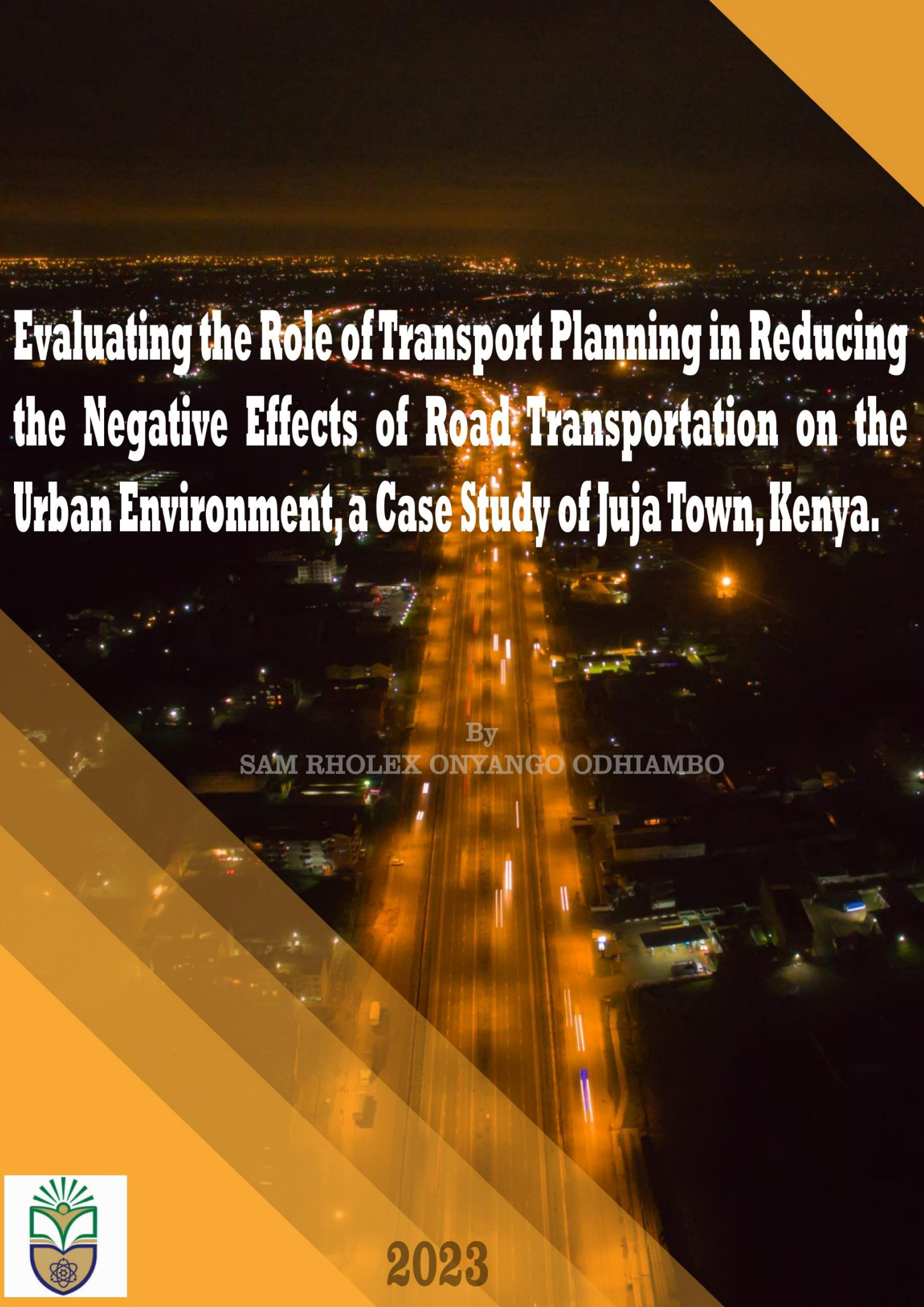

Evaluating the Role of Transport Planning in Reducing the Negative Effects of Road Transportation on the Urban Environment, a Case Study of Juja Town, Kenya.

By
SAM RHOLEX ONYANGO ODHIAMBO

2023

DECLARATION

This planning research project is my original work and has whatsoever not been presented for examination and award of degree in any other university.

Signature: ..  Date: ……06/11/2023……

Sam Rholex Odhiambo

(Candidate)

This planning research project has been submitted for examination and award of the degree with my approval as the Technical University of Kenya supervisor.

Signature: ……..  Date: ……08/11/2023……

Mr. Enock Chawere

(Supervisor

DEDICATION

“To all urban and regional planning students and professionals who believe in a better tomorrow through proper planning today.”

ACKNOWLEGEMENTS

I would like to thank all those who have in whatever way helped and encouraged me through this research project and through all my academic years

To my loving family, my mum Edna Okello, my Dad Elisha Agumba, my Sister Valentine Nudi, my brother Emmanuel Amoth and all my extended family members, I am truly gratefulfor your endless love, care and support through all my study years.

To the Technical University of Kenya, Urban Planning Department, I thank you all for the knowledge you have invested in me and I hope I will help in providing better solutions to ourchanging urban environment

To my competent lecturer, Mr Enock Chawere, you have been truly instrumental throughout my research work and I am deeply humbled by what you have taught me.

To all my classmates, let's go make the world a better place

"Erokamano"

"*Asante sana*"

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LIST OF ACRONYMS AND ABBREVIATIONS

AU	African Union
BC	Black Carbon
CBD	Central Business District
CIDP	County Integrated Development Plan
CO2	Carbon dioxide
EAC	East African Community
ETSs	Emissions Trading Systems
GHG	Green House Gases
INTS	Integrated Transport System
ITS	Intelligent Transport System
JKUAT	Jomo Kenyatta University of Science and Technology
KeNHA	Kenya National Highways Authority
KERRA	Kenya Rural Roads Authority
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KURA	Kenya Urban Roads Authority
NEMA	National Environment Management Authority
NEPP	Netherlands' National Environmental Policy Plan
NIUPLAN	Nairobi Integrated Urban Development Plan
NMT	Non-Motorized Transport
PCT	Personal Carbon Trading
PM	Particulate Matter
PrT	Private Transport

PuT	Public Transport
SDGs	Sustainable Development Goals
SSA	Sub Saharan Africa
SWOT	Strength, Weakness, Opportunity, Threat
UK	United Kingdom
VAT	Value-Added Tax
WHO	World Health Organization

CHAPTER 1 – INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Over the years humans have invented different modes and means of moving from one place to the other. The pattern of spatial growth, and consequently the direction and pace of transportation investment, can be shaped through the use of transportation planning. Many citizens of affluent cities already have access to basic mobility, giving transportation planners the luxury of concentrating on maintaining that mobility while lowering the system's externalities. In more underdeveloped cities, basic access and mobility are the key planning priorities.(Salon & Aligula, 2012) The world is fast changing with new and advanced transport means that try to connect people from all over the world. Over the past few years, most first-world countries are trying to look into the nexus between the environment and the current transport means.

In Africa, there have been several talks about connecting African countries such as the AU Vision 2063 which aims at providing a world-class infrastructure that crisscrosses African countries including the high-speed train flagship project. All these projects come with a negative impact on the natural environment. Modern transportation is virtually entirely dependent on oil. In 2008, 61.4% of all oil was used for transportation, and as demand for transportation has increased, numerous issues have arisen. These include urban sprawl, traffic congestion, traffic safety, and environmental concerns including noise, air pollution, effects on ecosystems, and emissions of greenhouse gases (GHG).(Banister et al., 2011)

In Kenya, the transport sector has several institutions such as KURA, KERRA, and KeNHA that are charged with the responsibility of upgrading and maintaining the road networks. Other institutions that work in hand with the transport sector include the Planning Department, which among others, charged with regulating developments and controlling development permissions, and NEMA, charged with the responsibility of maintaining a good and clean environment for the current and future generations. The country has made progress in trying to maintain a good environment while improving infrastructure at the same time. Some of the major steps include Vision 2030 and the National Spatial Plan aimed at having an integrated transport system.

Nairobi, in particular, developed the NIUPLAN that among others, aims at having a clean environment and a good flowing transport network that is user-friendly. The natural environment is a major component in the urban setting that should not be tampered with whatsoever. In recent years, unchecked rapid urbanization in Kenya characterized by increased population in the urban areas has resulted in serious pollution issues that are mainly brought by the transport systems.

Juja town in Kenya, Kiambu County, Juja Ward is no exemption. A case study of Juja town, targeting the residents in the urban settings and different levels of government tries to help understand the impacts of road transport on the environment. The town has serious transport problems such as poor drainage systems, undeveloped murram roads, narrow roads, and no proper NMT routes. The natural environment such as landscaping issues, trees, and gardens is negatively affected by transport issues. The local authorities in the town are doing little in trying to resolve the problems. The majority of the investors in the area are mainly concerned with the real estate sector and therefore prioritize building of houses and leaving the undeveloped roads untouched. To address the threat that climate change poses to urban areas, it is extremely important to ensure a low-carbon transportation sector. Transportation and mobility play a significant role in the quality of the environment in Juja town.

1.2 PROBLEM STATEMENT

Juja Town is characterized by undeveloped road networks, pedestrian-vehicular conflicts, air pollution from vehicles and murram roads, noise pollution from hooting vehicles, traffic congestion, and the degrading of the adjacent natural environment. The town has experienced immense population growth in the last decade. The town is projected to grow to a population of 53,223 by end of 2022, reaching 57,272 by 2024, and 65,137 by 2030.(CIDP_2018_2022 Kiambu, n.d.)This population is mainly between the ages of 25 – 45 because a majority of the residents are either working class or students at the Jomo Kenyatta University of Science and Technology (JKUAT). This high population has influenced the increased vehicular conflicts and traffic jams in the town.

Over the past few decades, the local, municipal and National governments have tried to help mitigate the road problems. Majority of the roads have been upgraded from earth to gravel by the county government. However, they are not up to the desired quality. Gatundu-Juja road was upgraded to Tarmac for faster connections between Gatundu and Juja. Juja entry road was also upgraded and provisions put in place for pedestrian walkways on the road shoulders. The main road in the study area is Thika super highway which was a major project from the National government. The highway was upgraded from Juja road to the Thika super highway and was officially launched by The Late President Hon. Mwai Kibaki in 2012.The project aimed to help in reducing traffic congestion. Recently, the National government started the BRT project on the Super highway to help mitigate road congestion and traffic pollution. The project is almost complete and is set to begin operations in 2022. There has also been an upgrade on the Juja bus stage that was done by Super Metro Sacco to provide better parking for the buses in the stage.

Majority of the projects have experienced more failures than success. Some of the successful projects include the Thika Super Highway that has fastened the linkage between the study area and the Nairobi CBD and the Juja entry road that has enabled better access to the study area. Majority of the road upgrading projects have experienced serious hiccups. The service and residential roads within the study area rough, muddy during rainy seasons, and dusty during dry seasons. The roads are narrow, some measuring 6m wide. There is also serious traffic congestion in the Super Highway especially during peak hours, causing traffic pollution.

