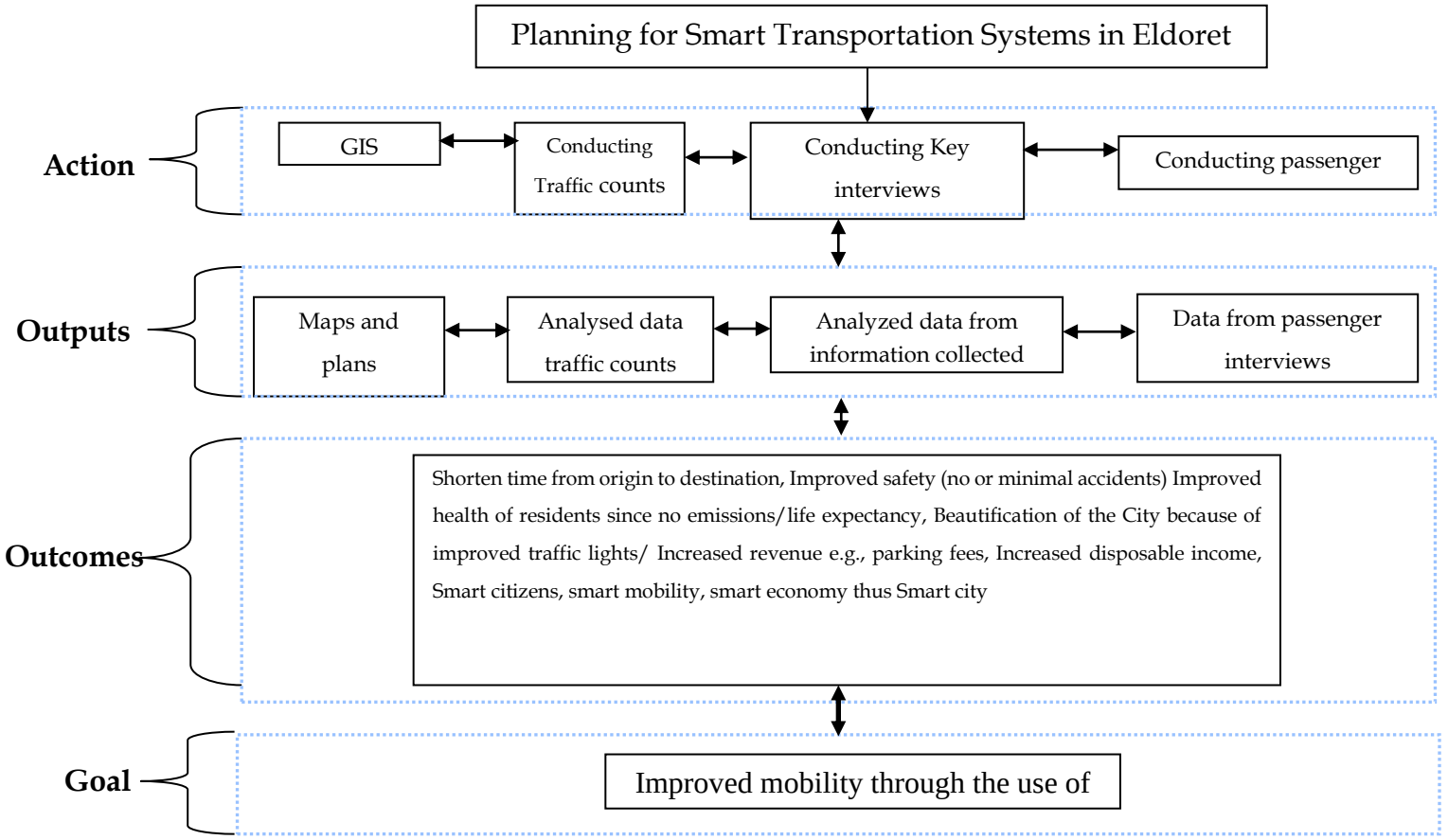

Figure 2.2 Theory of Change

(Source: Author, 2023)

CHAPTER THREE

RESEARCH METHOLOGY

3.1 Overview

Methodology is the systematic, theoretical analysis of the methods applied to a field of study, or the theoretical analysis of the body of methods and principles associated with a branch of knowledge. This chapter focused on the presentation of research methods that was used in the carrying out of the study. Its components include study area, research design, target population, sampling procedure and sample scope determination, research instruments, data collecting procedure and data analysis.

3.2 Study area

Eldoret Municipality is the County Headquarters of Uasin Gishu County. It is among the major commercial, agricultural and transportation hub within the North-Rift region. It is located along the Nakuru-Eldoret-Malaba Highway (G.o.K, 2013) and measures approximately 148 km^2.

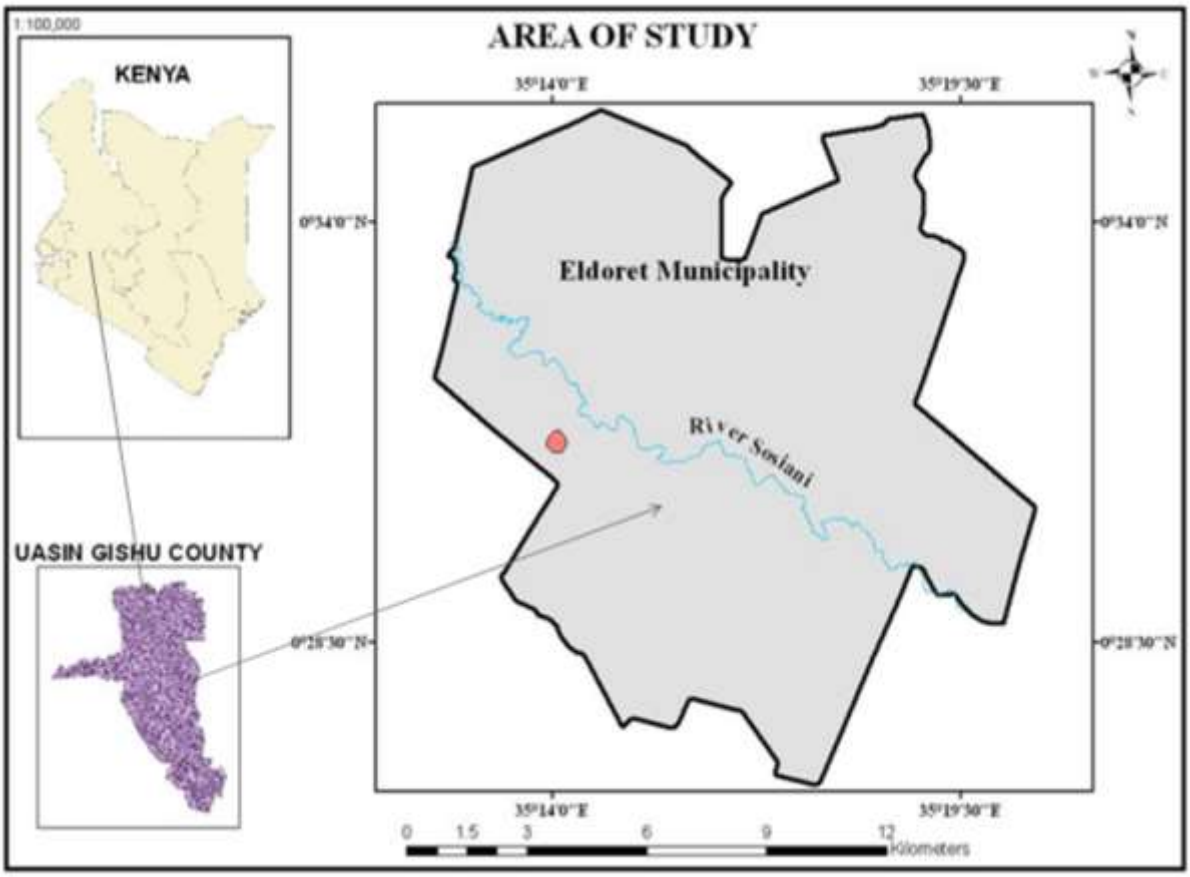

Figure 3.1 Study Area

(Source: Author, 2023)

3.2.1 Population

According to the 2019 Kenya population and housing census, the population of Eldoret Municipality was 475,716 with the county's population growth rate of 4.13% which is above the national population growth rate of 2.3% (KNBS, 2019).

3.2.2 Climatic Conditions

The Municipality experiences relatively high amount of rainfall with the average rainfall ranging between 624.9 mm to 1560 mm. The temperatures range between 7^0c and 29^0c favouring both crop farming and livestock-rearing (KNBS, 2013).

1.1 Nature and Sources of Data

Data was collected from both raw and secondary sources. The secondary sources of data entailed data from literature review while primary sources of data entailed collecting data from key institutions and personnel with relevant information. The primary source of data was stated according to each objective as shown in the table below.

Table 3.1 Sources of Data

Objective	**Source of data**
To establish the origin and destination patterns of traffic within the Municipality	• Department of Roads and Public Works • NTSA • Matatu Saccos • Bodaboda Associations • Traffic Police Traffic counts from selected Gordon points
To establish modal split in Eldoret Municipality	• Passengers • Department of roads • Traffic survey • NTSA

To determine infrastructure capacities for smart transport within Eldoret Municipality	• Department of transport • KENHA, KURA • Office of the Municipal Manager
To determine environmental effects of transport with consideration on noise & emission levels and carbon sinks.	• NEMA • Manager, Eldoret Municipality • KURA, KENHA • Department of Roads

1.1.1 To Establish Origin and Destination Patterns of Traffic Within Eldoret Municipality

This data was obtained from the traffic counts that were obtained at the four Gordon Points of the study. The number of traffic entering and leaving the central business district were identified and counted to determine how traffic flows in and out of the municipality at different hours and days of the week. Questionnaires were also administered to different stakeholders that is Department of Roads and Public Works, NTSA, Matatu Sacco and Bodaboda Associations to get their expert opinion on the destination patterns.

1.1.2 To establish modal split in Eldoret Municipality

This data was obtained by administering questionnaires and conducting interviews with passengers, member from department of roads traffic survey and NTSA. The respondents were asked on the means of transport they use while travelling to different places and for different occasions. The traffic counts were also useful in establishing modal split as the

different modes of transport that is matatu, private cars, walking among other were identified, counted and sorted.

1.1.3 To determine infrastructure capacities for smart transport within Eldoret Municipality

The available infrastructure that is roads, parking spaces, pedestrian walk ways were assessed. The presence, conditions were assessed by observation and mapping where a map of parking space availability was produced. Mapping was also used to determine the availability of road infrastructure where the major routes were mapping. The Gordon points on the major routes which formed the major data collection points were also mapped.

1.1.4 To determine environmental effects of transport with consideration on noise & emission levels and carbon sinks.

This was collected by use of questionnaires and interview schedules. Various stakeholders from National Environment Management Authority (NEMA), Manager, Eldoret Municipality, Kenya Urban Roads Authority (KURA), Kenya National Highways Authority and stakeholders from the department of roads Uasin Gishu County.

3.3 Research Design

This particular study used mixed methods study design which encompasses the use of both qualitative and quantitative methods for both data collection and analysis. This is because more results were yielded when both approaches are used because of the fact that they complement one another. Qualitative method of the study used descriptive design and collected and analysed data on the nature of transportation modes, challenges facing the

transportation and strategies to address the challenges. The quantitative method of data collection and analysis captured information on traffic counts under various traffic modes, distances to various destinations and the number of passengers under different modes. Qualitative data included data yielded from focused group discussions and one on one interview schedules.

3.4 Sampling Procedures

3.4.1 Systematic random sampling

The study adopted systematic random sampling technique to select respondents. The respondents were selected from the seven Gordon points that were been identified and are spread out across the entire study area. Systematic random sampling was adopted to ensure that all the respondents from the four Gordon points are properly represented by avoiding biasness while that could be brought about by simple random sampling. The Gordon points were used as data collection points. This included Kipchoge Stadium Gordon Point along Eldoret-Iten road, Poa Place Junction Gordon point along Eldoret-Nakuru, Sosiani River Gordon Point along Eldoret Kisumu Road and Paul's Bakery Godorn Point along Eldoret-Kitale Road.

3.4.2 Purposive Sampling

This method entailed the selection of key informants that gave specific information regarding the topic of study. Key informants were selected from relevant Government agencies for the purpose of this study.

3.5 Sample size

The study adopted the formula below for the determination of sample size.

$$n = \frac{N}{1+N(e)^2}$$

Where n=sample size

N=target population size

e=sampling error which is 5%

(Mugenda and Mugenda, 2003)

Based on the above formula, the total number of respondents was 280 who were distributed in the seven Gordon points. This therefore means that each Gordon point had 40 respondents.

3.6 Data collection Tools

This entailed the use of both primary and secondary methods of data collection. Primary methods included the use of questionnaires, interviews, observation, use of global positioning system (GPS) and photography while secondary methods of data collection involved the use of literature review which includes collecting data from sources such as journals, books, articles and records of an agency.

Data was gathered based on each objective.

Table 3.2 Data Collection Tools

Objective	**Data collection tools**

To establish the origin and destination patterns of traffic within the Municipality	• Traffic counts schedule • Key informant interviews • Field based surveys (occupancy levels) • Observation schedule • Global Positioning System (GPS) • Photography • Questionnaires
To establish modal split in Eldoret Municipality	• Passenger interview schedules • Traffic count schedules
To determine infrastructure capacities for smart transport within Eldoret Municipality	• Key informant interviews schedules • Passenger interviews schedule
To determine environmental effects of transport with consideration on noise & emission levels and carbon sinks.	• Key Informant Interview schedules • Passenger Interviews • Photography • Observation schedules
To determine the economic effects/impacts resulting from a smart transport system within the municipality	• Key Informant Interview schedules

3.6.1 Questionnaires

The questionnaire consisted of list of both structured and unstructured questions to obtain standardized results which were analysed and interpreted.

3.6.2 Key Interview Schedules

Interviews were conducted from key informants such as County Physical Planning, County Lands Office, Eldoret Municipal Office, Kenya National Highways Authority (KENHA), Kenya Urban Roads Authority (KURA), the Department of Roads and Public works, National Environmental Management Authority (NEMA), Non-Governmental Organizations (NGOs) and the private sector.

3.6.3 Observation schedules

Observation was also a key method of data collection. This was undertaken by use of a structured observation schedule. Observation was carried out at various locations within the study area with special emphasis on the seven Gordon points identified. The table below shows the nature of data that was observed. A sample of an observation schedule is available at the annex (IV) of this report.