The failures of the projects can be attributed to a number of issues. The existing building and zoning regulations are either not being implemented or the planning authorities are not providing correct directions on the matter. There is also no proper coordination between the local and national government and politicians are influencing the decision-making processes. The existing zoning regulations in the town are not well articulated and are not being followed to the latter. This has encouraged unregulated developments that have led to narrow marram roads with no wayleaves. The current local government is doing little in trying to upgrade the transport situation in the town.

The problems identified have serious effects on the natural environment and the people working and residing in the town. High carbon emissions, air pollution from dusty roads and traffic jams, global climatic constraints caused by increased greenhouse emissions and Low pedestrian safety in the town are the main issues to be analyzed in the town.

1.3 MAIN OBJECTIVES AND RESEARCH QUESTIONS

1.3.1 Objectives

The main objectives of the research project include;

❖ To assess the status of the urban environment in juja caused by road transport.

❖ To investigate the causes of urban environmental degradation in Juja town caused by road transport.

❖ To come up with solutions that help in mitigating the negative transport problems on the urban environment in Juja town.

1.3.2 Research Questions

From the objectives above, the main research questions include;

❖ What is the status of the urban environment in juja?

❖ What are the causes of the urban environment degradation in juja by road transportation?

❖ What are the possible solutions that can be put in place to help mitigate the negative transportation issues on the urban environment in Juja town?

1.4 STUDY ASSUMPTIONS

Poor transport planning and implementation is the main causes of urban environmental degradation such as undeveloped roads, pollution, congestion, and urban heat. Proper transport planning in juja town will result to better urban environment in the town. These would include having transportation strategies that would provide sustainable transportation.

1.5 JUSTIFICATION AND PURPOSE OF STUDY

Transportation has both positive and negative effects on our environment. The rapidly growing Juja town will quickly turn into a "concrete jungle" if left unchecked. If there is nil intervention, Juja town will succumb to environmental degradation characterized by increased urban heat, increased pedestrian accidents due to low pedestrian safety, increased health respiratory problems caused by the dusty roads that catalyze the effects of particulate matter and low connectivity and circulation within the study area. There are two main objectives in transportation planning: to give people enough mobility to go to the jobs, goods, and services they want and need, and to give them that mobility in a way that minimizes the detrimental effects of travel on the environment.(Salon & Aligula, 2012)

This study aims to understand and appreciate the importance of proper transport planning in mitigating the negative environmental externalities caused by road transport in Juja town. The increase in motorized transport at the expense of the urban environment is a topic that is widely discussed in different forums across the globe. The topic is sensitive in the sense that uncontrolled transport externalities can lead to hazardous changes in the environment. One of the seventeen sustainable development goals (SDGs) includes having sustainable cities and communities that provide a quality clean environment. Vision 2063 on Africa we want, identifies that although Africa produces just about 5% of the global carbon emissions, there is a need to address the rise in carbon emissions and global climate change(African Union. Commission, n.d.) The EAC member states place a high priority on developing transport networks. Some of the main weaknesses identified in the SWOT analysis include poor road networks, unplanned urban settings, high congestion rates, and increasing air pollution(EAC Vision 2050 FINAL DRAFT OCT- 2015, n.d.)

Due to Kenya's fragmented road system, a national integrated transportation system is required (INTS). That is the physical integration of public transportation services, the informational integration of public transportation, the integration of transportation authorities, and the provision, management, and pricing of infrastructure for both public and private transportation. (National Spatial Plan, n.d.)

Kenya's goal under Vision 2030 is to become a middle-income industrialized nation that offers all of its residents a good quality of life. Through 2030, various models are used to estimate carbon dioxide emissions from burning fossil fuels that could lead to long-term environmental deterioration. (Nyangena, n.d.) Juja town is a perfect example of a town changing due to transportation neglect and proper transport planning is necessary for the town to meet its full potential. For Juja town to develop sustainably, the transport sector should be the cornerstone of any development projects

1.6 SCOPE OF STUDY

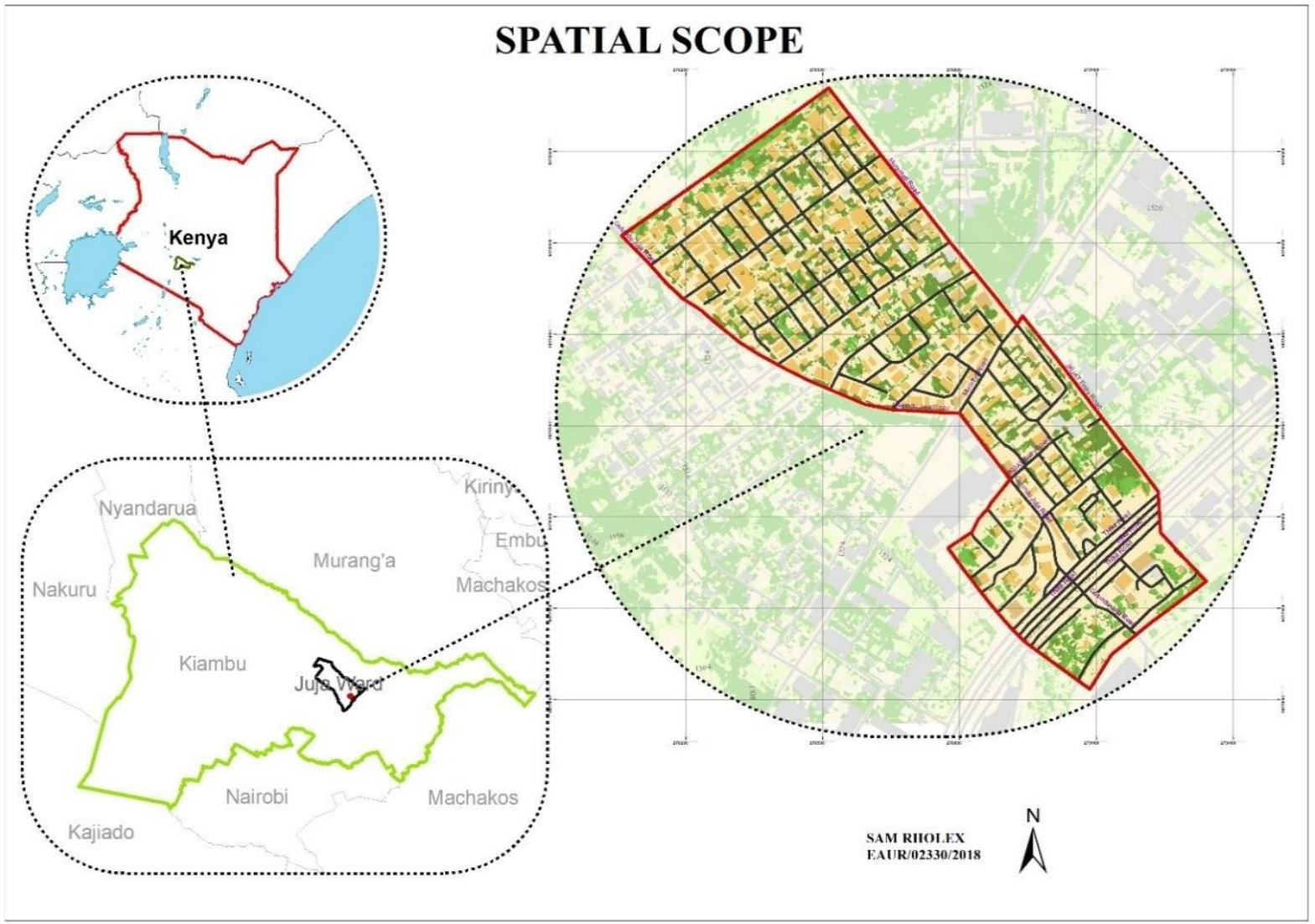
1.6.1 Theoretical Scope

The project research was driven by the need to identify the role transport planning plays in having a good urban environment in Juja town.

1.6.2 Spatial Scope

The study area is located in Kiambu County, Juja Sub–County, Juja Ward, Off Thika Super Highway. The area is enclosed by major roads such as Gatundu Juja road to the west, JKUAT Entry Road and Muramati Road to the east, and Thika Super highway to the south. The total area of the site is approximately 3 km^2 . The major neighborhood structure is JKUAT, to the east. The study area is approximately 34 km from Nairobi CBD. Map 1 below shows the scope of the study area.

STUDY AREA SPATIAL SCOPE



Map 1: Study Area Scope

Source; Author

1.7 STUDY ORGANIZATION

This planning research report is organized into six (6) main chapters;

CHAPTER ONE

Introduces the topic and study area. It provides background information on the issue, identifies the issue, details the study's objectives and research questions, and provides information on the assumptions made as well as the significance, justification, and scope of the planning research study.

CHAPTER TWO

Gives a thorough analysis of the literature on numerous transport-related issues that have an impact on urban environments. Additionally, it presents the research study's theoretical and conceptual framework.

CHAPTER THREE

Describes the research approach, research design, research environment, and research techniques. It explains the procedures utilized for data gathering, processing, and presentation, as well as sample approaches. A work plan and a budget are used to depict the chapter's activity schedule.

CHAPTER FOUR

Maps, sketches, drawings, and the synthesis of numerous pertinent themes are used to provide a complete analysis of the study region and to present the area's current state.

CHAPTER FIVE

Mostly discusses the data analysis and analysis of data. To provide a true image of the research region and offer legitimacy to the prior recommendations, the primary and secondary data obtained are correlated and examined together.

CHAPTER SIX

Outlines pertinent planning conclusions and suggestions by the information acquired in the earlier chapters of the research report to conclude the planning research study.

CHAPTER TWO – LITERATURE REVIEW

2.1 INTRODUCTION

Transportation is the backbone of any urban setting and it plays a critical role in the growth and development of many countries. Man was designed to move and the urge to move from place has grown immensely with the rise in technology. In addition, worldwide ownership of cars is expected to triple to over 2 billion by 2050. (Al-Guthmy & Yan, 2020) Given how important transportation infrastructure and services are to urban systems, its expected function is to promote bettering quality of life and achieve sustainable urban growth. In many nations, increased pollution and environmental deterioration are a result of the expansion of social and economic activity.(Asri & Hidayat, n.d.)

2.2 THEORETICAL AND OPERATIONAL DEFINITION OF TERMS

Transport Planning:

Relates to the preparation and execution of measures intended to solve certain issues.

Transport Policy:

Transport policy entails creating a collection of ideas and assertions that are developed to attain particular goals regarding the social, economic, and environmental conditions as well as the operation and performance of the transportation system.

Black Carbon:

Black carbon is the dark sooty substance released by gasoline and diesel engines. Particulate matter, or PM, is a major component of it and is an air contaminant. (Epa & Office of the Assistant Administrator, n.d.)

Greenhouse Gases:

A greenhouse gas (GHG) is a gas that produces the greenhouse effect by absorption and emission of radiant energy in the thermal infrared range. Water vapor (H2O), carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and ozone are the main greenhouse gases in the atmosphere.

Particulate Matter (PM):

The name is given to an airborne combination of liquid droplets and solid particles. Dust, grime, soot, and smoke are examples of particles that are large enough or dark enough to be visible to the unaided eye. Some can only be seen with an electron microscope because they are so tiny. They include $PM_{2.5}$ and PM_{10}.

Traffic Congestion:

A problem with road networks that develop as traffic volume rises and is characterized by slower speeds, longer travel times, and more queuing. Congestion starts to happen when there is a high enough demand for transportation that interactions between cars cause the flow of traffic to slow down.

Intelligence Transport System (ITS):

Application of sensing, analysis, control, and communications technology to ground transportation to increase efficiency, safety, and mobility. A variety of applications that analyze and share information are part of an intelligent

transportation system, which helps to reduce environmental impact, enhance traffic management, reduce congestion, and benefit both business users and the general public.

2.3 GLOBAL PERSPECTIVES

Issues associated with road transport have been raised and published in different forums across the globe. Some of the widely talked about issues include the policies set in the sector, black carbon emissions, increase in the level of particulate matter in the roadways, greenhouse gas emissions, and traffic congestion. This research focuses on some countries across the globe that experience the same scenarios and how they have tried to mitigate the issues.

2.3.1 Transport Policy Making In the UK

The policy-making process is normally a long procedure that involves different stakeholders such as government officials, experts in the area as well as the general public. Policymaking in transport planning requires in-depth research and analysis of the problems and ways through which they can be reduced or mitigated. Policymakers of use “windows of opportunities” to implement new policies. With the publication of the government's "Roads to Prosperity" white paper in 1989, the UK's transportation strategy underwent a reevaluation (DOT, 1989).

Based on projections of increasing trends in the use of private vehicles, this drew up a comprehensive road construction program for the country. The exorbitant expense of building the road systems outlined in the document and whether it would ever be able to meet the anticipated needs were two of the plan's many critics. This led to a review of the techniques and procedures employed by transportation planners in predicting this expansion. (Noland, 2007) One of the main concerns was that transportation planners adhered to the "predict and provide" concept. In other words, they would forecast future patterns in transportation based on demographic shifts such as rising population, income, and car ownership, and then simply provide for the roads and amenities. (Noland, 2007)

Over the past 10 to 15 years, there have been substantial changes in the transport policies of numerous nations. These advancements have expedited and matched research into how policies affect people's behavior. There is now widespread agreement among transport researchers, in particular, that it is impossible to develop one's way out of congestion. (Noland, 2007)

POLICY MAKING PROCESS

Figure 1 below summarizes the policy making process.

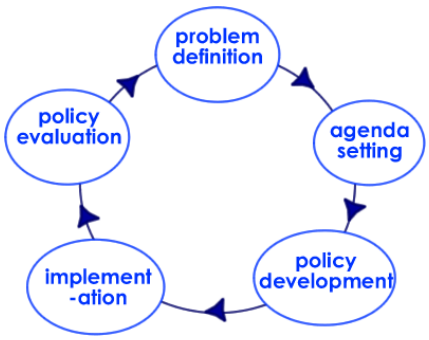


Figure 1: Policy Making Process

For transport policy to be instrumental in solving problems, there should be an analysis of the passengers’ travel behavior. Policies are then put in place to try and modify those travel behaviors. (Hensher, 2002)

Best Mitigation Cases

Some of the main spatial (specific transport change) linked instruments in trying to have a clean environment include;

Traffic pricing (mix of charges and taxes), a parking fee, Restrictions or limits on parking, road toll fees, limiting access for cars to some areas, and non-motorized transport. (Hensher, 2002)

Aspatial policy-linked instruments include;

Sales tax on brand-new cars (skewed and eliminated), registration fees for vehicles (by age, weight, fuel), obtaining and using company vehicles, Maximum vehicle age in the parking lot, Carbon tax, which is connected to alternative fuels mandatory emissions tests, buying and destroying of high emission vehicles by the government, Automobile engine/transmission technology, alternative fuels - electric vehicles, and automobile vehicle design (weight, drag)(Hensher, 2002)

2.3.2 Black Carbon Vehicle Emission In China

A major environmental issue, black carbon has detrimental effects on both our climate and human health. Black carbon exposure is linked to health issues like cancer and respiratory conditions. It also contributes to climate change as a result of its capacity to absorb light as heat. For instance, as the air heats due to the presence of black carbon, precipitation and cloud patterns may quickly shift. China's high rates of usage of coal and biofuels are primarily responsible for high BC emissions. The steadily increasing BC emissions in China is a global concern. BC emissions in China in 2050 are predicted to be 920–2183 Gg/yr under various scenarios; and the industrial and transportation sectors stand to benefit the most from technological improvements. Different modes of transport represent up to 26% of the total black carbon emissions and there is a need to find alternative transport solutions to help reduce black carbon emissions.

Best Mitigation Cases

Curbing black carbon in the transport sector can be addressed in three main ways; Tightening new vehicle standards, in-use vehicle retrofitting and elimination, alternative fuel and electric vehicle penetration(Sun et al., 2017). Figure 2 below summarizes the best mitigation measures.

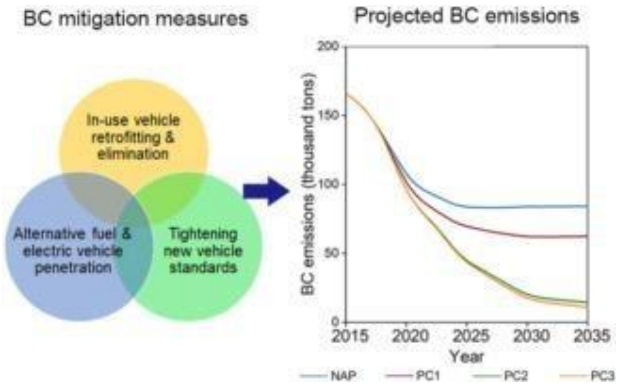


Figure 2: Mitigation Measures

Source; ScienceDirect.com

2.4 REGIONAL PERSPECTIVES

Africa is fast developing country and new transportation projects are developed every day. Transportation is a key sector in connecting the continent. There have been many efforts trying to have a better Africa, including the Agenda 2063 and the EAC vision 2050.

2.4.1 Particulate Matter ($PM_{2.5}$ & PM_{10}) on Roadways In Sub Saharan Africa (SSA)

One of the biggest environmental problems facing humanity in the 21st century is urban air pollution. Particularly, fine PM (particles with aerodynamic diameters less than 2.5 μm) has a significant impact on human health, visibility, ecology, the weather, and the climate. The aerosol features, such as size, chemical composition, and numerical concentration, have a significant impact on these PM effects. PM can be created in the atmosphere by the gas-to-particle conversion process or directly released into it. As well as being transported, processed by clouds, and removed from the atmosphere, the primary and secondary PM also go through chemical and physical changes. (Zhang et al., 2015)

Sub-Saharan African (SSA) urban areas are quickly urbanizing, and this harms the quality of the air. Some of the contributing factors include expanding car fleets, inadequate road infrastructure, traffic congestion, and high emissions per vehicle. Between 1992 and 1999, car imports rose by 50% most of which were old, inefficient second-hand vehicles imported from the United Arab Emirates and Japan.(van Vliet & Kinney, 2007a) In SSA, PM concentrations in and around roads are particularly significant due to the amount of traffic, commerce, and other human activity that occurs there. Roadways with high traffic volumes can produce pollution hotspots where the health risks are greater than those that are present more generally throughout a city, and where the poor are disproportionately affected (Kinney and O'Neill 2006).(van Vliet & Kinney, 2007b) Emerging data from the new monitoring network in Accra point to the possibility that annual average PM10 concentrations are frequently much higher than WHO targets and recommendations, and that exposure and disease burdens may be particularly high for people who drive, work, or live close to congested roads (Nerquaye-Tetteh 2006).

The World Health Organization has modified its global air quality recommendations for particulates less than 10 and 2.5 μm in diameter (PM_{10} and $PM_{2.5}$ respectively) as well as an intermediate target concentration to be used by developing nations to gauge their progress toward the guideline level (WHO 2006). The intermediate targets for yearly average PM_{10} concentrations begin at 70 μg m3 and go all the way down to the 20 μg m3 threshold. The initial yearly target for $PM_{2.5}$ is 35 μg/m3 , and the recommended level is 10 μg/m3 . (van Vliet & Kinney, 2007a)The question of how current ambient particulate matter concentrations in SSA cities compare to these numbers is reasonable. Figure 3 below assesses the size of PM particles.

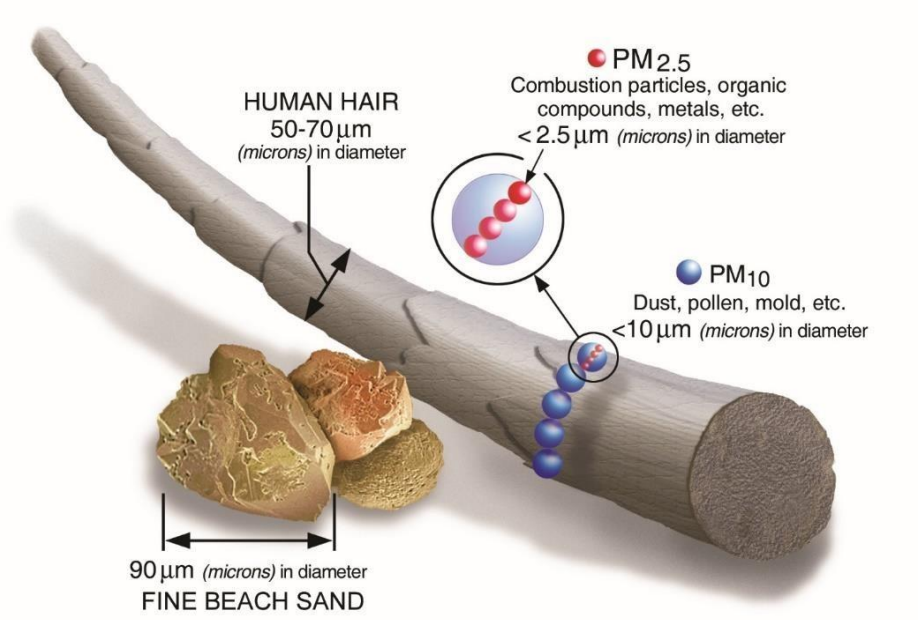


Figure 3: Assessing the size of PM

Source; Elsevier, 2015

2.5 LOCAL PERSPECTIVES

Kenya is no exemption in the current hazards caused by transport pollution. The country is at risk of exposing her citizens to serious transportation, health and climatic challenges.