3.6.4 Traffic Count Schedule

Traffic counts were undertaken in four Gordon points within the study area. The Gordon points were spread across the study area and were strategically placed along the major roads. The table below shows the Gordon points.

Table 3.3 Gordon Point

Gordon point	**Route**	**Coordinates**
Kipchoge Stadium	Eldoret-Iten	
Poa Place Junction	Eldoret-Nakuru	
Sosiani River-Kisumu Road	Eldoret-Kapsabet	
Paul’s Bakery	Eldoret-Kitale	

Traffic counts established traffic volumes in both directions, peak periods (hours) and also establish the modal split.

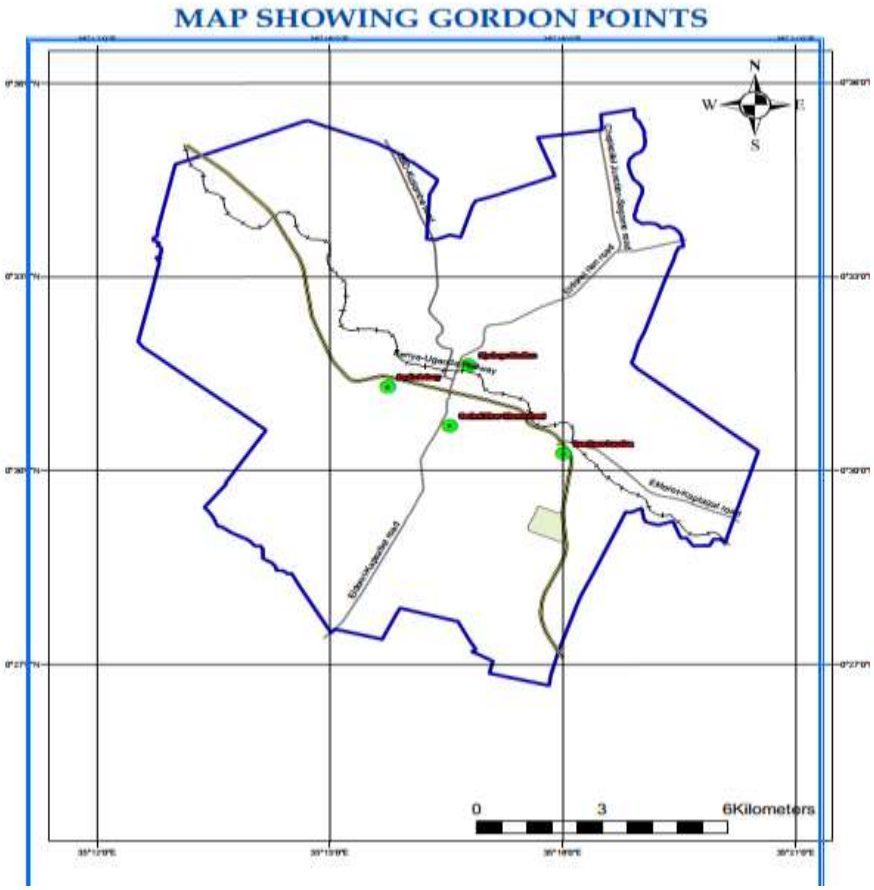

Figure 3.2 Gordon Points

3.7 Validity and Reliability of research instruments

So as to determine the validity and reliability of research instruments, the Cronbach's Alpha method was used. This was used to get the estimates of the reliability of scores and thus establish whether the scores will be reliable or not. An alpha value of .05 was established for this study.

3.8 Data analysis and Presentation

Data analysis was done through the use of statistical package for social sciences (SPSS), MS Excel and use of Arc GIS 10.5 software. In the use of SPSS, a code book was generated where data was thereafter entered for purposes of analysis. Descriptive statistics such as the use of frequency distributions, pie charts and percentages were used in data presentation. Data was also presented in form of graphs, charts and tables. For qualitative data analysis, information was obtained from empirical literature of the open-ended questions of the questionnaire. MS Excel will was also used to generate graphs for interpretation. Data analysis was done according to each objective.

3.8.1 To Establish Origin and Destination Patterns of Traffic Within Eldoret Municipality

Data for this objective was analyzed using Ms Excel. This were the traffic counts in and out of the study area at the four Gordon points. The frequencies were computed and the results presented using figures.

3.8.2 To establish modal split in Eldoret Municipality

The modal split was analyzed using SPSS version 20. The traffic counts from various modes of transportation were identified and coded, and entered into SPSS. The modal split of traffic in the study area was determined by running the frequencies for various transportation modes. The results were compared using figure such as bar graphs to determine the modal split in the study area.

3.8.3 To determine infrastructure capacities for smart transport within Eldoret Municipality

Content analysis was used to assess the data from the respondents. GIS mapping was also used to map parking space availability the major traffic routes in the study area. The responses from the participants on availability of various transport infrastructure were also coded and analyzed.

3.8.4 To determine environmental effects of transport with consideration on noise & emission levels and carbon sinks.

Noises levels at various points on the major traffic routes were measured in decibels and analyzed. The carbon emission levels was measured in ppm and analyzed. Oxygen and hydrogen sulphide levels were also measured in percentage (%) analyzed and presented using graphs and tables.

Table 3.4 Data Collection Matrix

Objective	Nature of Data	Sources of Data	Methods of Data Collection	Variables	Methods of Data Analysis
To establish the origin and destination patterns of traffic within the Municipality	• Mode of transport • Destination areas • Origin • No. of Traffic • Traffic flows • Time • Transport cost • No. of each mode on the road • Congestion levels • Condition of infrastructure	• Department of roads and Public works • Traffic count • NTSA • Matatu saccos • Boda Bodaboda associations • Traffic Police Department • Traffic counts from selected Gordon points	• Traffic counts schedule • Key informant interviews • Field based surveys (occupancy levels) • Observation schedule • Global Positioning System (GPS) • Photography • Questionnaires	• Location of residential areas • Work places • Traffic volumes • Traffic flows • Nature of road • Transport costs • Congestion levels • Number of vehicles	• Statistical Package for Social Sciences (SPSS) • MS excel • Geographical Information Systems (GIS)

To establish modal split in Eldoret Municipality	• Mode of transport available • Modal choice • Transport cost • Travel distance • Time taken	• Passengers • Department of roads • Traffic survey • NTSA	• Passenger interview schedules • Traffic count schedules	• Means of transport • Modal choice • Modal travel time • Travel distance • Travel cost	• SPSS • MS Excel
To determine infrastructure capacities for smart transport within Eldoret Municipality	• Number of parking spaces • Traffic volumes • Parking cost	• Department of transport • KENHA, KURA • Office of the Municipal Manager	• Key informant interviews schedules • Passenger interviews schedule	• Number of parking spaces • Traffic volumes	• SPSS • MS excel
To determine environmental effects of transport with consideration on noise & emission levels and carbon sinks.	• Condition of roads • Congestion levels • Transport cost • Availability of transport infrastructure	• NEMA • Manager, Eldoret Municipality • KURA, KENHA • Department of Roads	• Key Informant Interview schedules • Passenger Interviews • Photography • Observation schedules	• Condition of roads • Congestion levels • Transport cost • Availability of transport infrastructure	• SPSS • MS Excel

To determine the economic effects/impacts resulting from a smart transport system within the municipality	• Income levels • Economic status of the City • Revenues	• Department of Finance • Socio-economic surveys	• Key Informant Interview schedules	• Revenues • Incomes	• SPSS • Ms excel

CHAPTER FOUR

RESULTS

4.1 Overview

This Chapter present the findings of the study systematically as per the objectives. The first objective was to establish the origin and destination patterns of traffic within the Municipality, the second was to establish the modal split in Eldoret Municipality, third was to determine infrastructure capacities for smart transport within Eldoret Municipality, the fourth was to determine the socio- economic effects associated with urban mobility systems within the municipality while the fifth objective was to determine the relationship between urban mobility patterns and environmental effects of transport systems on noise and emission levels in. The findings are presented using figures, table and maps.

4.2 Socio-economic Characteristics of Respondents

Socioeconomic characteristics of the respondents were determined by administering questionnaires to the respondents that is drivers, passengers, bodaboda riders and the management of various matatu saccos. The data was analyzed and presented according to various socioeconomic indicators as illustrated in the following section.

i) Gender of Respondents

The data was coded that is '1' for Male and '2' for Female and entered into SPSS for analysis. Figure 4.1 illustrates the gender distribution of the respondents in the study area. Male respondents formed 78.57% of the sample while female respondents made up 21.43%.

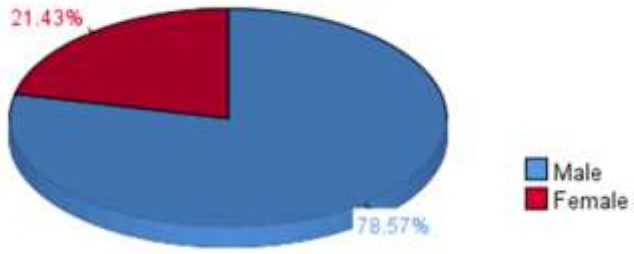

Figure 4.1 Gender of the Respondents

ii) Marital Status of Respondents in the Study Area

Figure 4.2 illustrates marital status of the respondents. From the findings, 78.57% of the respondents were married while 21.43% were single.

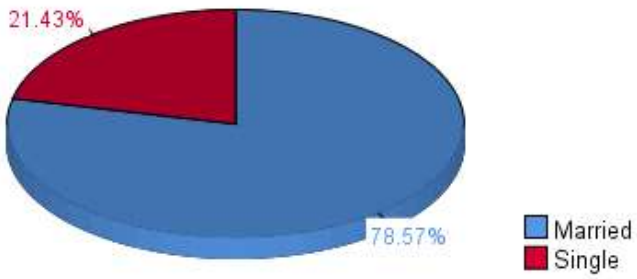

Figure 4.2 Marital Status of Respondents

iii) Occupation

Figure 4.3 is a pie chart illustrating employment status of respondents in the study area. From the findings, 73.21% of the respondents were in employment while 26.79% were unemployed.

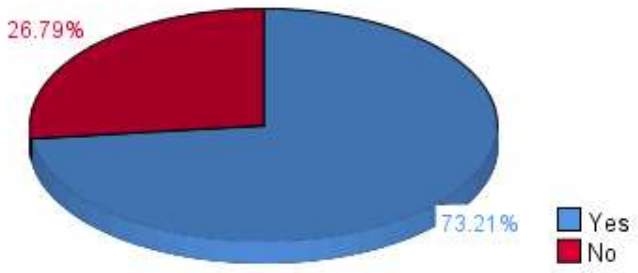

Figure 4.3 Occupation

The employment sector consists mainly of self-employed 65.91%, employment in the non-governmental organizations (NGO) 13.64%, employment in limited companies 9.09%, employment in Saccos 6.82% and government with the least of employees that is 4.55%. Figure 4.4 illustrates the kind of employment in the study area.

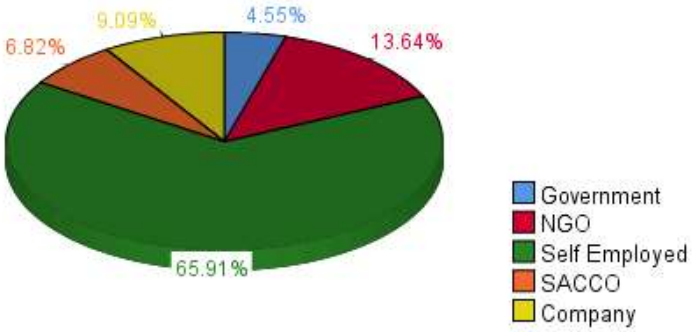

Figure 4.4 Occupation Sector in the Study Area

iv) Education Levels

Most of the respondents that is 60% had tertiary level of education, 25.45% had secondary level of education while 14.55% of respondents had primary level of education. Figure 4.5 illustrates the education levels of respondents in the study area.

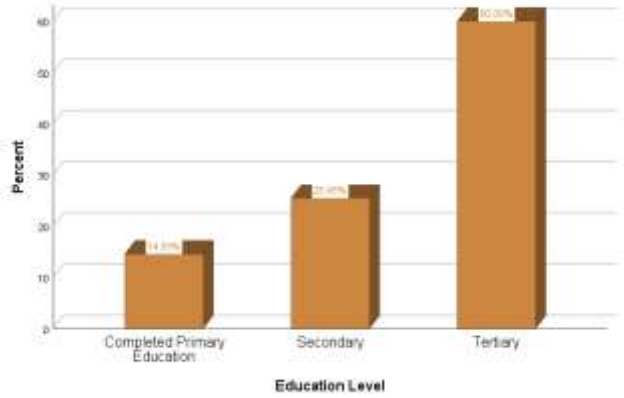

Figure 4.5 Education Level of Respondents

v) Income Levels of Respondents

Income level of respondents was found to be 40.43% above Kshs. 20,000, 29.79% between Kshs. 16,000 to 20,000, 19.15% between Kshs. 10,000 to 15,000, 6.38% between Kshs. 6,000 to 10,000 and 4.26% below Kshs. 5,000. Figure 4.6 illustrates the study findings on the income levels of the respondents.