2.5.1 Particulate Matter Emissions In Nairobi

A survey on PM concentrations was done in Nairobi and along Thika road in 2006. Nairobi's urban background $PM_{2.5}$ values varied from 15 to 28µ g/m-3 , with a mean of 20 µg/m-3 . The route between Nairobi and Ruiru had much higher concentrations of $PM_{2.5}$, with values ranging from 397 to 431 µg/m-3 (mean: 414 µg/m-3). The average BC concentration at the backdrop location was 5.7 105 m-1 , whereas the average BC concentration on the road was almost 10 times higher at 60 105 m-1 (van Vliet & Kinney, 2007b) According to the study's findings, Nairobi's streets have significantly higher $PM_{2.5}$ concentrations than a nearby urban background location that is not near any roads. $PM_{2.5}$ is more likely to reflect emissions from the combustion of fossil fuels (such as gasoline and diesel), biomass, and other organic materials, except for dust storm events. Given the pattern of concentrations, it seems likely that roadway $PM_{2.5}$ was primarily influenced by motor vehicle emissions.(van Vliet & Kinney, 2007b) The nearby city of Nairobi's economy is heavily reliant on urban transportation, which contributes significantly to the country's gross domestic product (GCP). However, the city's particle matter air pollution is primarily caused by traffic-related pollution. With high amounts of airborne black carbon found close to roads, traffic emissions have a significant impact on the city's air quality. (Muge et al., 2020) According to reports, imported cars in the city have a 2 to 3 times lower fuel economy than cars from their countries of origin. This is primarily because secondhand cars from Japan account for 97% of the new fleet. (Muge et al., 2020)

2.5.2 Greenhouse Emissions In Nairobi

This study aims to evaluate the extent and quantity of vehicle pollutant emissions in Kenya, a case study of Juja Town, as well as their impact on regional air pollution, urban air quality, and global warming. The amount of CO_2 in the

atmosphere is currently 400 ppmv and is steadily increasing. The concentration of greenhouse gases must stabilize at roughly 450 ppm CO_2 to stay within the global 2°C temperature limit. (Dhar et al., 2013). Cities like Nairobi, which have experienced rapid urbanization, inadequate planning, growing motorization, and disjointed public transportation systems, have seen an increase in automobile emissions, particularly during times of heavy traffic on the city's roads and in its central business district. According to projections made by the Kenyan government (2018), the percentage of total greenhouse gas emissions attributable to car ownership would reach 14.7% by 2030. Road transportation is thought to be responsible for 99% of Kenya's non-aviation transportation sector's greenhouse gas emissions (Cameron et al., 2012). Urban road networks face a significant challenge with traffic congestion, particularly in developing cities. It increases fuel consumption and travel time, pollutes the environment, reduces productivity, and burdens the economy with significant social, environmental, and economic costs.

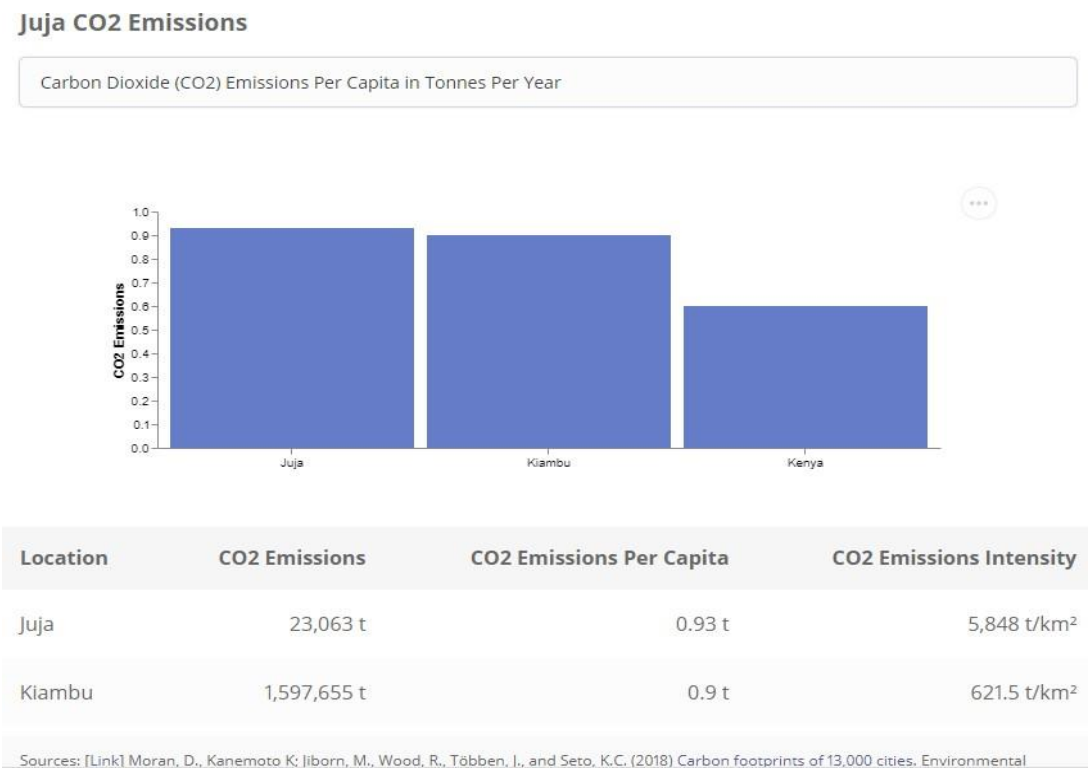
Best Mitigation Cases

Alternate emission paths such as having low carbon emitting vehicles could be used to reach the stabilization goal. (Dhar et al., 2013) Institutional coordination and appropriate policy mechanisms must be considered to reduce greenhouse gas emissions in the urban transportation sector.(Sitati et al., 2022) One of the main mitigation measures that can be taken to reduce greenhouse emissions is carbon taxing, carbon pricing, or carbon trading. Market methods are effective at changing behavior and lowering emissions, most notably carbon taxes and Emissions Trading Systems (ETSs) (IPCC, 2014; Stern, 2007). However, implementing fuel taxes has proven challenging due to public opposition, as evidenced by the 2018 uprisings in Kenya, where the government attempted to enact a value-added tax (VAT) of 16% on fuel before lowering it to 8% as a result of the President's intervention (Kamau, 2018)

A variant of ETS called personal carbon trading (PCT) was created expressly for downstream regulation focused exclusively on people or families. It runs on an "issue and surrender" cycle where emissions are capped, quotas are given out to participants by a regulatory body, circulated among participants in a trading environment, and then returned to the regulatory body (Fleming & Chamberlin, 2011). A PCT policy distinguishes itself from a carbon price by capping overall emissions. Additionally, it directly addresses the source of demand by encouraging people to use their environmental property rights more effectively (Fawcett & Parag, 2010). Although PCT has not yet been implemented, it has garnered significant scholarly and political interest. (Fawcett, 2010; Al-Guthmy & Yan, 2020)

2.5.3 CO_2 Emissions In Juja

Juja's greenhouse is steadily rising because of increased uncontrolled urbanization and unchecked traffic pollution. Figure 4 below shows Juja's CO_2 emission trends.



Location	CO2 Emissions	CO2 Emissions Per Capita	CO2 Emissions Intensity
Juja	23,063 t	0.93 t	5,848 t/km²
Kiambu	1,597,655 t	0.9 t	621.5 t/km²

Sources: [Link] Moran, D., Kanemoto K; Jiborn, M., Wood, R., Többen, J., and Seto, K.C. (2018) Carbon footprints of 13,000 cities. Environmental

Figure 4: Juja CO_2 Emissions

Source; City-facts

2.6 THEORETICAL FRAMEWORKS

This part includes a module for a proposed strategy as well as descriptions of the ideas underlying the subject area's current difficulties. These theories comprise:

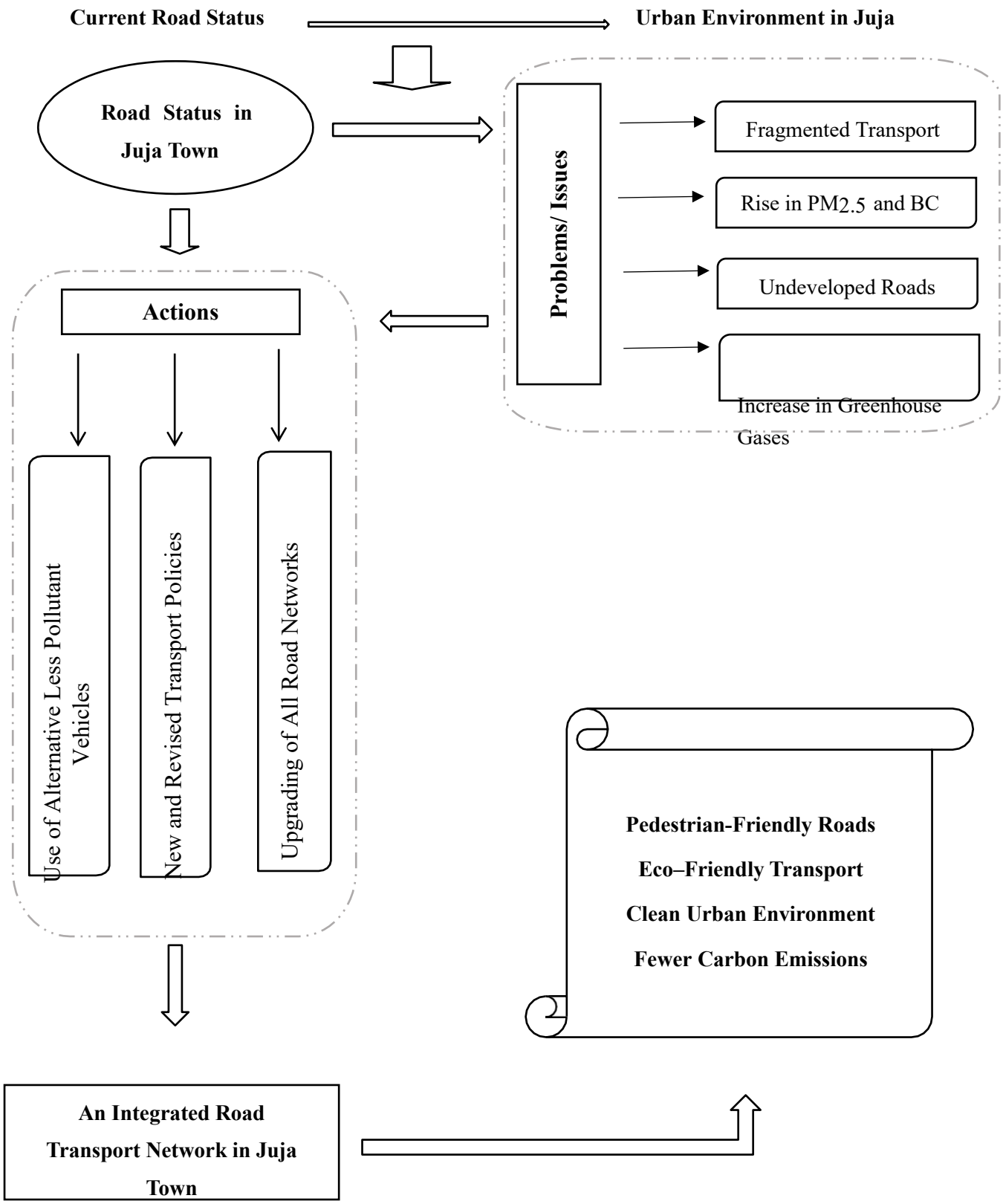
The theory of New Urbanism has two main principles associated with transport planning, that is, walkability and connectivity. Most locations must be accessible on foot in 10 min or less from home or work. Streets must be designed with pedestrians in mind, and in some instances, they must be completely car-free. Traffic is spread out by a linked street grid, which also makes walking easier. Walking is made enjoyable by a high-quality pedestrian network, a public realm, and a hierarchy of tiny streets, boulevards, and lanes. (Scheepers_BJ_Chapter_3, n.d.)

The theory of Transport Justice is mainly concerned with fair transportation systems. A transportation system is only considered fair if it consistently offers everyone a suitable amount of accessibility. (Martens, n.d.) Usually, a wide range of sources is used to finance transportation infrastructure and services. These sources come from a variety of user fees (such as fuel taxes, parking fees, and public transportation fares), infrastructure-related payments (like road taxes, property taxes related to transportation, and sales taxes related to transportation), and general taxes (such as income, property, and general sales taxation). Where the user is unable to pay the required charges due to high fees, then the transport justice is not catered for.(Martens, n.d.) Congestion-related accessibility issues are just as unfair as those brought on by insufficient public transportation or any other factor. However, justice considerations also suggest that inclusive solutions are greatly favored over more exclusionary kinds of interventions like road widening or traffic management plans whenever they are accessible and satisfy the needs of the greatest number of people at once. (Martens, n.d.)

Place of Possibility Theory mainly deals with uncertainties in transport analysis. Accountability is one of the issues that the transport sector is now dealing with. A critical question is how to honestly and rationally state what we know and do not know so that the public and decision-makers are aware of the dangers and the boundaries of prediction. In this regard, we must comprehend the various aspects of data and analysis process uncertainty and apply the proper analytical approach.(Kikuchi & Chakroborty, 2006)

Mobility Justice by Mimi Sheller offers a fresh perspective on the shift to more just mobilities at the micro, meso, and macro stages. It places discussions of low-carbon transitions and sustainable transportation in the context of broader unequal mobility regimes, considering refugees' and migrants' rights to cross borders, but also the larger macro mobilities of the planet and the smaller micro-mobilities at the bodily scale (especially as influenced by race, gender, disability, and sexuality), as well as even at the nanoscale (for example, concerning viral mobilities) (Sheller, n.d.)

2.7 CONCEPTUAL FRAMEWORK



2.8 HYPOTHESIS

Hypothesis (H1):

Vehicular emissions such as greenhouse gases, Particulate matter and black carbon on road transportation leads to deterioration of the urban environment in Juja Town.

According to traffic census data from the Kenya Institute for Public Policy Research and Analysis (KIPPRA), public vehicles—mostly small, high-emitting minivans or "matatus"— transport 78% of Nairobi's passengers and account for 36% of traffic volume, while private cars carry only 22% of the city's passengers. However, the second-hand private vehicle fleet accounts for 64% of the city's total vehicular volume. On Thika Road, where the monitoring was done, private and public vehicles account for roughly half of the total traffic volume (49% private and 51% public), but public vehicles carry 86% of the passengers (KIPPRA 2006).

In 2006, a survey of PM levels was conducted in Nairobi Metropolitan Region and along Thika Road. With a mean of 20 µg/m-3, Nairobi's urban background $PM_{2.5}$ readings ranged from 15 to 28 µg/m-3 . The $PM_{2.5}$ concentrations along the route from Nairobi to Ruiru ranged from 397 to 431 µg/m-3 (mean: 414 µg/m-3), which was significantly higher than the average. In comparison to the average BC concentration on the road, which was nearly 10 times higher at 60 105 m-1 , the average BC concentration at the backdrop location was 5.7 105 m-1 .(van Vliet & Kinney, 2007a)

Compared to an urban background site within Nairobi but away from roadways, $PM_{2.5}$ concentrations are significantly higher on Nairobi's roads. $PM_{2.5}$ is more likely to reflect emissions from the combustion of fossil fuels (such as gasoline and diesel), biomass, and other organic materials, with the exception of dust storm events. Given the pattern of concentrations, it seems likely that roadway $PM_{2.5}$ was primarily influenced by motor vehicle emissions.(van Vliet & Kinney, 2007a)

The result calls for more stringent transport legislation, environmentally friendly transportation mechanisms, and rising environmental quality demands.

2.9 EMPIRICAL CASE STUDIES

2.9.1 Netherlands' Policy for Sustainable Development (NEPP)

The Netherlands' National Environmental Policy Plan, or NEPP, was adopted in 1989. NEPP is an illustration of both environmental preservation and a strategy for reducing pollution brought on by transportation. The NEPP acknowledges that protecting environmental quality in the name of what it refers to as "sustainable development" will be a process that takes many years. It includes the environmental policy's medium-term strategy, which aims to achieve sustainable development over a longer time frame. (Rita) The primary goals of NEPP are: Vehicles must be as clean, quiet, safe, and cost-effective as possible; the mode of passenger transportation chosen must result in the least amount of energy consumption and pollution; and the locations where people live, shop, work, and spend their free time will be coordinated to reduce the amount of travel required. (Rita). Figure 5 below shows the Dutch Three-Track Approach.

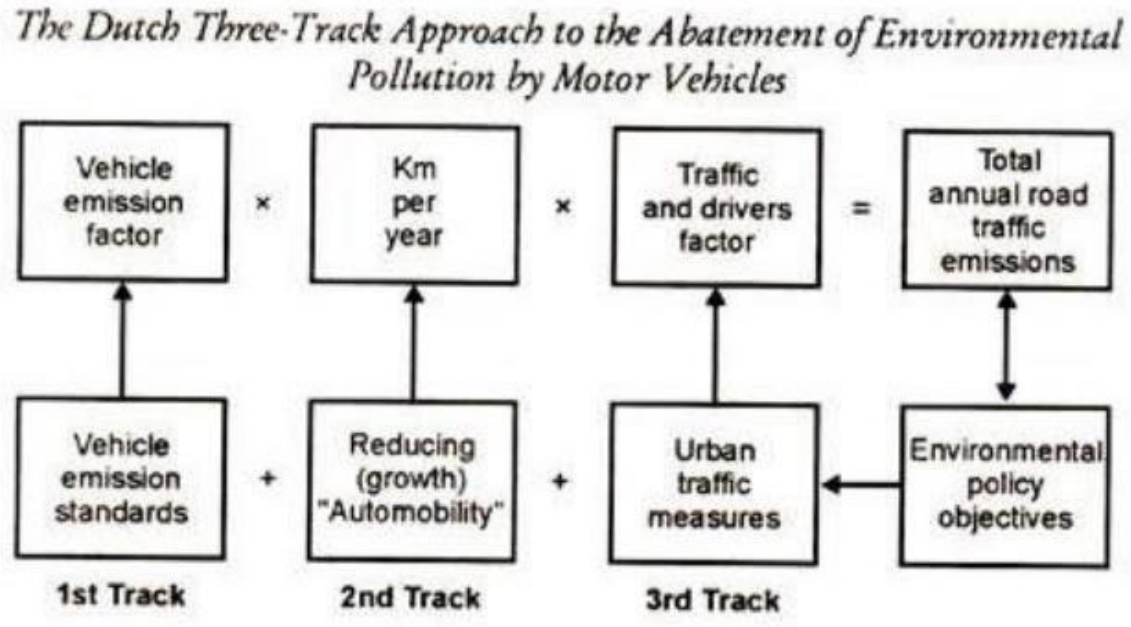


Figure 5:The Dutch Three-Track Approach

Source; Rita J

CHAPTER THREE – RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter seeks to understand the various methods that were used to justify the hypothesis and clarify on the procedures for the next chapters. There are different methodologies that were used in the research based on their relevance to the topic. This research adds new information to the body of knowledge already in existence, thereby advancing it with the aid of research, observation, comparison, and experimentation.

3.2 RESEARCH APPROACH

This project research used two main research approaches, quantitative and qualitative approaches.

Quantitative Approach; Involved the creation of statistical data that were subjected to strict, systematic, and statistical examination. This included survey research in juja town, and creating an artificial environment where the data needed could be produced.

Qualitative Approach; Involved with evaluating attitudes, beliefs, and behavior subjectively. The research methodology produced findings that were either non-quantitative or that did not undergo thorough quantitative analysis. Focus group interviews, projective techniques, and depth interviews were employed.

3.3 RESEARCH DESIGN

The project research deployed two main research designs.

Explanatory Design; It was the initial phase of research, and the main goal was to have an insight on the phenomena in Juja Town. The intention was to identify the main issues for a more precise examination or for establishing a hypothesis. I also looked at prior studies or research.

Descriptive Design; Also known as statistical research, this describes phenomena as they exist. This design tried to answer the questions of what, who, where, how, and when. It was used to analyze the current circumstances in Juja town.

3.4 RESEARCH SITUS

The research area is located in Juja Town, within the administrative jurisdiction of the Nairobi Metropolitan Authority and within the service jurisdiction of Kenya National Highways Authority (KeNHA), Kenya Urban Roads Authority (KURA) and Kenya Rural Roads Authority (KeRRA). The Town is located in Juja Ward, Juja Constituency, Kiambu County.

3.5 RESEARCH METHODS

The research used two main methods; Observational and Opinion-based methods. Observational methods included use of pictures, videos, sketches and notebooks for collecting data while opinion-based involved use of questionnaires, key informant interviews and public participation.

3.6 DATA COLLECTION TECHNIQUES

The research deployed both primary and secondary data collection techniques.

3.6.1 Primary Data Collection

These are data obtained from direct encounter with respondents and observations during site visits. The research deployed the following primary data collection techniques.

3.6.1.1 Transport Surveys

The study used three main types of transport survey methods.

Origin-Destination Survey;

The survey demonstrated the pattern and nature of travel by outlining who is traveling where, with whom, when, and via what mode and route. It also showed congestion routes, public transportation systems and infrastructure needs.

The survey focused mainly on students from Jkuat as they are the main occupants of the area. I collected data on strategic routes such as along Jkuat entry road, and along Gatundu-juja road. Table 1 below shows how the origin-destination survey was analyzed.