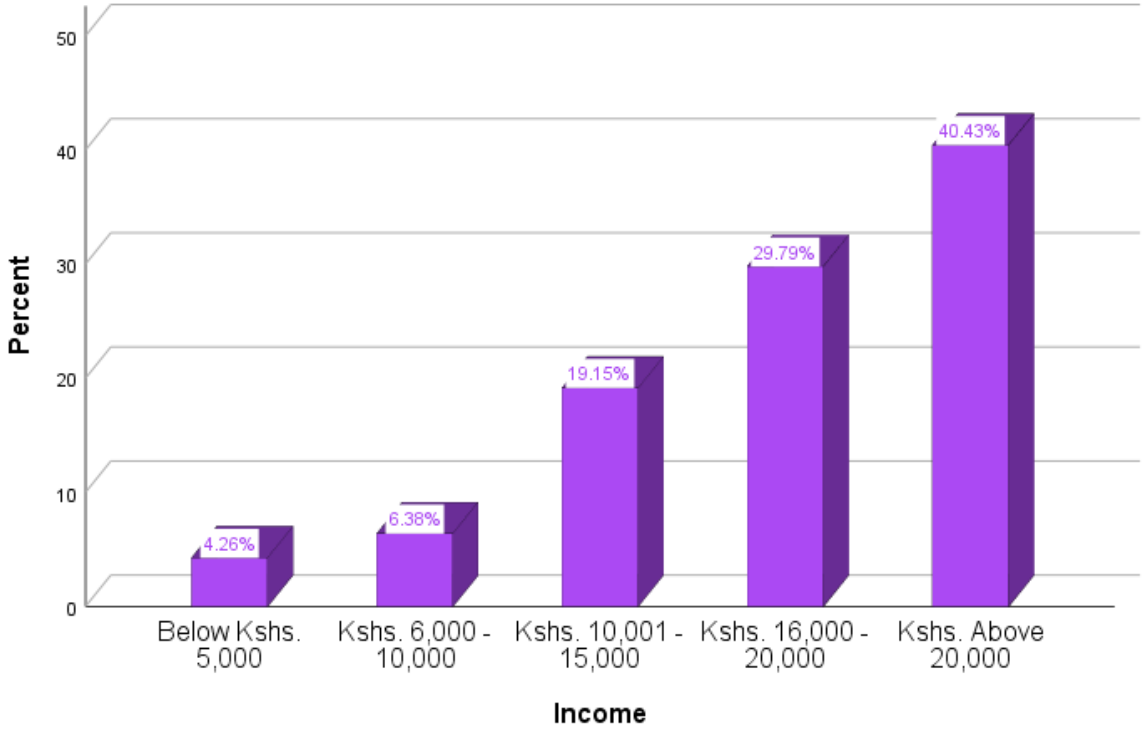

Figure 4.6 Income levels of Respondents

4.3 Origin and Destination Patterns of Traffic in Eldoret Municipality

The first objective of the study was to, establish the origin and destination patterns of traffic within the Municipality were:

4.3.1 Hourly average incoming traffic volumes were determined from four Gordon Points It was established that the highest number of incoming traffic is experienced between 7.00 am and 10.00 am thereafter, the levels of traffic flow to the town starts to drop gradually up to 7.00pm where traffic flow into the town is lowest.

Figure 4.7 illustrates the hourly incoming traffic at the four Gordon points.

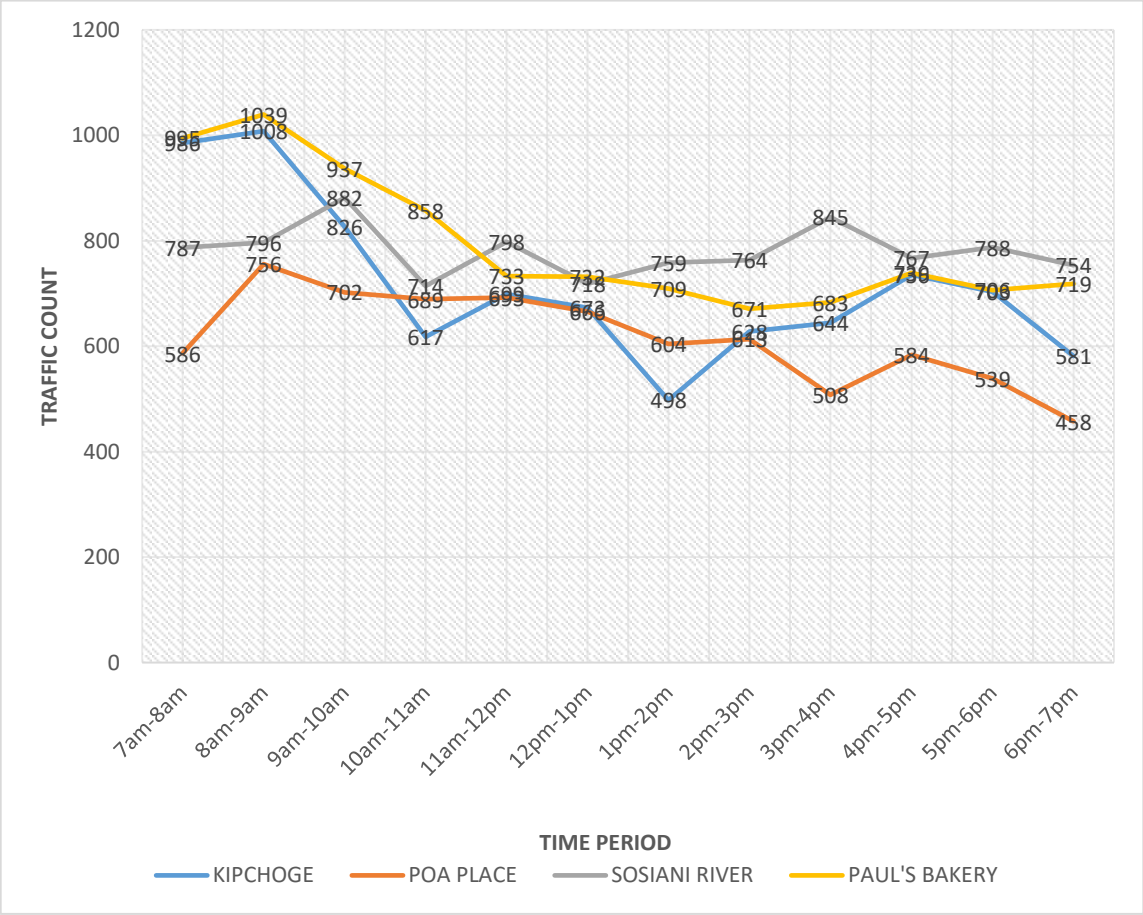

Figure 4.7 Hourly Incoming Traffic at the Four Gordon Points

4.3.2 Daily Average Incoming Traffic Volumes Across Various Modes of Transport at the Four Gordon Points

It was noted that Kipchoge Gordon point, at Iten- Eldoret road an average of 2687 of incoming cars per day was the highest in Eldoret town, followed by 2603 motorbike per day, 1859 matatus a day, 1047 pedestrians, 284 lorries a day, 52 bicycles a day 28 tuktuks a day, 22 trucks and buses being four (4) buses per day.

Figure 4.8 illustrates the average daily incoming traffic from various origin into the town at various Gordon points namely Kipchoge, Poa Place, Sosiani and Paul's Bakery.

Figure 4.8 Incoming Traffic at Various Gordon Points

At Poa Place Gordon point, on average 3005 cars were recorded per day followed by 574 matatus, 1299 motorcycles, 553 trucks, 428 pedestrians, 355 lorries, 106 bicycles, bus and tuktuk were the least at 25 buses and 16 tuktuks per day respectively.

Sosian Gordon point exhibited the following modal split for vehicles entering the town. The highest number of motorcycles recorded was 3016 motorcycle per day, followed by 2873 cars 1622 matatus, 846 pedestrians, 428 lorries, 224 buses, 175 bicycle, 138 tuktuks and 36 trucks per day.

At St. Paul's Bakery Gordon point, 2465 motorcycles per day were counted followed by 2183 cars, 1816 matatus, 1256 pedestrians, 668 bicycles, 526 trucks, 490 lorries, bus and tuktuk with an average of 52 and 32 per day respectively.

4.3.3 Hourly Average Outgoing Traffic Volumes at the Four Gordon Points

Figure 4.9 illustrates the hourly outgoing at the four Gordon points. The lowest level of outgoing traffic is experienced between 12.00 noon and 3.00pm across the four Gordon points while the highest levels of outgoing traffic is experienced between 5.00pm and 7.00pm where outgoing traffic is highest.

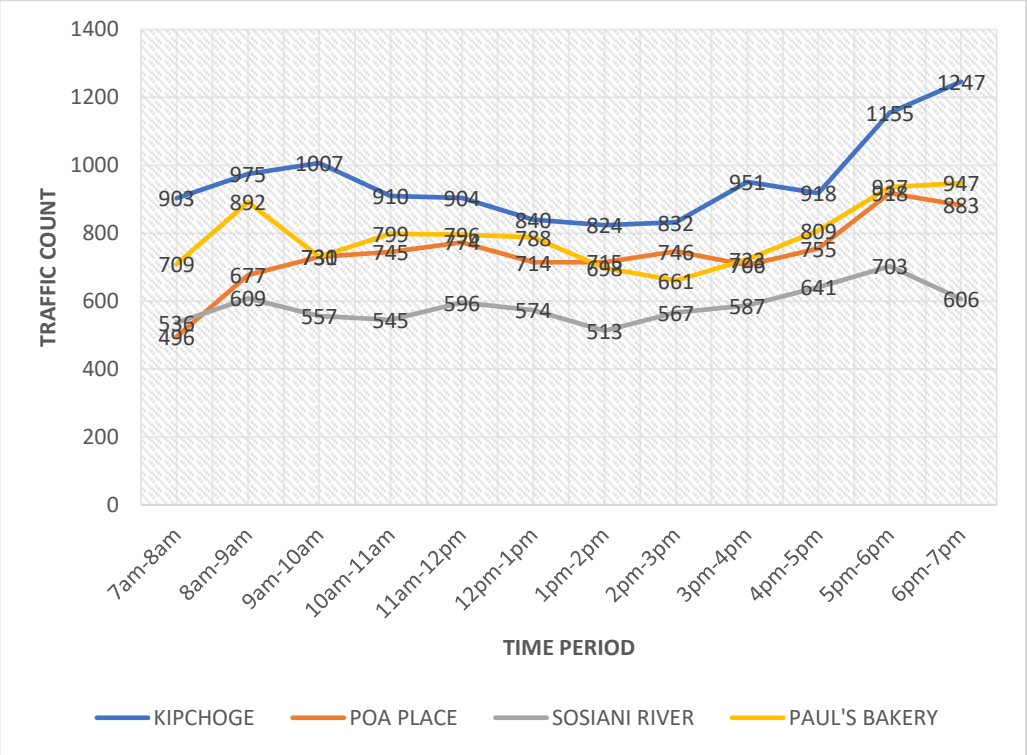

Figure 4.9 Hourly Outgoing Traffic at the Four Gordon Points

4.3.4 Daily Average Outgoing Traffic Volumes Across Various Modes of Transport at the Four Gordon Points

Figure 4.10 illustrates the average daily outgoing traffic from town to various destination at the four Gordon points namely Kipchoge, Poa Place, Sosiani and Paul's Bakery. The figure also shows the modal split that is different types of vehicles passing the Gordon points out of the town.

At Kipchoge Gordon point, motorcycle had the highest average daily outgoing traffic (4658 motorcycles per day). Car (average of 3211 cars per day), matatu (average of 2083 cars per day), pedestrians (average of 945people per day), lorry (average of 312 per day), bicycle

(average of 98 bicycles per day), tuktuk (average of 34 vehicles per day) and buses (average of 28 bus per day).

At Poa Place Gordon point, car (average of 3524 vehicle per day) was the highest, matatu (average of 1789 vehicles per day), motorcycle (average of 1558 motorcycles per day), pedestrians (average of 712 people per day), truck (average of 659 trucks per day), lorry (average of 390 lorries per day), bicycle (average of 131 bicycles per day), bus (average of 59 buses per day) and tuktuk (average of 31 tuktuks per day).

At Sosiani Gordon point, average outgoing car was the highest transport mode at 2280 cars per day, motorcycle (average of 1828 motorcycle per day), matatu (average of 1245 vehicles per day), pedestrian (average of 909 people per day), lorry (average of 308 vehicles per day), tuktuk (average of 188 of tuktuks per day), trucks (average of 36 lorries per day) and bicycles (average of 16 bicycles per day).

At Paul's Bakery Gordon point, motorcycle was the highest mode of transport at average of 2525 motorcycles per day, car (average of 2116 cars per day), matatu (average of 1877 vehicles per day, pedestrians (average of 1168 people per day), bicycle (average of 638 bicycles per day), truck (average of 485 trucks per day), lorry (average of 481 lorries per day), tuktuk (average of 108 per day) and bus (average of 58 per day).

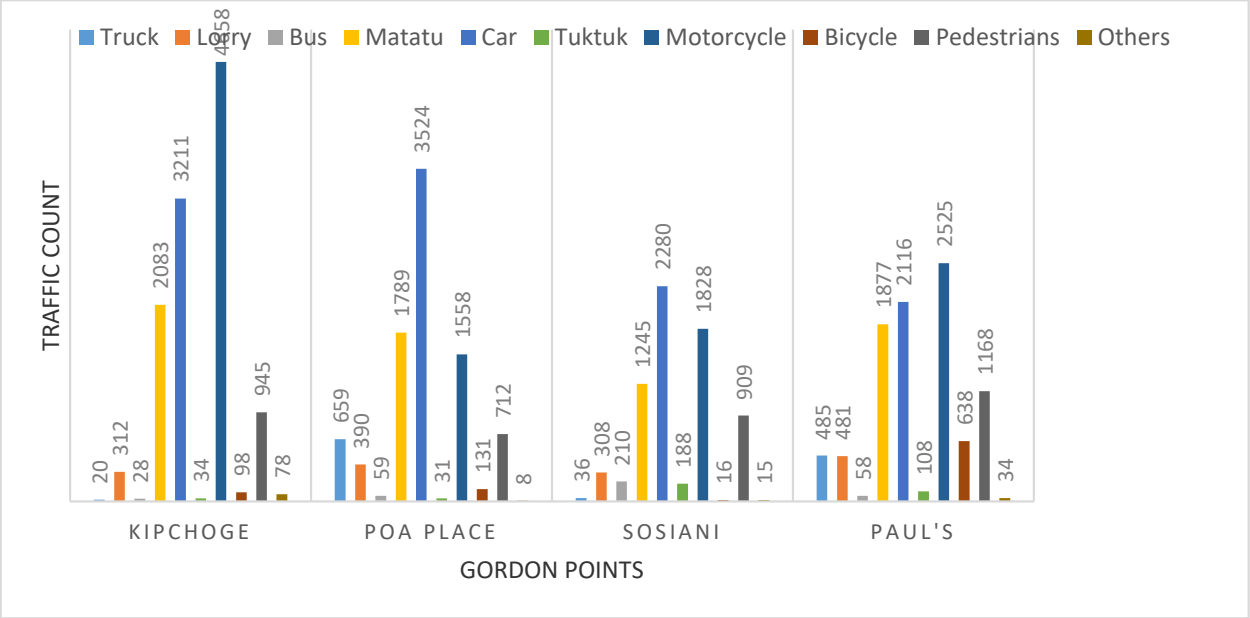

Figure 4.10 Outgoing Traffic at Various Gordon Points

4.3.5 Time Delay in Traffic from Origin to Destination

Figure 4.11 illustrates the time taken by the respondents from their origin to their destination. From the findings 60.71% of the respondents use less than 30 minutes, while 23.21% use more than 2 hours. Other respondents were 8.93% between 1hour and 2 hours and 7.14% between 30 minutes and 1 hour.

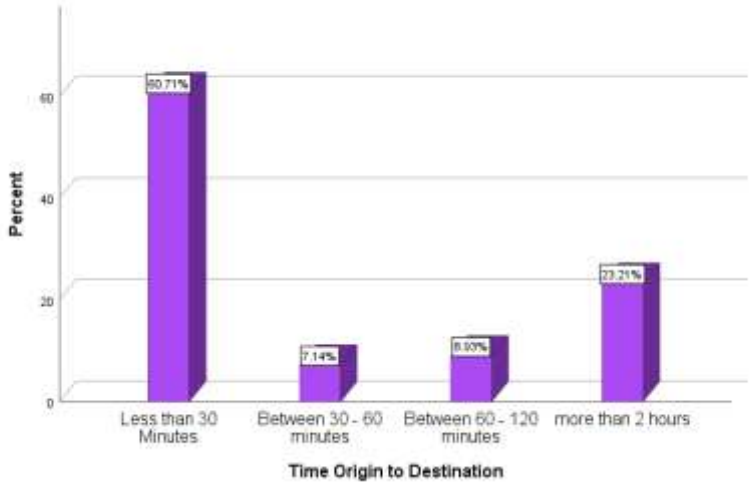

Figure 4.11 Time from Origin to Destination

Figure 4.12 illustrates the amount of time wasted in traffic delays. From the findings, most of the respondents 72.22 % waste about 30 minutes in traffic delays, 16.67% about 30 minutes to 1 hour, 9.6% between 1 hour and 2 hours while 1.85% more than 2 hours.

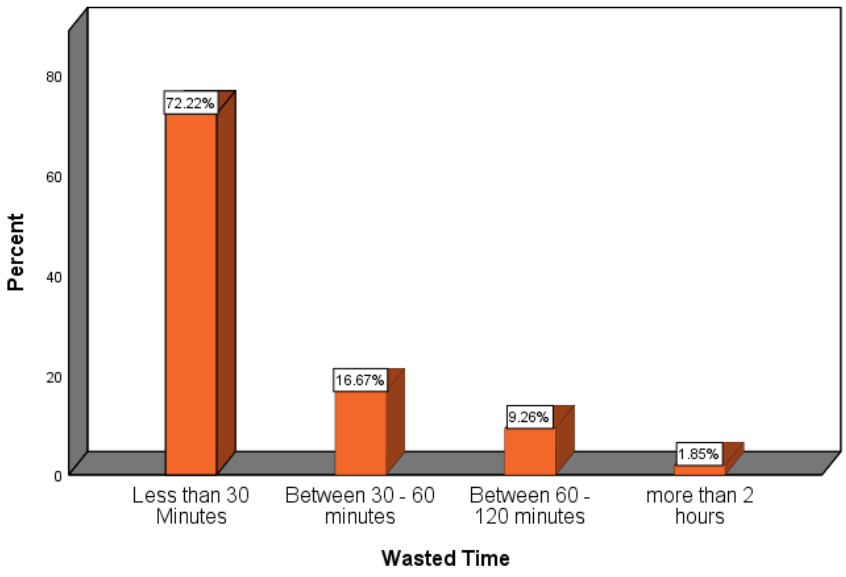

Figure 4.12 Time Wasted in Traffic Delays

4.3.6 Transportation Costs and Payment Modes

Figure 4.13 illustrates the respondent's perception on the cost of transport in the study area. The findings show that 74.07% of the responds believe the cost is affordable, 14.81% cheap while 11.11% believe cost is expensive.

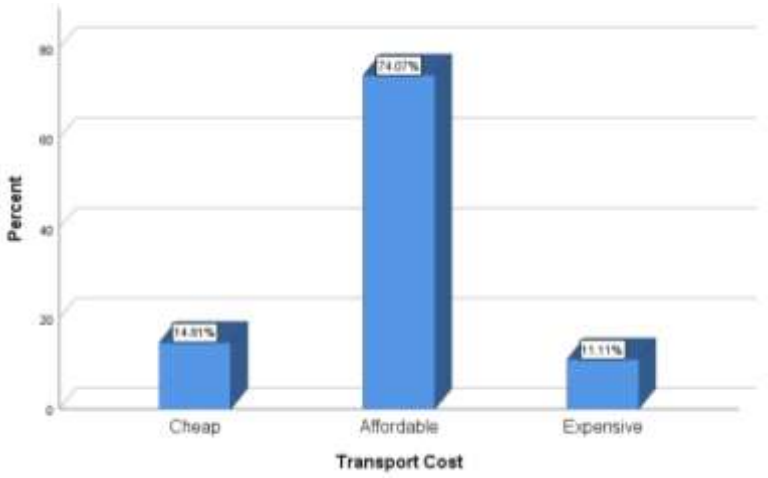

Figure 4.13 Transport Cost Rating

Figure 4.14 illustrates the payment methods used by the participants in paying their transportation costs. The respondents asked to state the form of payment they used to pay for transport expenses. From the findings 94.44% used cash while only 5.56% used mobile money.

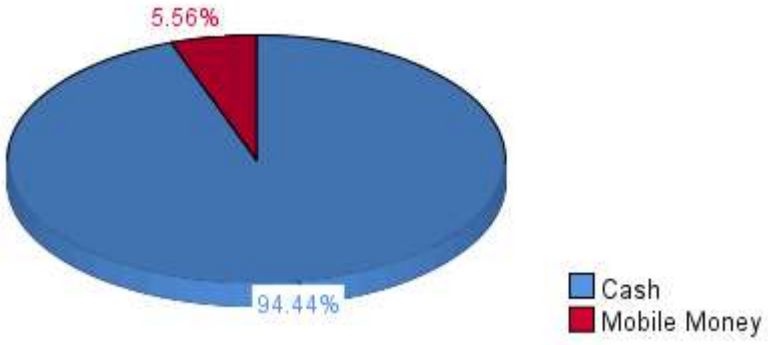

Figure 4.14 Payment Method

4.4 Modal Split in Eldoret Municipality

This section presents the finding for objective two to establish the modal split in Eldoret Municipality. The findings are presented in figures as shown.

i) Modes of Transport in the Study Area

Figure 4.15 presents the modes of transport employed by the respondents to move from one place to another. The results show a high preference for matatu 39.29%, motorcycle 26.79%, car 12.5%, bus 10.71%, walking 7.14% and tuktuk at 3.57%. No respondent mentioned that they would use Train and bicycles mode of transport.

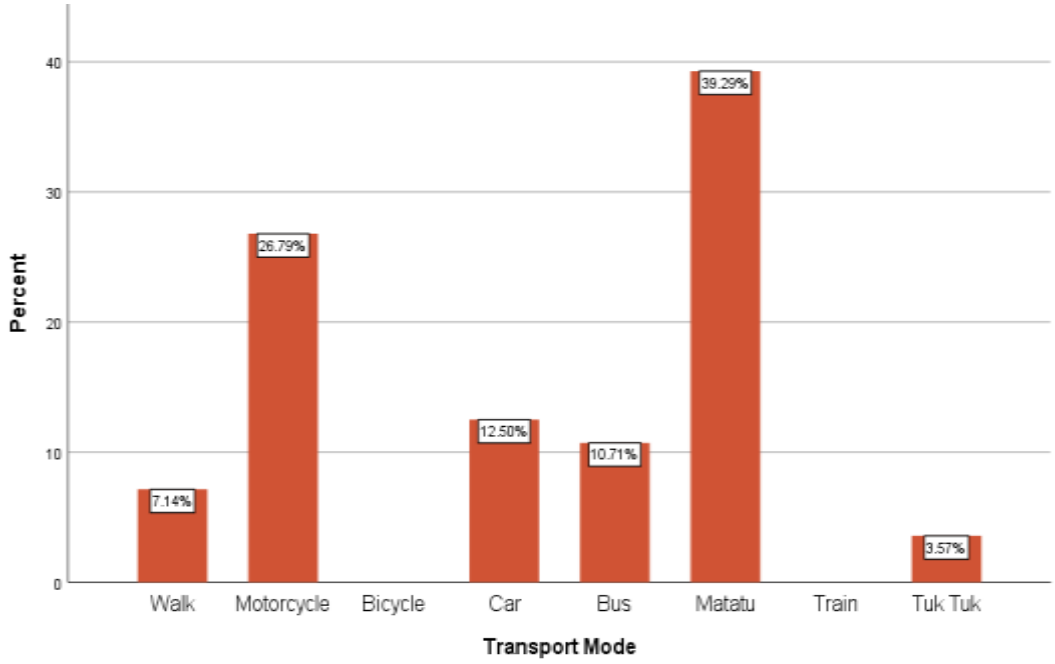

Figure 4.15 Modes of Transport

ii) Reasons Underlying the Use of Various Transport Modes

Matatu was the most preferred means of transport due to convenience 19.64% and Reliability 16.07%, motorcycle was preferred as it was cheap 12.5%, convenient 10.71% and reliable 3.57%. The rest were bus due to reliability 8.93% and 1.79% convenient, car was 7.14% convenient, 3.57% cheap and 1.79% reliable. Figure 4.16 illustrates the reasons underlying the use of various transportation modes.

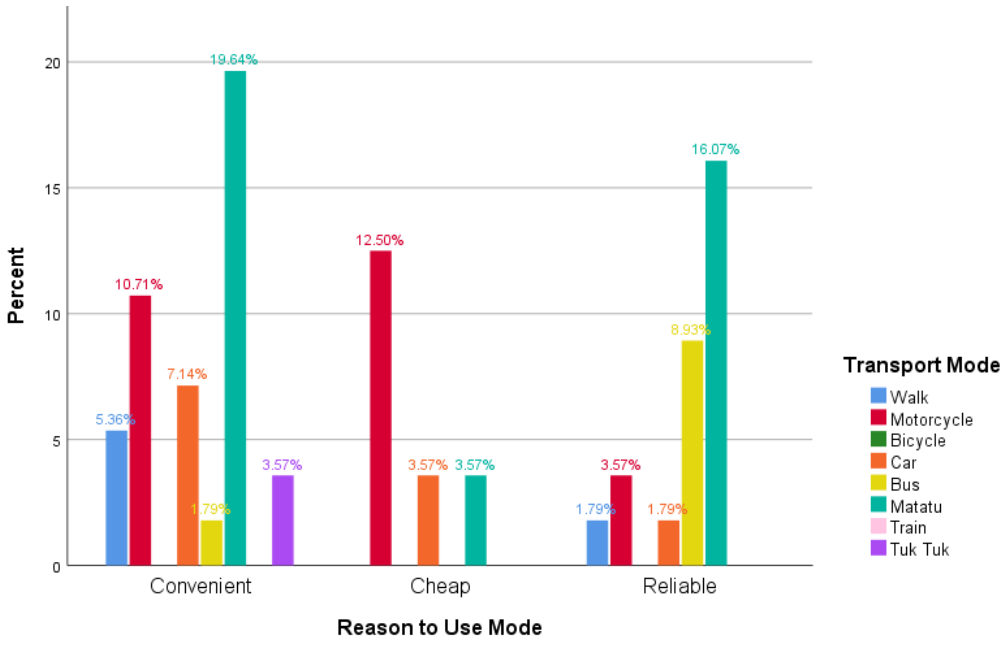

Figure 4.16 Reason for Preferred Modes of Transport

iii) Frequency in use of Public Transport

From the findings 46.43% of the respondents use public means daily, 26.79% use public means occasionally, 14.29% rarely, 8.93% weekly and 3.57% monthly. Figure 4.17 illustrates how often the respondents use public transport means.

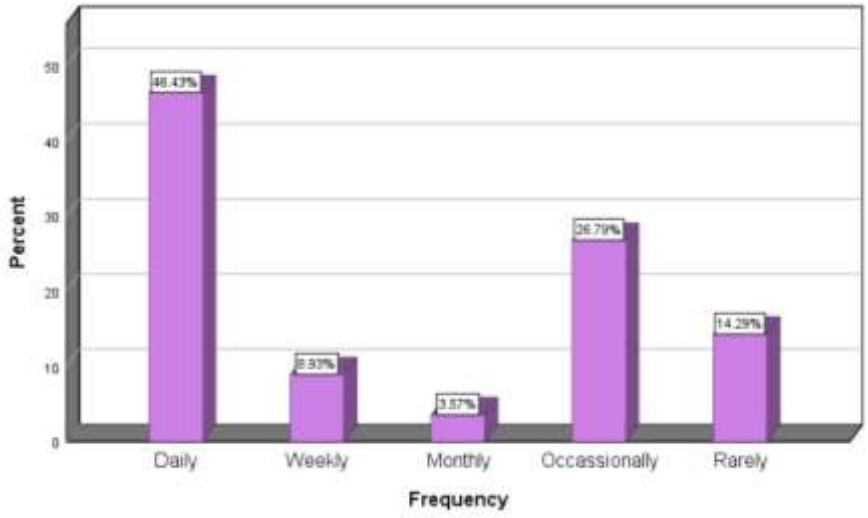

Figure 4.17 Frequency in use Public Transport

iv) Challenges Facing Transportation

Traffic congestion had the highest sum of respondents citing 62.96% as a transport challenge followed by poor road conditions and high transportation cost at 12.96% each, traffic accidents at 7.41% and insecurity at 3.7%. Figure 4.18 illustrates the challenges facing transportation in the study area

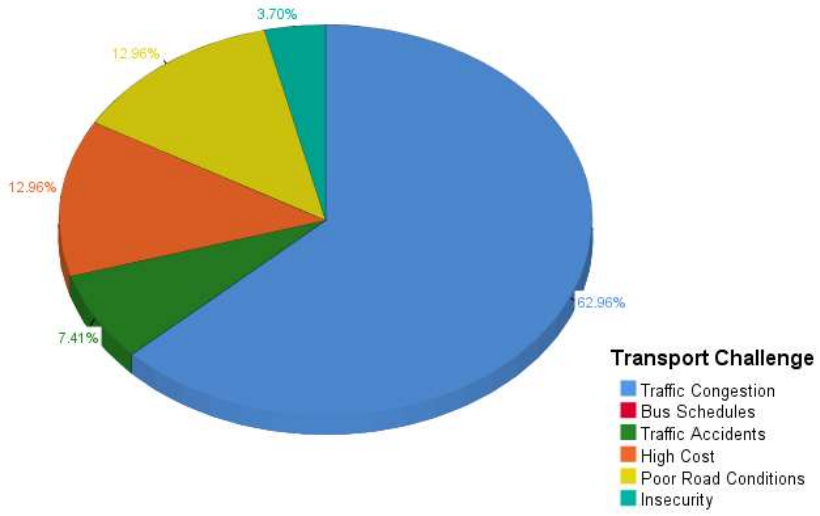

Figure 4.18 Challenges Facing Transportation in the Study Area

Interview with Uasin Gishu County department of Roads and Public Works revealed that Langas – Ol Donyo Lessos road and Mandago roads within Eldoret Municipality were severely damaged and needed improvement. The interview also suggested that all the roads in the municipality were in dire need of ring roads, installation of traffic lights, cameras and street lighting. There was need to have five major BRT stations with in the municipality that is one within the CBD, one at Kapseret near Eldoret International Airport, one at Maili Tisa and another one at Cheplaskei area. There was also demand for specific pick up and drop off points.