Land-Use Surveys;

This research survey made it possible to pinpoint the precise location and degree/density of land-uses in Juja town. Additionally, it made it possible to establish travel demand and forecast future land-use growth in and around Juja town.

Traffic Volume Survey;

The survey helped to determine the quantity of vehicles and people utilizing a transportation system, determining the demand at the time, determining capacity of roads, identifying need for road expansion and rehabilitation, establishing traffic control systems, studying traffic accidents, and helped analyze transport costs. The research survey was done mainly through tallying and filling of check lists in various roads within the site. The main roads targeted were the high traffic volume roads such as the Thika Super Highway, Gatundu-Juja road and Juja Entry Road. Additionally, the survey also focused on the interesting boda-boda business that serves as a major transport means in the town.

3.6.1.2 Questionnaires

Done by filling of both open-ended and close-ended questionnaires. Respondents received the questionnaires physically in the field or by mail. The respondents included students, landowners, businessmen drivers and the local authorities in Juja town. They were expected to read and comprehend the questions and to fill in the appropriate sections in the questionnaire.

3.6.1.3 Interviews

The oral-verbal stimuli were presented as part of the interview method of data collection, and respondents responded verbally. The research incorporated both personal and telephone interviews. Personal Interviews; Involved speaking to the respondents face-to-face while asking questions. Telephone Interviews; Busy but important key informants such as some landlords were called via the phone.

3.6.1.4 Observation

The planning research study used observation sheets for systematic planning, documenting, and subjecting to checks and controls on the validity and reliability of phenomena observed. This involved the use of sketchpads and notebooks

3.6.1.5 Photography

This technique involved taking different pictures of different phenomena in Juja town. The photos captured were used to explain the occurrence in the site. Involved the use of cameras.

3.6.2 Secondary Data Collection

Some of the secondary data reviewed and analyzed include:

3.6.2.1 Literature Review

Books, magazines, research papers, research journals, studies, blogs and publications were some of the sources from which the data for the research study was acquired. This gave a framework for assessing the study's applicability and contrasting the findings with other findings to direct planning analyses in the future. Data from Particulate Matter (P.M 2.5) was derived from a survey in 2006 by Van Vliet E and Kinney P, in collaboration with Colombia University. They used transportable air sampling equipment that take integrated filter samples for background and roadway monitoring. Particles larger than 2.5 µm were eliminated using a stainless-steel cyclone (BGI Inc., Waltham, MA). After the cyclone, air was sucked in by a BGI personal sample pump and fine particles were collected at a flow rate of 4 l min-1 onto a Teflon filter contained in a plastic cassette. Filters were transported to Columbia University where they were analyzed for mass ($PM_{2.5}$) and black carbon (BC)(van Vliet & Kinney, 2007b) I also derived secondary data from key institutions in Juja town such as the department of transport and infrastructure, the county government of Kiambu, Thika municipality and the Ministry of transport and infrastructure.

3.6.2.2 Case Studies

The research study compared Juja town to any other areas that were similar to it. The best practices in sustainable transportation systems and regulations were used to select case studies. Global and local case studies were studied in relation to the topic and for better transportation practices in the study area.

3.7 SAMPLING

Five sampling steps were used to identify the sample in for the research as shown in the table below;

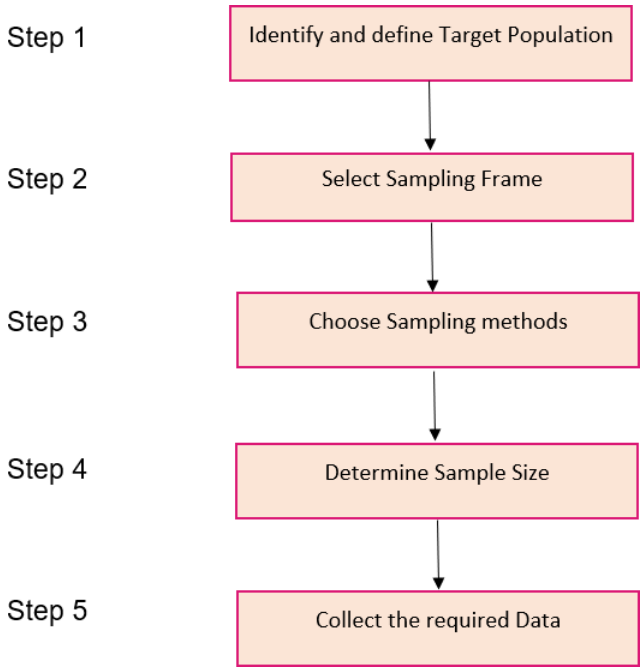


Table 1: Sampling Steps

3.7.1 Target Population

The target population in the study area were identified as the locals and mainly students that are residing in the study area.

Number of people = Population Density * Study Area

Population Density = 6,291/km2

Study Area = 0.56 km2

Target Population = 6,291*0.56

= 3,523 People

3.7.2 Sampling Frame

The sampling frame comprised of a list of students, boda-boda riders, motorcyclists, business men, landlords and key informants that reside or work in Juja town.

3.7.3 Sampling Methods

The research survey mainly used simple random sampling, under probability sampling. The method ensured that every conceivable sample combination had an equal chance of being chosen and that every item in the population had an equal chance of being included in the sample. Every individual in Juja town had an equal chance of being selected in the sample size.

3.7.4 Sample Size

From the sampling frame. A small section was chosen using simple random sampling to come up with the sample size from which the research survey questions were asked.

n= N/1+N(e) 2

where; n = sample size N= Target population e= Allowable error

3523/ 1+3523(0.1)2 = 97 people.

3.7.5 Data Collection

The required data were collected using primary data collection discussed above. The collection techniques included interviews and administering of questionnaires.

3.8 DATA PROCESSING, ANALYSIS AND PRESENTATION

DATA PROCESSING TECHNIQUES

Coding, Charting, Diagramming, Tabulating

DATA ANALYSIS TECHNIQUES

ArcGIS, Sketchup, Ms Office Suites, ArchiCAD, Lumion, Adobe Illustrator and Photoshop

DATA PRESENTATION TECHNIQUES

Maps, Charts, Tables, Graphs, Photographs, Texts, Sketches, Plans, Sections and elevations

Both primary and secondary data, as well as spatial and non-spatial data, were processed. After data collecting, the planning study project entailed a complex data processing process. Data were then analyzed and presented after being submitted to both qualitative and quantitative examination.

3.9 PILOT STUDY/ RECONNAISSANCE VISIT

The pre-visit was done in one day as the area is not very wide. It included meeting with relevant authorities in the area such as the Chief. It included analysis of the general land activities in the site that helped in preparing the actual 5-day survey schedule of the Juja town.

3.10 RESEARCH ETHICS

The research adhered to all the six domains in research ethics; scientific integrity, institutional integrity, collegiality, protection of human rights, animal welfare and social responsibility.

In adhering to Scientific integrity, the study involved technical competence, data manipulation and statistical methods. The study was also done in collaboration with the Technical University of Kenya, Department of Spatial Planning and Design and therefore adhering to institutional integrity.

The study survey was done with human rights in mind. It involved protecting the residents of Juja town from harm, respecting the locals, providing justice, informed consents and assent.

Collegiality is the relationship among researchers. It was deployed in the research through peer reviews, authorships and data sharing.

Social responsibility was evident in the research through public educations of the locals in Juja town, advocacy, assessing the environmental impacts and defining research priorities in Juja town.

3.11 WORK PLAN AND TIMETABLE

The research study's work schedule was set within the 12 weeks of the academic semester. Through the creation of numerous outputs for the project report and project posters for presentation, many sections of the planning research project were successfully finished during this time. Table 3 below shows the work plan schedule.

ACTIVITY	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK10	WEEK11	WEEK12	OUTPUT
Problem Identification in Juja town													Concept note
													Introduction
Goals and Objectives													Objectives
Review of Transport literature sources													Literature Review
													Methodology/Research Tools
Survey and Data Collection in Juja town													Data Collection and Findings
													Data and Situational Analysis
Analysis and Synthesis													Synthesis of Design Issues
Plan Formulation for Juja town													Land use plan of Study Area
													Relevant Case Studies
													Concept and Visions
													Structural Analysis
													Structure Plan
													Proposed Land Use Plan
													Proposed Master Plan
													Sections and Elevations
													PDPs- Action Area Plans

Policy Formulation for Juja town													Sections and Elevations
													Cost and Financing
													Policy Action/Justification
Implementation													Implementation Matrix
Monitoring and Evaluation													Legal/Institutional Framework

Table 2: Work Schedule

3.12 RESEARCH BUDGET

In order to complete each duty, the researcher managed and funded for the research. Table 4 below provides an illustration.

ACTIVITY	*ITEM*	*UNIT COST (Ksh)*	*NO. OF UNITS*	*EXPENDITURE (Ksh)*
1 Day Reconnaissance in Juja Town	Bus fare to and from the site	200	1	200
Primary Data Collection for 5 days	Bus fare	200	5	1000
	Base map	100	1	100
	Questionnaires	20	30	500
	Checklist	10	5	50
Project Outputs	Printing of Project Report	2000	3	6000
	Binding of Project Report	300	3	900
	Printing of Project Posters	4500	1	4500
Total				**13,250**