4.5 Infrastructure Capacities for Smart Transport Within Eldoret Municipality

The third objective of the study was to determine infrastructure capacities for smart transport within Eldoret Municipality. The variables considered for this objective included road

conditions, parking space availability, the need for high-capacity vehicles, bicycle lanes, motorcycle lanes, pedestrian walkways and street lighting.

i. **Road Conditions** The findings show that 70.91% feel the roads in a fair condition, 27.27% feel they are good while 1.82% reported that the roads were in bad conditions.

Figure 4.19 presents the study findings on the road conditions according to the respondents.

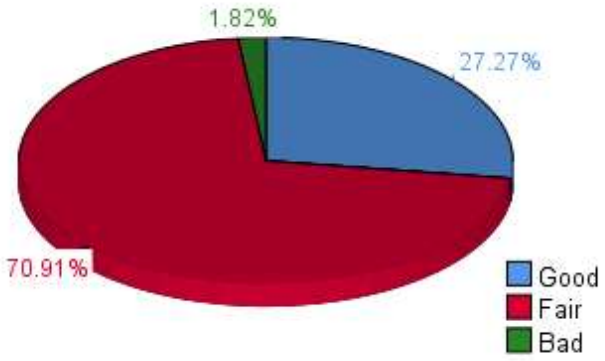

Figure 4.19 Road Conditions

Angular parking, flush parking, detached flush parking and unspecified parking are the common parking type in the municipality. In the central business district, the major form of parking is angular parking and flush parking which offer single parking space per vehicle. Figure 4.20 shows a map presenting parking space availability in Eldoret Municipality.

ii. **Parking Spaces**

Table 4.1 illustrates the parking space statistics in the study area. It includes findings on parking spaces availability, the current demand and the deficit.

Table 4.1 Parking Space Statistics

Parking Type	**No of Parking Spaces**	**Total Number of Incoming Vehicles**	**Deficit**
Angle	1,538	36,853	34,826
Flash	433		
Mixed	31		
Unspecified Parking	**25**		
Total	**2,027**		

Parking challenges in the study area include:

- Parking on Uganda Road (A8) - contributes to congestion
- Unmarked parking spaces - CBD
- Parking of vehicles in undesignated areas

- Drivers searching for parking spaces also contribute to congestion.
- Low parking charges - minimal influence on commuter behavior
- On-street parking- frequent traffic disruptions

Figure 4.20 is a geographical illustration of parking spaces in Eldoret Municipality.

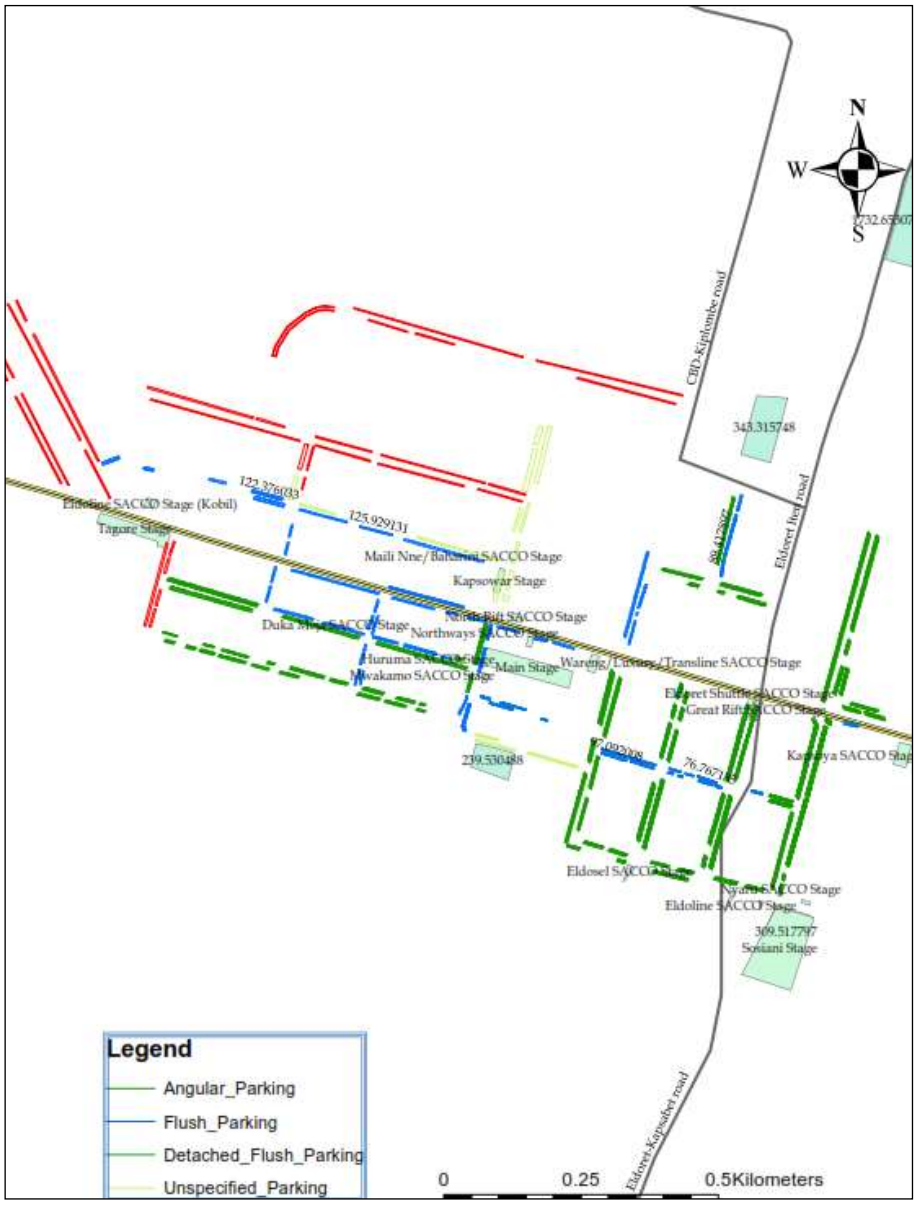

Figure 4.20 Parking Space

4.5.1 Respondents' Opinion on the Introduction of High-Capacity Vehicles and Provision of Bicycle Lanes

The respondents were asked to state whether they could welcome the idea of introducing high-capacity vehicles. As shown in Figure 4.21, 87.5% of the respondents welcomed the idea while 12.5% were against it.

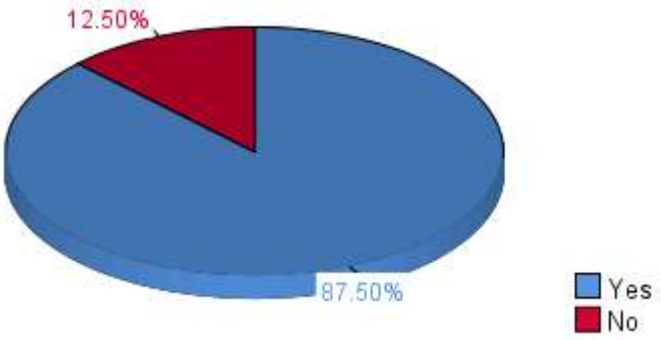

Figure 4.21 Support for High-Capacity Vehicles

It was determined that provision of bicycle lanes was supported by 94.55% of the respondents as opposed to only 5.45% who were against. Figures 4.22 illustrates findings the respondents' support for provision of bicycle lanes

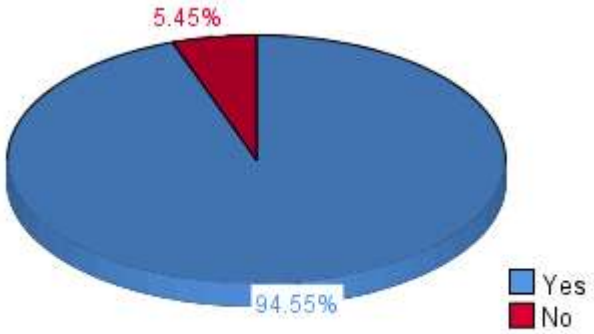

Figure 4.22 Support on provision of bicycle Lanes

4.5.2 Availability of Motorcycle, Bicycle and Pedestrian Lanes from Origin to Destination

i) Availability of Motorcycle and Bicycle Lanes in the Study Area

The findings on the availability of motorcycle and bicycle lanes in estates show that only 33.93% of the respondents reported to have motorcycle and bicycle lanes in the estate as opposed to 66.07% who did have this infrastructure. Figure 4.23 illustrates findings on the availability of motor and bicycle lanes from various origins and destinations.

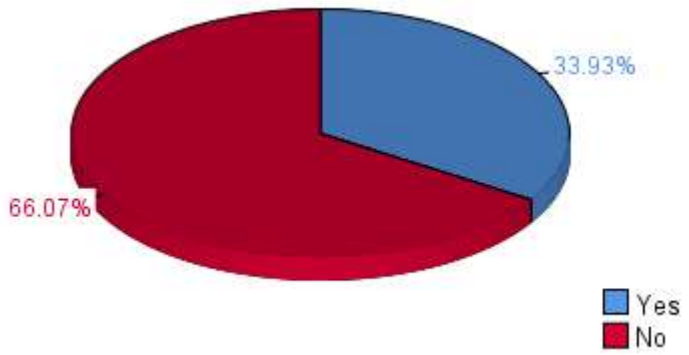

Figure 4.23 Presence of Motor and Bicycle lanes the Municipality.

ii) Availability of Pedestrian Sidewalks

Majority of the respondents 85.71% reported to have pedestrian walkways in the estate unlike 14.29% who reported to be missing this infrastructure in the estates. Figure 4.24 presents findings on the availability of pedestrian sidewalks in the estate from different origins to various destinations.

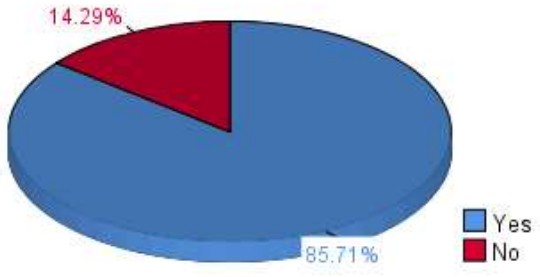

Figure 4.24 Presence of Pedestrian sidewalks

Non-motorized transport faces challenges among them: Encroachment by Matatus and bodaboda - Muliro, Oloo and Lower Kenyatta Streets, Blocking by loading/offloading

activities - Ronald Ngala & Uganda Road, Worn-out walkways - Kisumu and Tagore Roads, Absence of walkways - Mitaa Road and most residential estates, Inadequate pavements - narrow streets in the core CBD, High pedestrian volume - Kimalel and Elijah Cheruiyot streets, Narrow walkways - Kimalel and Elijah Cheruiyot streets, Incompleteness of NMT corridors - inadequate zebra crossings & footbridges, Minimal cyclability - core CBD due to narrow streets

Plate 4.1 illustrates the state of non-motorized transport infrastructure in the study area.

Plate 4.1 Non-Motorized Transport Infrastructure Along Oloo Street Eldoret Municipality

(Source: Author, 2023)

The majority 60.71% of the respondents reported to have street lights in their estates. Figure 4.25 are finding on the presence of street lights in the estates.