Table 3: Research Budget

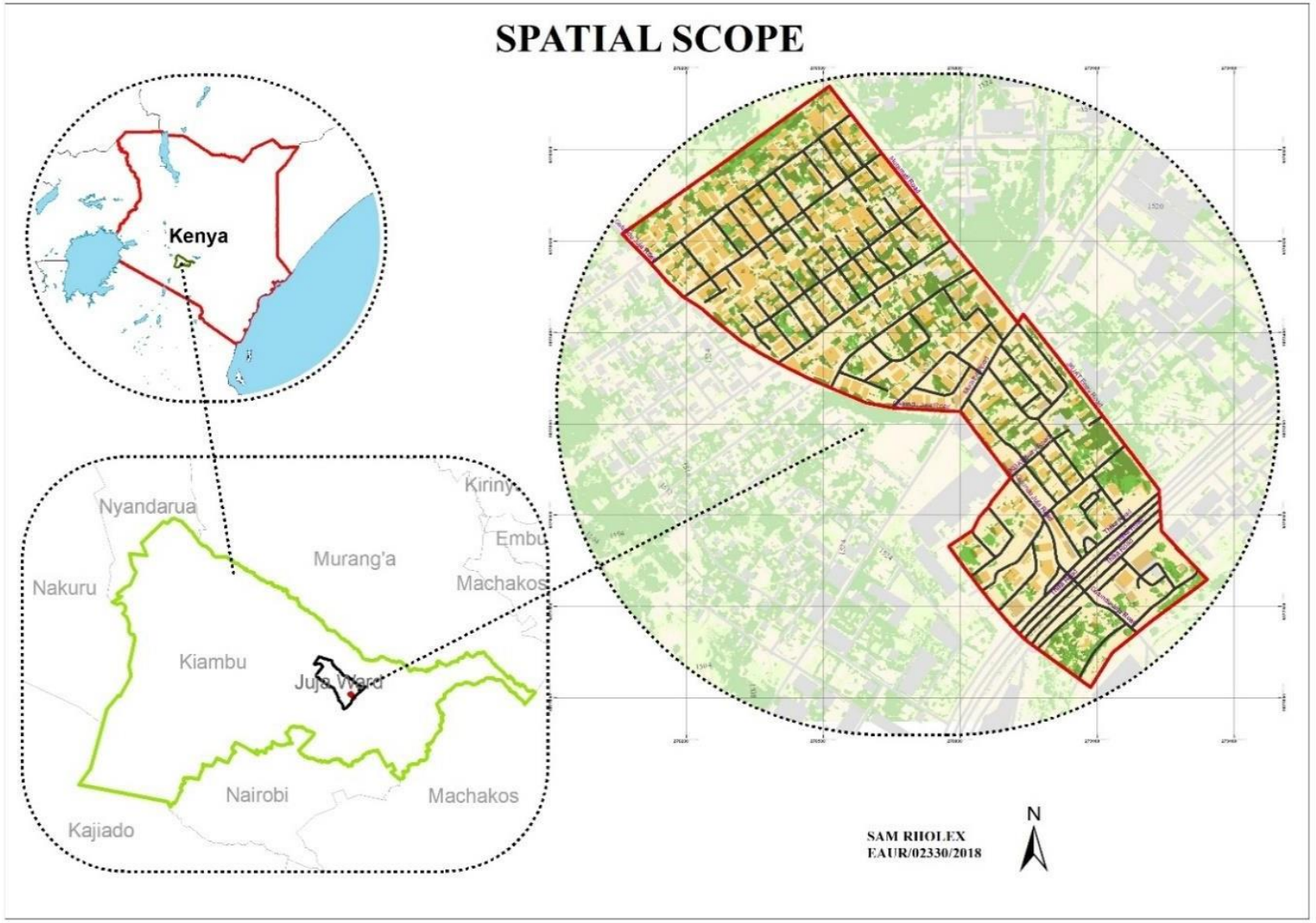
CHAPTER FOUR – STUDY AREA

4.1 INTRODUCTION

Juja town is one of the main satellite towns in the Nairobi metropolitan region and it serves many functions. The town has grown over the years mainly because of Jomo Kenyatta University of Agriculture and Technology and is projected to grow more as population increases. The town has undergone significant infrastructural development but the transport sector has been left dormant with little improvement. The main developments have been in terms of real estate as developers mainly focus on housing. This chapter seeks to have a deep understanding on the current situation in the site and the causes of the negative transportation impacts on Juja town. We analyze the sites' location and context, historical developments, physiographical characteristics and infrastructural developments.

4.2 LOCATION AND CONTEXT

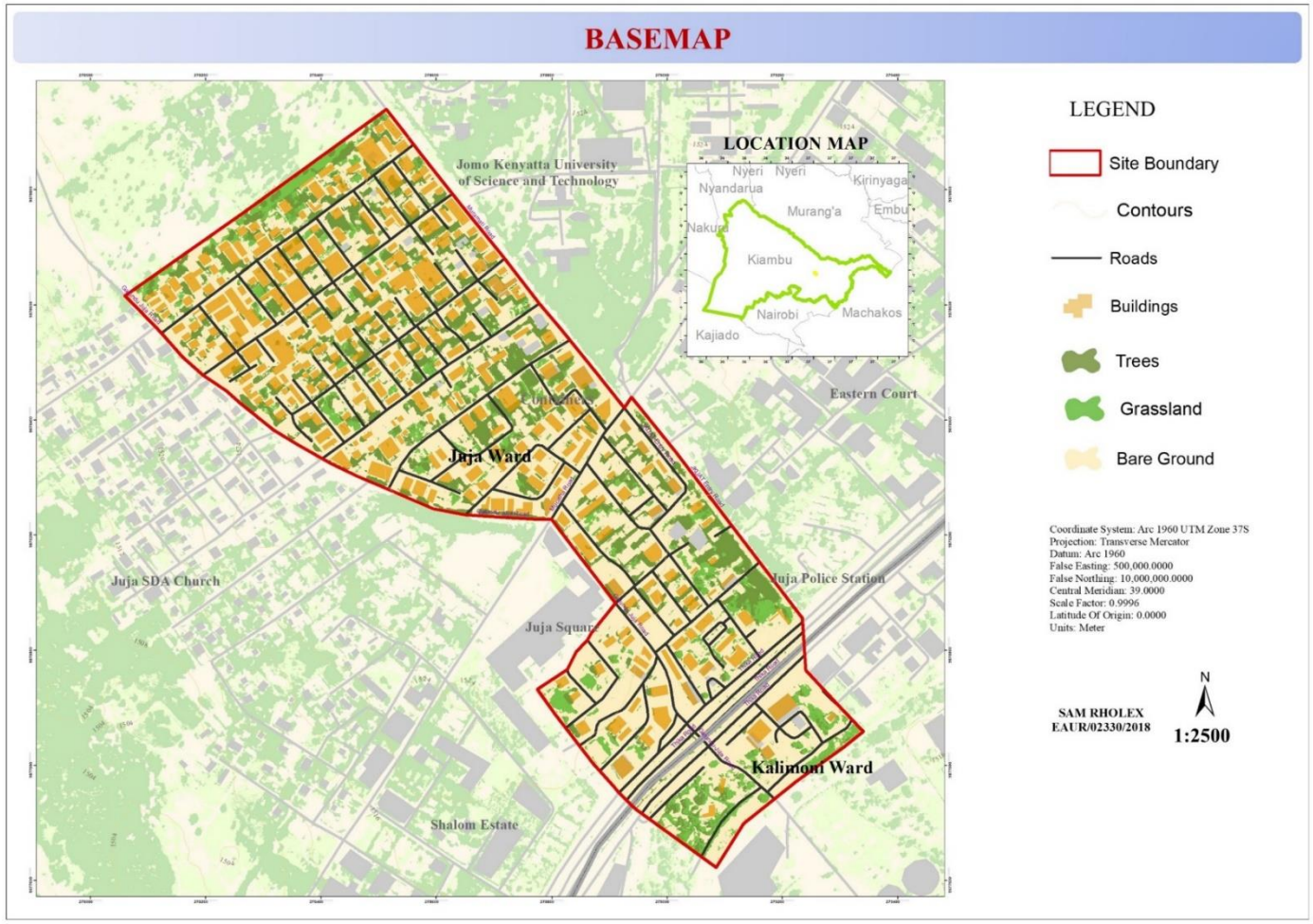
The study area is located in Kiambu County, Juja Sub–County, Juja Ward, Off Thika Super Highway. The major neighborhood structures are JKUAT and Juja police station, to the east and Shalom Estate to the west. The study area is approximately 34 km from Nairobi CBD. It is enclosed within (x, y) coordinates (-1.0975750, 37.0059660) to the north-west, (-1.0973040 , 37.0173510) to the north-east, (-1.1092660 , 37.0074730) to the south-west and (-1.1086090 , 37.0176750) to the south-east. See map 2 below;



Map 2: Context Map

4.3 BASEMAP OF STUDY AREA

The area is enclosed by major roads such as Gatundu Juja road to the west, JKUAT Entry Road and Muramati Road to the east, and Thika Super highway to the south. The total area of the site is approximately 3 km2 . The area mainly comprises of residential and commercial. See map 3 below.



Map 3: Base map

4.4 HISTORICAL DEVELOPMENTS

Juja was previously called “Weru wa Ndarugu”. According to records in the McMillan Memorial Library, the name Juja arose due to superstition stories from a white settler named McMillan who settled in the area in the 1900s and bought 19,000 acres of land. The town has grown immensely in the recent years mainly because of the Jomo Kenyatta University of Science and Technology that was officially opened in March 1982. Population in Juja town has increased over the years with an increase of 7.5% from 2000 to 2015. The population is projected to grow as more activities attract more people in the area. The town has attracted many real estate investors due to the high demand for housing mainly for the students. This increase in population has also attracted many commercial activities in the recent years such as Amkar Digital Enterprises, Pento gas point, Super shop & cereals, Anna super butchery, amongst others. The roads within the site have also developed over the years as some have been upgraded from earth to gravel. The 2.6km Gatundu-Juja road was upgraded to bitumen in 2020, The 724m long Mucatha road was tarmacked and the 107m long Jkuat entry road was also tarmacked. The following satellite images of the site explain the change in land uses and transport routes across different years.

In 2003, the only tarmac road in the site was Thika road. All the other roads where either murram or earth. There were also little developments in the site characterized by few buildings as shown in plate 1 below.

Plate 1: Juja Town in 2003

Source: Google Earth

By 2010, Thika road was being upgraded to Thika super highway. Juja Entry Road was also upgraded to bitumen complete with pedestrian walkways on the road reserves. Plate 2 below shows Juja town in 2010.

Plate 2: Juja Town in 2010

Source: Google Earth

Currently, Gatundu-Juja road, and Mucatha road have been tarmacked, and Thika road has been upgraded to Thika super highway. Although there has been some significant development in the site, there is need to incorporate sustainable transport planning in the developments going forward. Plate 3 below shows a satellite image of Juja town in 2022.