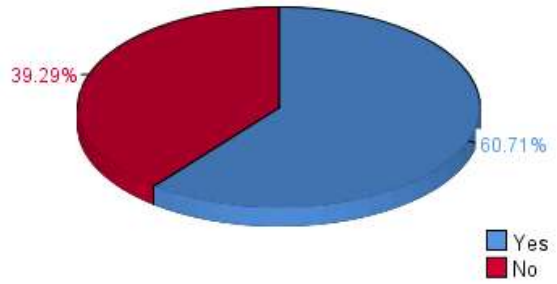

Figure 4.25 Presence of Street Lights

4.5.3 Air Transport in the Study Area

There are two major air transport facilities namely; Eldoret International Airport and Eldoret Airstrip

4.5.4 Railway Transport n the Study Area

Kenya-Uganda Railway passes through Eldoret Municipality with a total length- 19.15 km. A railway station is located within the CBD whose major role is to transport raw materials to factories and finished goods to markets. There is untapped potential of Rail transport in terms of PSV transit, the development of light rail system can boost the ferrying of passengers from various destinations

Figure 4.26 illustrates the CBD Railway station in the study area that is Eldoret Municipality. The railway station is faced with challenges which include: Urban Decay, Old dilapidated and abandoned structures, Worn out Infrastructure and Underutilized prime land

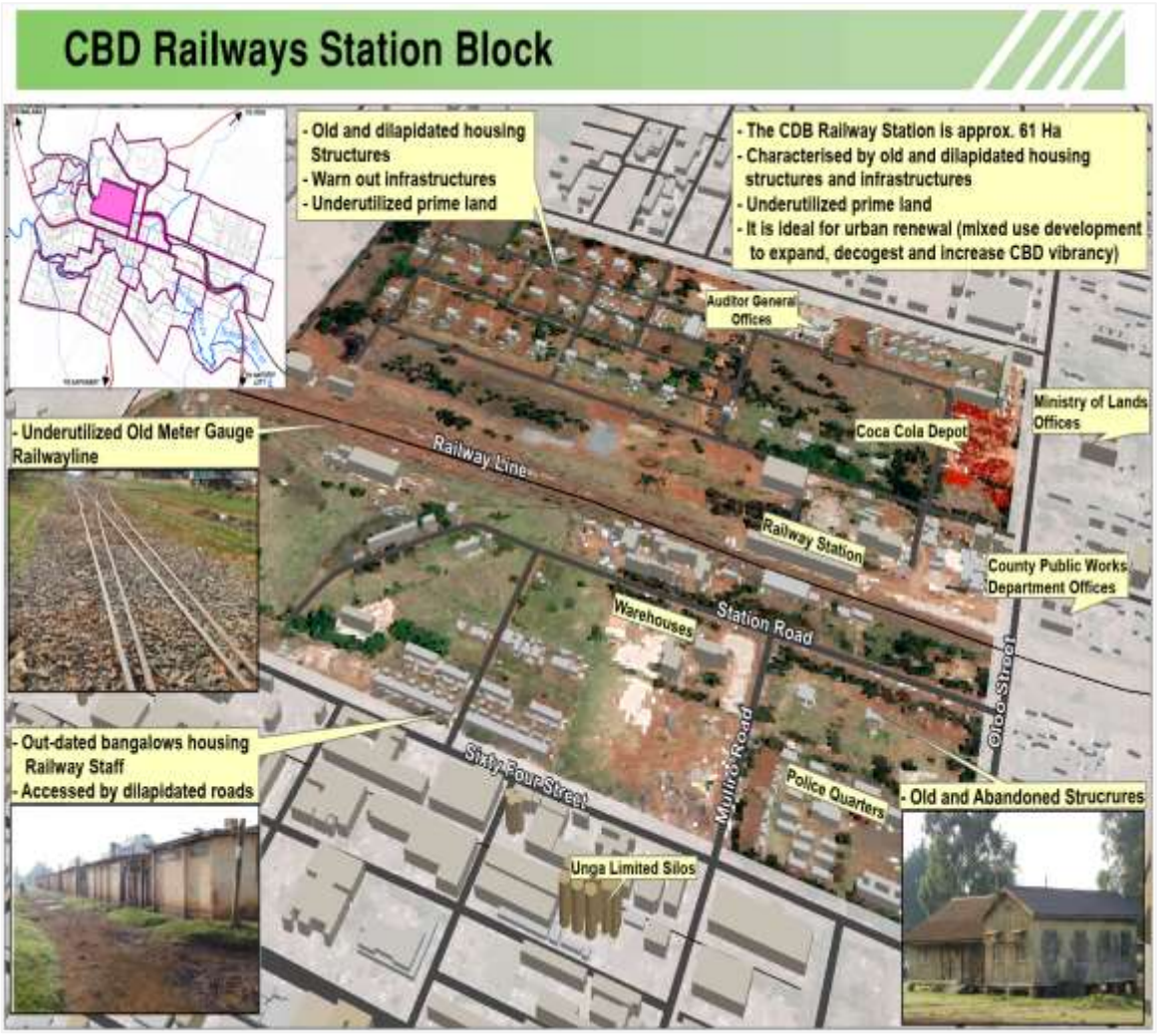

Figure 4.26 CBD Railway Station Block

(Source: Author, 2023)

4.6 Traffic Desire Lines in Eldoret Municipality

Traffic desire lines and graphs were used to illustrate traffic demands in Eldoret Municipality as presented in the following section. This presents an opportunity to identify and rank traffic routes thus enabling plan for various traffic routes depending on their needs. There are four

(4) major desire lines in the study area namely A (Outspan) to CBD, B (Kapseret) to CBD, C (Maili Nne) to CBD and D (Chepkoiled Junction) to CBD as illustrated in Figure 4.27.

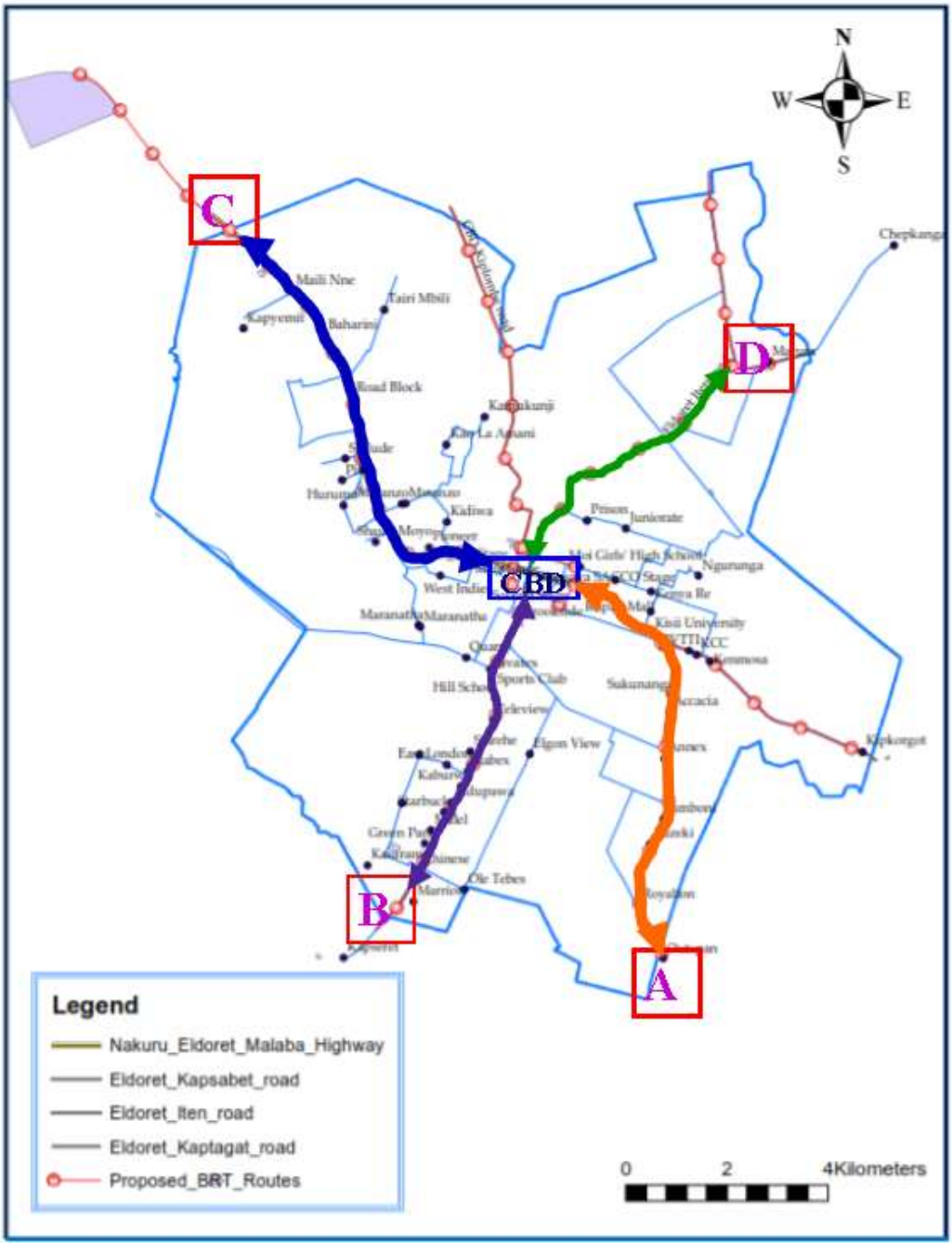

Figure 4.27 Desire Lines in Eldoret Municipality

Figure 4.28 is a graphical illustration of the total daily desire line statitstics for motorized transport that is Trucks, Lorry, Bus, Matatu, Car, TukTuk and Motocycle in Eldoret municipality. In order to achieve smart transportation in Eldoret municipality, interventions measures need to be matched to desire lines depending on the need. Link C – CBD has the highest need for smart transport interventions with demand of 10,143 traffic entities per day followed by A – CBD with 9,874 traffic entities, B – CBD with 8,861 traffic entities and D – CBD with having the least traffic entities of 7,035 per day.

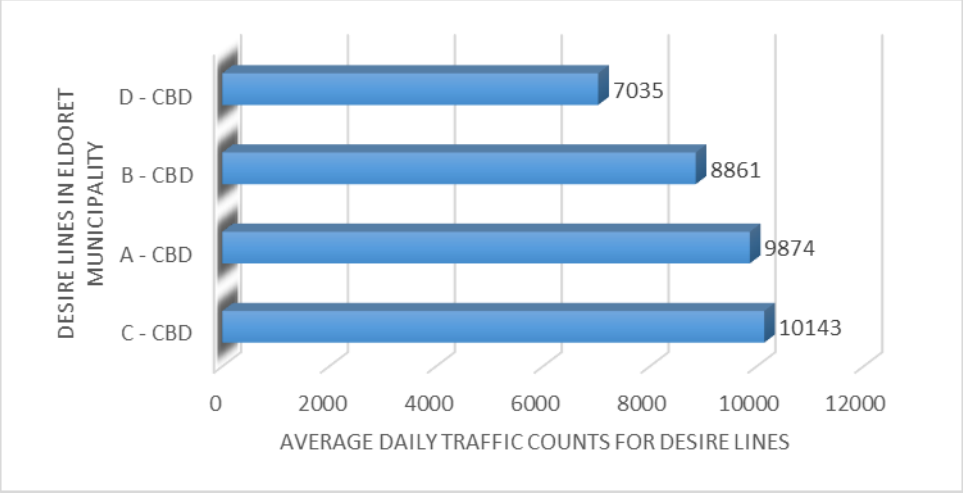

Figure 4.28 Traffic Desire Line Statistics

4.7 Assessment of Noise pollution and selected gases in Eldoret town Kenya.

This section presents the findings on the fifth objective to determine the relationship between urban mobility patterns and environmental effects of transport systems on noise and emission levels.

4.7.1 Noise levels

The sites with elevated noise levels were site 2 at Kenmosa Junction followed by site 4 at Total Sosiani, this was attributed to traffic climbing up hill and hooting vehicles or traffic speeding downhill. The elevated noise level also was contributed to by loud music of matatus and vehicles carrying loud speakers for product promotions. The study noted elevated levels of noise during morning hours compared to mid-day hours of the study. Table 4.2 and Figure 4.29 illustrates the findings on noise levels in the study area.

Table 4.2 Noise Levels in the Study Area

Site	1	2	3	4	5	6	7
Noise levels in decibels	85.34	91.42	85.24	89.4	86.5	85.28	86.22

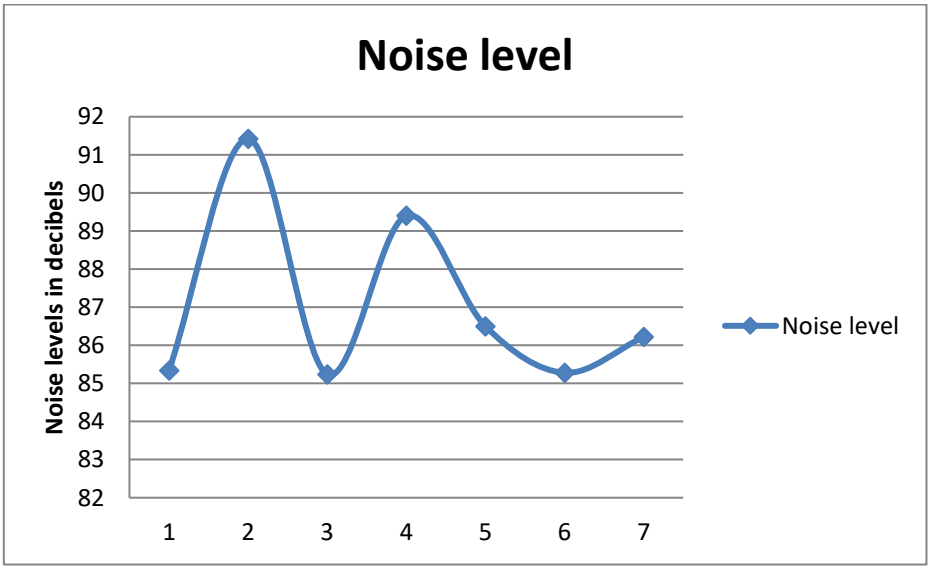

Figure 4.29 Noise in Eldoret Municipality

There's a weak positive correlation R2 = 0.1053 between average daily traffic at the four Gordon points and noise level at the Gordon Points. The R2 square value is closer to zero thus, the interaction is not significant. Nonetheless, correlation between two variables does not necessarily mean causation, as such further research needs to be undertaken to establish the cause. Figure 4.30 is a graphical representation of the correlation between, Traffic at the Gordon Points and Noise Levels.

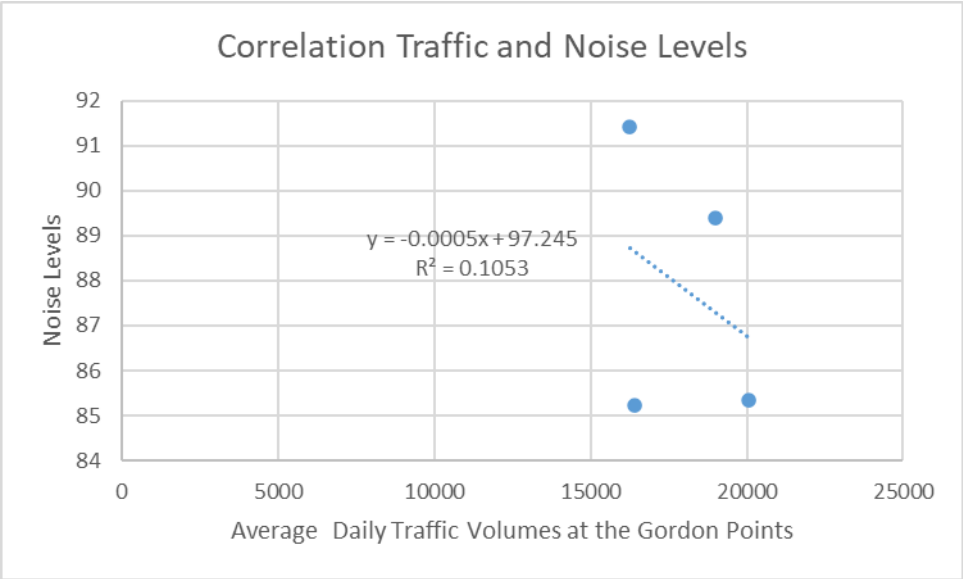

Figure 4.30 Correlation between Traffic at Gordon Points and Noise Levels

4.7.2 Oxygen levels

The level of oxygen was above the normal percentage of 19.5% to 21% in the atmosphere, this was the case in all the sites, this indicated the risk of possibility of air around Eldoret town being able to support combustion oxygen gas being able to support this more justification needed. Table 4.3 and Figure 4.31 illustrates the findings of oxygen levels in the study area.

Table 4.3 Oxygen Levels in the Study Area

Site	1	2	3	4	5	6	7
Oxygen levels in %	23.42	23.26	23.2	23.2	23.4	23.12	23.1

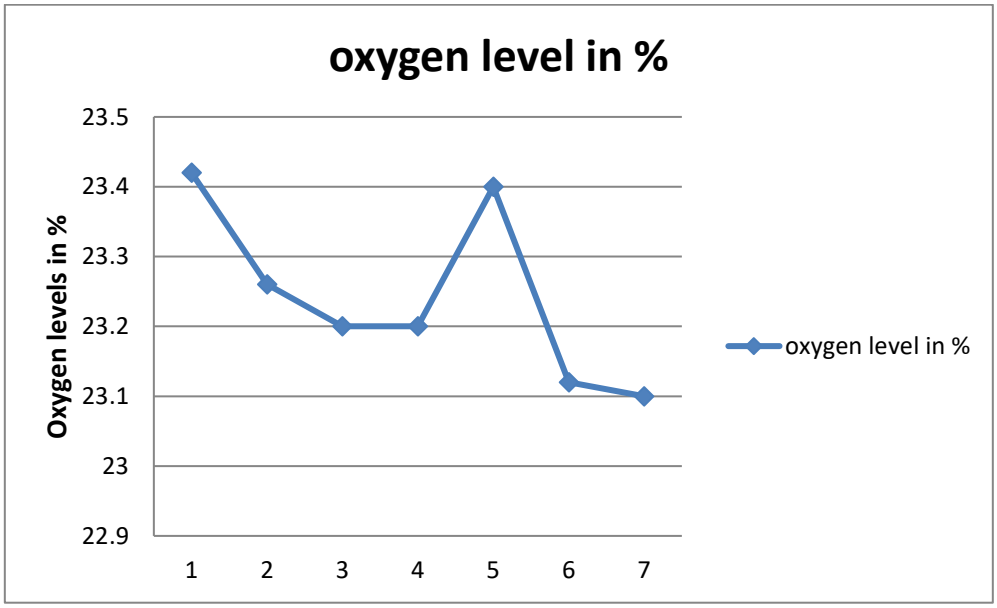

Figure 4.31 Oxygen Levels in the Study Area

4.7.3 Carbon monoxide

Carbon monoxide was detected whenever jam happens on the sampling sites, however traces of CO was detected along the streets of Eldoret town as a result of car exhaust. The study established elevated levels in the first three days and reduced in the 6th and 7th day. This indicated exposure was high during weekdays as oppose to weekends. Table 4.4 and Figure 4.32 illustrate the findings on carbon monoxide levels in the study area.

Table 4.4 Carbon Monoxide Levels in the Study Area

Site	1	2	3	4	5	6	7
CO levels in ppm	5.28	5.08	3.66	4.26	4.16	3.66	0.66

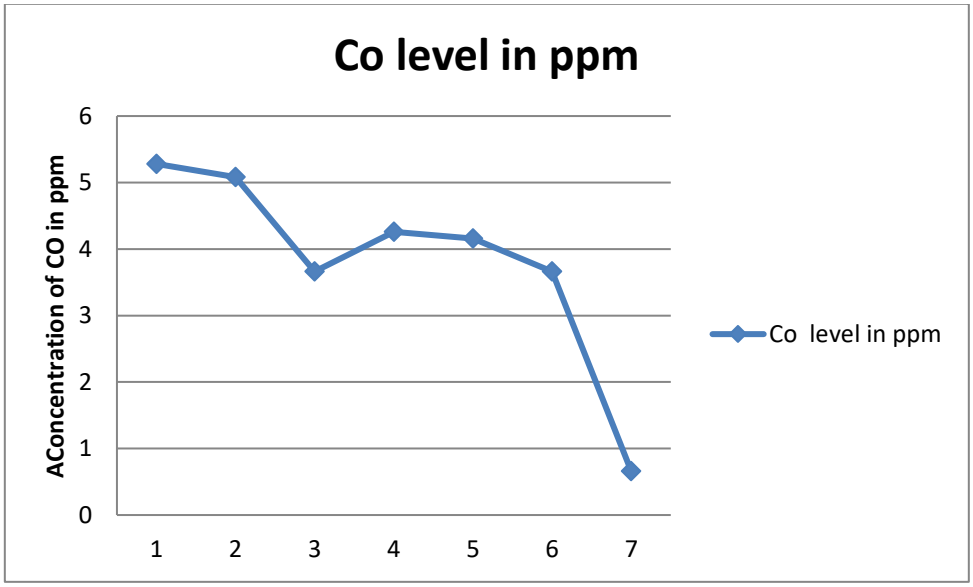

Figure 4.32 Carbon Monoxide Levels in the Study Area

There's a weak positive correlation R2 = 0.1607 between average daily traffic at the four Gordon points and carbon monoxide level at the Gordon Points. The R2 square value is closer to zero thus, the interaction is not significant. Nonetheless, correlation between two variables does not necessarily mean causation, as such further research needs to be undertaken to establish the cause. Figure 4.33 is a graphical representation of the correlation between, Traffic at the Gordon Points and Carbon monoxide Levels.

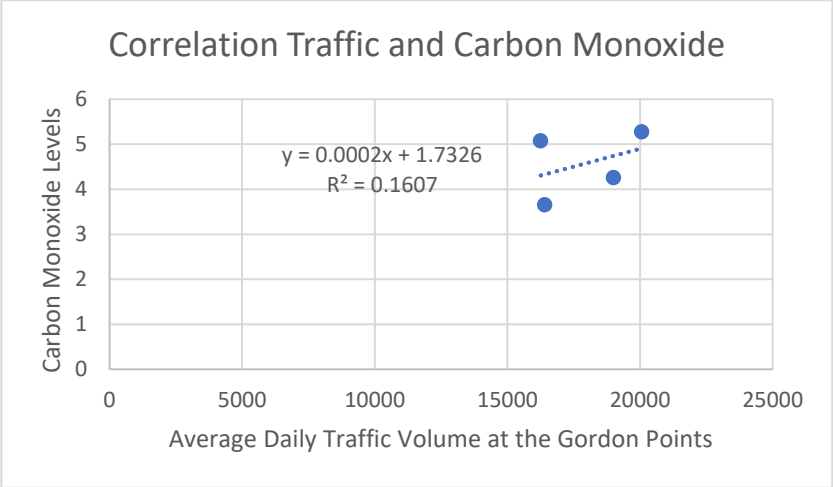

Figure 4.33 Correlation Between Traffic and Carbon Monoxide Levels

4.7.4 Hydrogen sulphide gas (H2S)

This gas was not detected throughout the study period

4.7.5 LEL (combustible Gases)

There was no detection of LEL combustible gas in all the study sites

CHAPTER FIVE

DISCUSSION

5.1 Overview

This chapter presents discussions on the findings of the study in comparison to similar studies conducted elsewhere. The discussion is presented systematically as per the objectives.

5.2 Smart Transport and Socioeconomic Characteristics

Socio-economic characteristics have an impact on the choice and use of various smart transport alternatives an individual can choose from. For instance, the concern over gender disparity in the emerging concepts of smart, green and integrated transport is not new in literature. In Sustainable Development Goals (SDGs), goal number five – gender equality and women empowerment is emphasized in all development activities. In this study, the number of females in the transport sector is lower as opposed to that of men evident by gender distribution the number of respondents interviewed. Gender equality in mobility and transport has been undermined in policy and research both at the global and national level (Priya Uteng and Turner, 2019). It has been noted that women also exhibit more sustainable travel habits than men thus low number of females in the transport sector (Uteng, 2012). Research in the transport sector in developing countries indicate that women's travel are multi-purpose, complex and resource constrained compared to male travel (Uteng and Lucas, 2017). Further, safety issues such as fear of sexual harassment and personal security on public transport and public spaces is a great concern among women negotiating daily mobilities (Uteng, 2012). Cultural restrictions placed on the mobility of girls and women in

accessing public spaces influence the time, space and duration of women travel. More so, affordability of transport services affects women travel as most are constrained from income sources and services (Uteng and Lucas, 2017). In the transport sector, women and men are restricted to separate domains where men are mainly involved with transport while women are often restricted to service functions (Hirdman, 2003). The dominance of masculinity in the transport sector across the world also tends to put women off (Kronsell, 2005). It is essential that smart mobilities and smart cities planning help the agenda of creating inclusive cities especially in the transport sector.

The study showed that most of the residents had achieved tertiary and secondary level of education. A study on impacts of transport on education conducted in Morocco demonstrated that good transport network has the potential of improving access to education especially for girls (Priya Uteng and Turner, 2019). It is therefore essential that towns serving a larger population like Eldoret municipality put in place smart transport infrastructure. It has been demonstrated by Porter (2007), in three countries that is Ghana, Malawi and South Africa that, in rural villages that have got poor and or expensive transport services majority of the students were absent from school on market days. Due to irregular and erratic public transport in these countries, students serve to transport local products to the market which consumes the school time. One example of smart transport ideas introduced to bridge the inadequacies in the traditional transport system is an innovative program in India in the state of Bihar to provide secondary school going girls with bicycles as a way of improving accessibility to school (Muralidharan & Prakash, 2017).

Lessons from the Global North demonstrate the fundamentality of putting in place measures to ensure inclusivity when planning for smart mobilities and smart cities. Past smart transport solutions have been found to exclusively promote particular groups that is the young, educated, high-income at the expense of other marginalized groups (Priya Uteng and Turner, 2019).

5.3 Origin and Destination Patterns

Recognizing the mobility in urban environments is the initial stage of evaluating the long-term sustainability of transportation systems' management (Slavić & Mrnjavac, 2019). To understand this in the context of Eldoret Municipality, the study sought to determine traffic flow at four Gordon points. This served to determine the hourly incoming and outgoing traffic volumes across various mode of transport. An integrated approach to all levels of traffic mobility is considered the most practicable option automobile dependent cities have in avoiding life quality deterioration as a result of traffic flow (Dvir & Yemini, 2017). To have a sustainable urban mobility, there is need to integrate walking and cycling, have intermodality and mobility management (Przybyłowski, 2018). It is fundamental that stakeholder and public participation be part of sustainable mobility planning (Lindenau & Böhler-Baedeker, 2014). With the current high urbanization rates, most urban dwellers lack the capacity and resources to guarantee a sustainable urban development (Slavic & Horvat, 2020). The booming urban population challenges mobility. Sustainable urban development depends on successful management of urban growth where efficiency of sustainable transport systems are key to quality of life. It is therefore crucial to understand how traffic flow at various critical points that is Gordon points to assess sustainability. The key for sustainable

urban mobility is to ease congestion, accidents and pollution. Knowledge on the actual mobility patterns is essential in understanding traffic mobility shortcomings (Przybyłowski, 2018).

The hourly incoming traffic volume at the four Gordon points that is Kipchoge, Poa Place, Sosiani River and Paul's Bakery reduces as the time of the day goes. This illustrates a high demand on transport systems into the town during morning hours of the day. On the other hand, outgoing traffic at the four stated Gordon points is highest during the evening hours of the day. To manage mobility, calls for systematic approach (Priya Uteng and Turner, 2019). To develop a transport system that is independent calls for constant research on demand for transport infrastructure. Origin and destination patterns in urban areas require a resource efficient transport system to ensure mobility and accessibility(Jones, 2014). Sustainable urban transport for smart cities should offer accessible, sustainable, safe, integrated environmentally friendly and efficient traffic system to meet the demand of all (Kiba-Janiak & Witkowski, 2019). Smart transport for smart cities seeks to influence individual travel behaviour using various professional transport measures to reduce the use of drive alone private cars, reducing the effects of car dorminance and the provision of alternative transport options. Sustainability in smart cities emphasises on reduced car use and relocating road space to sustainable transport modes an street activities and encouraging alternative travel such as walking, cycling and promoting liveable cities (Jones, 2014).

5.4 Modal Split

The traffic behaviour and attitudes of the local population are inevitably related to the quality of the existing traffic system. Eldoret municipality was found to have a number of modes of

transport that is the use matatu that is public transport, motorcycle, car, bus walking and the use of tuk tuk vehicles. Other modes of transport in the town were bicycle and train. Sustainability in transport is defined with regards to economic, environmental and social/ equity dimensions (Santos et al., 2013). Sustainable transport can only be achieved with sustainable modes of transport as well as sustainable travel behaviour. Generally, it is agreed that, private cars do not enhance sustainability, whereas public transport and non-motorized modes such as walking and cycling promote sustainability (Black, 2010). It thus crucial for one to determine why people prefer to use private car, public transport and non-motorized modes respectively. With this knowledge in mind, it is easier to develop policies that can enhance transport sustainability. This study sought to solve this challenge by seeking to determine the reasons underlying the use of various transport modes. The underlying analogy is that, understanding the mobility behaviour by determining common factors that influence modal split in the study area can provide a basis for designing sustainable transport policies.

The factors outlined as being the reasons behind the use of various transport modes include convenience, cost (cheap) and reliability. The goal therefore is to understand the factors that can lead to a decrease in the share of certain travel modes especially private means that are unsustainable. Modal split in transport is associated with a numbers of that is ranging from choice which depends on mode characteristics (Santos et al., 2013). For instance, Chen et al. (2008), observes that car ownership is associated with increased share of trips by car and decreased share of trips by public transport. On the other hand, car purchase costs and petrol prices have a negative impact on mobility by car (Dargay & Hanly, 2007). Age has also been known to impact on modal split such that as people get older, they may have different

preferences regarding mode choice. The decline in health, physical and functional abilities may lower the confidence of old people in walking and driving (Sabir, 2011).

The study also analysed the challenges facing transportation in the study area. The most cited challenge was traffic congestion, poor road conditions, traffic accidents, insecurity, high cost of transport among others. To help avert these challenges, polices aimed at attracting potential public transport users, including private car users include cheap fares, road pricing and high car park charges have been employed (Parry 2009). Policies in favour of public transport such as lowering fares, increasing number of mass transit vehicles have transformed public transport in terms of making trips to work. The use of bicycle has been directly linked to the availability and length of bicycle network. The allocation of space on road carriage way as bicycle lanes have been known to achieve an increase in bicycle share of trips to work (Santos et al., 2013).

5.5 Infrastructural Carrying Capacity for Smart Transport in Study Area

Infrastructural carrying capacity refers to the numbers of transportation entities that can be supported by a given infrastructural system. Roads are the links that make accessibility to locations and facilitate trade, exchange of goods and services as well as transfer of knowledge and other benefits (Ayeni et al., 2018). Roads are the major form of transport in the study area, nevertheless roads in the study are inadequate for smart transport. Various factors can influence infrastructural carrying capacity. Urban areas hold a sizable population and such demand on transport infrastructure quickly overshadows the infrastructure carrying capacity.

Improving the technology however can impact on the infrastructural carrying capacity positively. Technology is improvement which result in improved ways of doing to better the

output. These could include the innovation in terms of ways of infrastructural construction to accommodate more pressure and enhance lifespan of infrastructure (Albert & Von Haaren, 2017). In the construction industry for instance, new materials with high resilience, resistance and more weigh handling ability may be discovered and employed in the construction works.

The study presented findings on the road conditions, parking spaces, introduction of high-capacity vehicles, provision of bicycle lanes, pedestrian walk ways and street lighting. These can be categorized as regulatory factors. They may include the introduction of policies intentionally by the government to cure the anomalies in smart transport (Ayeni, 2019). This anomaly in smart transport might be infrastructural decay, population explosion among others. Regulatory policies are therefore fundamental to smart transport though with constant monitoring. All the same to manage the infrastructural carrying capacity means to be always on the look for shortages in infrastructural supply. There is always need to improve the stock of available infrastructure that is road carriage way, pedestrian walk ways, bicycle lanes and a mix of transportation means that is trains, buses among others so as to cater for day-to-day activities.

The infrastructural needs of the study area no different from other cities as they include transportation to hospitals, educational infrastructure, work among other requirements. Nonetheless, in the study area the growth of infrastructural needs is unmonitored and various infrastructural needs are not well accounted for. The activities in the urban setup that is economical, social, educational, commercial among others far outweigh the available infrastructure. This overworks and damage the available infrastructure sooner than expected. As such, understanding the infrastructural carrying capacity becomes handy in planning for

needed infrastructure for a given population, depending on the social, economic and commercial activity.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Introduction

This chapter presents conclusions and recommendations based on the research findings. It outlines the measures that need to be put place in order to achieve smart transport network in Eldoret Municipality.

6.2 Conclusion

Smart urban transportation system can be realized only through an integrated approach in the implementation of transportation policy. It is unethical and difficult to restrain car use and make it unaffordable without providing feasible and convenient alternatives to car use. The implementation of restrictive policies on car use must be second to the provision of high-quality public transportation systems as well as secure and opportune walking and cycling facilities. There is also need to create public awareness on the alternative smart transportation such as walking and cycling. Further, transportation changes to achieve a green transportation system should be accompanied with well-coordinated changes in land use policies. The public should be informed of the benefits of the new policies. Nevertheless, the policies should be implemented in a stepwise manner.

6.3 Recommendation

i. Congestion pricing, higher fuel taxes and vehicle fees are some of the cost related ways of promoting fuel efficiency and more environmentally friendly cars. Such

kinds of policies are essential for promoting public transportation, walking and cycling.

ii. There's need to develop an expressway overpass from Pioneer to Kipchoge stadium and a second one from from Annex to Maili nne so as to decongest the central business district.

iii. There's need to introduce smart parking in the study area such that travellers will leave personal cars outside the CBD and enter the town using mass transit public means.

iv. The County Government of Uasin Gishu to put in place policy measures to use vacant and undeveloped plots within the municipality for parking

v. To County Government of Uasin Gishu to integrate parking facility in all new plans for development including building plans that require approval from the county

vi. The county should introduce mass transit – park and ride facility within the municipality

vii. The county government should introduce greenery and beautification programmes along the main road, pedestrian walk ways, and cycling lanes.

viii. Garage in the municipality should be located in designated sights to avoid oil spillage into the surrounding environment and water bodies such as Sosiani River.

ix. There is need to integrate transit, cycling and walking as alternatives to the car. For car-restrictive measures to hold, safer, convenient and cheaper alternatives to cars should be made available for the public to use.

x. There is need for public information and education to influence travel behaviour. These campaigns are essential in making clear policy benefits and the final positive impact.

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APPENDICES

Appendix I: Questionnaires

UNIVERSITY OF ELDORET

SCHOOL OF ENVIRONMENTAL STUDIES

DEPARTMENT OF ENVIRONMENTAL PLANNING AND MANAGEMENT

TRANSPORT ATION QUESTIONNAIRE

This study aims to present and seek solutions to the challenges facing the transport sector within Eldoret Municipality in order to provide **smart transport** solutions in a bid to make the Municipality a **Smart City**.

Information obtained shall be held confidential and shall strictly be used for the academic purposes only.

QUESTIONNAIRE NUMBER…….

ESTATE/AREA OF RESIDENCE……

DATE……

…

***MATATU* SACCOS**

- Name of Sacco……..

- Total number of *matatus* owned by the Sacco
- Origin and destination areas for the Matatus within the Sacco
- Number of matatus owned by your Sacco that ply the following routes

    a) Eldoret Town –Chepkanga

    b) Eldoret Town-Sogomo

    c) Eldoret Town-Langas

    d) Eldoret Town-Maili nne

    e) Eldoret Town-Kipkorgot

- Rate traffic congestion levels along these routes

    a) Good

    b) Fair

    c) Bad

Route	**Rate of traffic congestion**
Eldoret Town –Chepkanga	
Eldoret Town-Sogomo	
Eldoret Town-Langas	

Eldoret Town-Maili nne	
Eldoret Town-Kipkorgot	

- What are the transport charges along these routes

Route	**Transport cost**	
Eldoret Town –Chepkanga	Peak	
	Off-peak	
Eldoret Town-Sogomo	Peak	
	Off-peak	
Eldoret Town-Langas	Peak	
	Off-peak	
Eldoret Town-Maili nne	Peak	
	Off-peak	
Eldoret Town-Kipkorgot	Peak	
	Off-peak	

- Comment on the condition of road surfaces

a) Good

b) Fair

c) Bad

- Names of roads proposed for road widening
- Names of roads proposed for surface improvement
- State of the existing bus termini

a) Good

b) Fair

c) Bad

- Comment on the adequacy of existing bus termini

a) Adequate

b) Inadequate

- The bus stand is equipped with modern technology and is eco-friendly

a) Strongly agree

b) Agree

c) Neutral

d) Disagree

e) Strongly disagree

- The bus stand has adequate resource and capacity

  a) Strongly agree

  b) Agree

  c) Neutral

  d) Disagree

- Comment about public transportation in the town

  a) Fares too expensive

  b) No bus service

  c) Lack of parking

  d) Safety

  e) Parking cost too expensive

  f) Commuting takes too long

- Availability of internet connection in the *matatus*

  a) Available

  b) Not available

- Do you support the introduction of high capacity public transport vehicles such as Bus Rapid Transport

a) Yes

b) No

Reason

……

……

……

- State the challenges faced by the *matatu* industry in their day to day operations

***BODA BODA* SACCOs**

- Name of the Sacco/Association…….
- Total number of motocyles owned by the Sacco/association……
- Origin and destination areas for the motocyclycles owned by the Sacco
- Number of motocycles owned by your Sacco that ply the following routes

f) Eldoret Town –Chepkanga

g) Eldoret Town-Sogomo

h) Eldoret Town-Langas

i) Eldoret Town-Maili nne

j) Eldoret Town-Kipkorgot

- State whether there is provision of designated lanes along these routes
- Rate traffic congestion levels along these routes

  d) Good

  e) Fair

  f) Bad

- Provision of designated termini for motorcycles
- State the challenges faced by the *matatu* industry in their day to day operations

KEY INTERVIEW SCHEDULES

DEPARTMENT OF ROADS AND PUBLIC WORKS

1. Current status of the following transport infrastructure within the Municipality in terms of **condition** and **adequacy**

    a) Roads

    b) Matatu/bus termini

    c) Traffic lights

    d) Parking facilities

2. Plans to upgrade the existing transport infrastructure

    a) Roads

    b) Bus/matatu termini

    c) Traffic lights

    d) Parking facilities

3. Plans to construct additional transport infrastructure

    a) Roads

    b) Bus/matatu termini

    c) Traffic lights

d) Parking facilities

4. Any plans to relocate the existing termini to the periphery of the town

5. Plans to design and improve new/existing road junctions

6. State the roads prone to accidents

7. Names of roads to be given priority for improvements

8. Details of financial allocations to the roads sector

9. Details of road pedestrian routes and street lighting in terms of;

    a. Provision

    b. Condition

    c. Distribution

    d. Capacity

    e. Level of utilization

    f. Accessibility

10. Details of road network in the area (provide a map)

11. Availability of spatial plans with emphasis on transportation

12. Plans to introduce the use of technology (such as placing cameras at strategic locations, use of GPS, coordinated traffic signals) in the transportation system

13. Parking types available and occupancy levels

14. Mode of payment for parking services

NATIONAL TRANSPORT AND SAFETY AUTHORITY (NTSA)

- Statistics of roads accidents within the Municipality
- State the roads prone to accidents
- Number of public service vehicles licensed to ply various routes within the Municipality
- Measures put in place to reduce/stop the accidents

TRAFFIC POLICE DEPARTMENT

- Common traffic offences committed
- Level of adherence to traffic rules and regulations
- Measures put in place to ensure traffic rules and regulations are followed

KENYA URBAN ROADS AUTHORITY (KURA)/KENYA NATIONAL HIGHWAYS AUTHORITY (KENHA)

- Current status of the key roads (transportation corridors) within the Municipality in terms of ;
    1. Condition
    2. Adequacy

- Plans to upgrade the existing roads
- Plans to construct additional roads
- Plans to design and improve new/existing roads and road junctions to ease traffic flow
- Names of roads to be given priority for improvements
- Details of financial allocations to the roads sector under KURA
- State whether the funds are adequate
- Details of road network within the Municipality (provide a map)

OFFICE OF THE MUNICIPAL MANAGER

- Existing situation of the road network in terms of provision of;

-Non-motorized transport (NMT)

-Storm water drainage (SWD)

- State the available parking spaces for:

  a) Public Service Vehicles (PSVs)

  b) Private Vehicles

- What is the capacity of vehicles for the above parking spaces and state whether the capacity is adequate

- Measures put in place to control the parking spaces available
- Any plans to introduce additional parking spaces
- Plans to introduce the use of technology (such as placing cameras at strategic locations, use of GPS, coordinated traffic signals) in the transportation system
- Status of street lighting on the major transport corridors
- Missing links for transport infrastructure
- Payment method for parking services

PHYSICAL PLANNING DEPARTMENT

- Spatial plans with emphasis on transportation

-Location

-Capacity

- Number of bus parks
- Capacity of bus parks
- Adequacy of the bus parks
- State of the existing bus stations/parks
- Availability of bus laybys (bus stops)

NATIONAL ENVIRONMENT MANAGEMENT AUTHORITY (NEMA)

- Levels of Emissions from the transport sector in the following specific areas within the Municipality

  a) Uganda road (A104 Highway)

  b) Eldoret-Iten road

  c) Eldoret-Kapsabet road

  d) Parking areas for private cars

  e) Parking areas for public service vehicles

- Levels of noise levels within the Municipality

- Measures put in place to reduce both pollution from transport related activitie

DEPARTMENT OF FINANCE

- *Available economic resources*

- *Linkage between Regional Economy (Economic activities) and their impact to local economy*

- *Local Economy; location and distribution of economic activities i.e. Industry, Trade and Commerce, finance, service sector*

- *Employment and income levels per sector*

- *Production and utilization levels per sector*
- *Income distribution*
- *Available economic resources*
- *Support infrastructure for economic development*

PASSENGERS' INTERVIEW SCHEDULES

1. Place of origin: …….Place of destination……..
2. Preferred mode of transport
   a) Walk
   b) Motorcycle
   c) Bicycle
   d) Car
   e) Bus/matatu
   f) Train
3. Reason for preference to this mode of transport
   a) Convenient
   b) Cheap
   c) Reliable
4. How often do you use public transportation on average?

a) Daily

b) Weekly

c) Monthly

d) Occasionally

e) Rarely

5. Time taken from origin to destination

a) Less than 30 minutes

b) Between 30-60 minutes

c) Between 60-120 minutes

d) More than 2 hours

6. Rate of the cost of transport

a) Cheap

b) Affordable

c) Expensive

7. Payment method used to pay bus/matatu fares

a) Smart card

b) Cash

c) Mobile money

8. Do you support the introduction of high capacity public transport vehicles such as Bus Rapid Transport (BRT)?

   a) Yes

   b) No

9. Would you support the provision of cycle routes to facilitate the use of bicycles as a means of transport?

   a) Yes

   b) No

10. What do you feel is the major problem in bus transportation is facing today?

    a) Traffic congestion

    b) Bus schedules

    c) Traffic accidents

    d) High cost

e) Others, please specify_____

TRAFFIC COUNT TALLY SHEET **Sheet: ……of……**

Name of road: …… Road No: ……Direction From ……..…To……

Station Name: ……Station No: ….. Date: …….

	MOTORISED						NON-MOTORISED	
	1	2	3	4	5	6	7	8
Hours counted	Truck	Lorry	Bus	Matatu	Car	Motorcycle	Bicycle	Pedestrians
6am-7am								
7am-8am								
8am-9am								
9am-10am								
10am-11am								

11am-12pm								
12pm-1pm								
1pm-2pm								
2pm-3pm								
3pm-4pm								
4pm-5pm								
5pm-6pm								

A. OBSERVATION SCHEDULE

Name of Gordon point……

Nature of data	**What to observe**	**Outcome**	
Condition of road	Type of road surface	Tarmac	
		Earth	
	Size of road (width)		
Congestion levels	Rate of traffic flow	Good	
		Fair	
		Bad	
Mode of traffic	Transport modes available/used	Walking	
		Bicycles	
		Motorcycles	
		Matatus	
Transport infrastructure	Availability of the following transport infrastructure	Bus terminus	
		Parking facilities	

		Traffic lights	
		Drainage	
		Traffic signals	
	State of the infrastructure	Bus terminus	
		Parking spaces	
		Traffic lights	
		Drainage	

Appendix II: Similarity Report

University of Eldoret

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