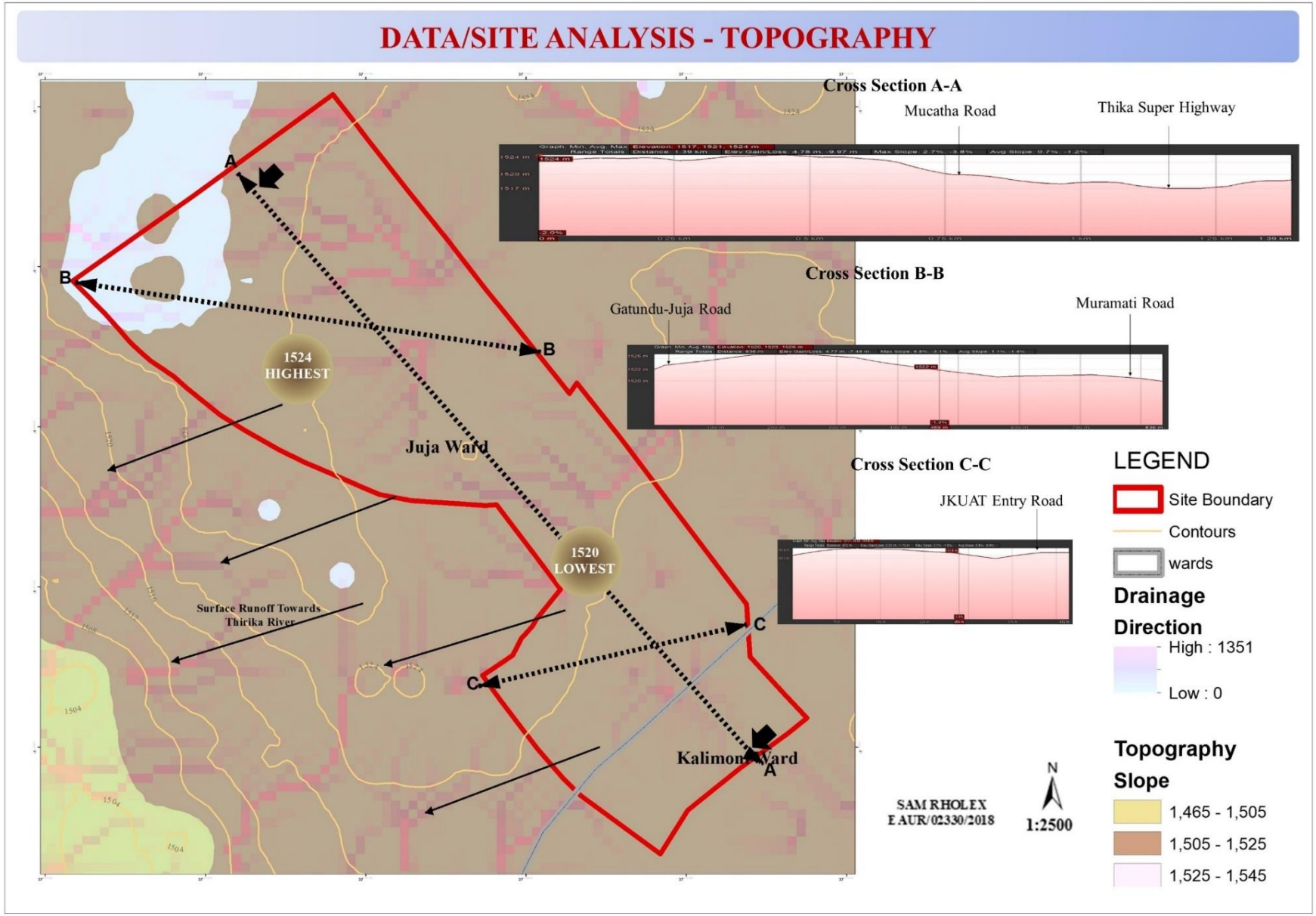
Plate 3: Juja Town in 2022

Source: Google Earth

4.5 PHYSIOGRAPHICAL CHARACTERISTICS

4.5.1 Topography

The study area is generally gently sloping with the highest point at 1524m above the sea level on the north eastern part of the site and the lowest point at 1520m above the sea level, along Mucatha road. The site therefore slopes from the north eastern part towards the south western part with a few ridges. This gentle sloping nature of the site makes it easy to construct road networks within the sites. This also makes it easy to construct other road related infrastructures such as bus stops, bus stages, parking lots, pedestrian walkways and cycling lanes. See map 4 below.



Map 4: Topography

4.5.2 Hydrology and Drainage

Juja town mainly drains from the east to the west and south towards Thirika river. The surface run-off is not well chartered for as there are no elaborate drainage patterns in the site. The majority of the roads are murram and this causes the surface run-off to settle on the carriageway and on the road shoulders. This influences transport during rainy seasons as it slows down circulation within the site. The muddy roads during rainy season also have a huge impact on the pedestrians as there are no elaborate routes for the pedestrians. The area also has low infiltration rates and this makes it harder for the surface run-off to infiltrate the earth. The potholes serve as a major carriage for the surface run-off and since there are no proper mechanisms to direct the water to Thirika river, the locals are faced with serious impacts ranging from diseases to transportation hiccups.

4.5.3 Geology And Soils

4.5.3.1 Soil Texture

Juja Town has clayey type of soil texture. This red clay has three main characteristics; plastic behavior when wet; swelling behavior and low permeability. This means that the soil retains a lot of water after a rainy day/night. Retaining water on a gently sloping site that has no drainage pattern results to negative transport and environmental issues such as diseases caused by stagnant waters and flow traffic flow.

4.5.3.2 Soil Drainage

Due to the type and structure of the soil in the site, it is evident enough that the site is poorly drained. Poor drainage results to acute levels of flooding on heavy rainy seasons and this affects transport and the natural environment. Poor drainage would require good mitigation measures to help in drainage of storm water. This has not been the case as there has been little effort put majorly by the locals in the site who are influenced directly. Some of the roads are raised and the materials used are rocky and not permeable. This results to stormwater diverting into the adjacent buildings especially along the access roads within the site as well as along Muramati road.

4.5.3.3 Soil Infiltration

Since the site has clayey soil, that is mainly characterized by low permeability, there is high water retention rates. This makes it had for infiltration to occur and in the processing resulting to high rates of stormwater and surface runoff. Low infiltration rates are also evident in the materials used to upgrade the roads as they have low permeability forcing the surface runoff to residential homesteads and thus affecting the livelihoods of the tenants. The residents are forced to short term mitigation measures such as providing temporary paths for the water.

4.5.3.4 Rock Type

The site has one main rock type, Tertiary Plutons. These rock types have low permeability due to their fine nature. This also catalyzes on the issues of high-water retention in the area. This analysis helps in understanding the best mechanisms and the best materials to use in upgrading the transport systems in the area. The rock type also informs on the routes to use for the non-motorized transport so as to avoid frequent maintenance of the networks.

4.5.3.5 Soil Type

Juja town has one main soil type, that is, ferrosols. This soil type originates from clayey composition. It is characterized by high water retention and is poorly drained.

4.5.4 Climate

Climate analysis comprises both the macro and micro climate.

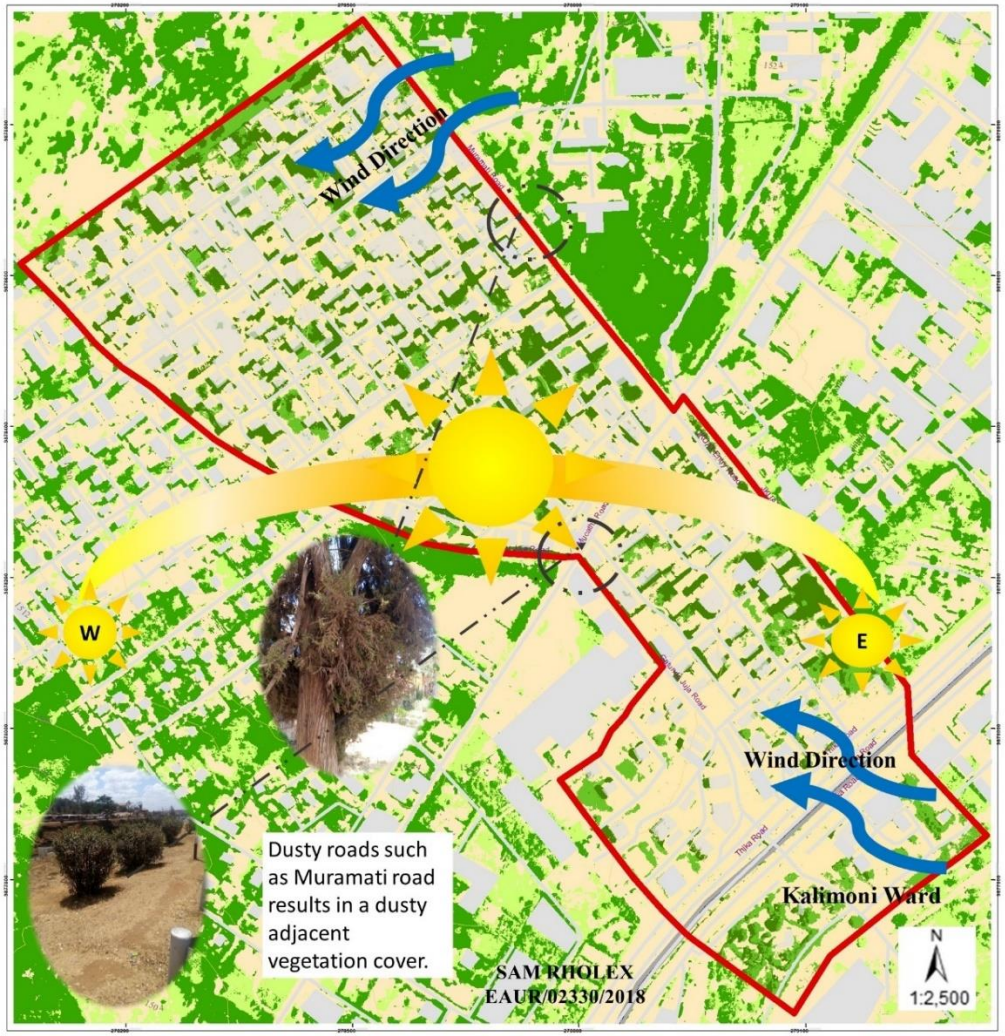
4.5.4.1 Macro-Climate

Juja has a mild summer temperature and a marine west coast. Juja generally experiences 214.26 rainy days (58.7% of the time) and receives about 129.81 millimeters of precipitation yearly. (CIDP_2018_2022 Kiambu, n.d.) This rainy seasons in the site influences the modes and means of transport in the site. During rainy seasons, the roads are muddy and impassable, during dry seasons, the murram roads are dusty and this catalyzes the effects of particulate matter to the locals in the town.

The dusty roads also influence the adjacent natural environment in the site. The Town's annual temperature is 20.83 degrees Celsius, which is 1.67% colder than the national average for Kenya High temperatures in the town especially in the month of January influences the effects of urban heat. The heated tarmac roads such as the Thika super highway result in increased urban heat. With increase in developments and less natural environment, there is a projected trend of change in the climate caused by road transport. The wind direction and wind speed in the area also influences the road transport in terms of location of roads. The site has no significant high wind speeds so the cyclists in the area have no major wind challenges.

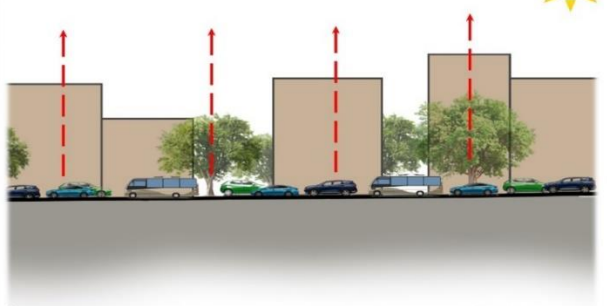
The average wind speed is at 7.77 kmh with the highest speed at 11.0kmh. The average precipitation is at 2.99mm, and the average dewpoint is at 13.040C. The sun path is as shown in the map 5 below.

DATA/SITE ANALYSIS - CLIMATE



Juja has a mild summer temperature. The ward's annual temperature is 20.83 degrees Celsius (69.49oF), which is 1.67% colder than the national average for Kenya. Juja generally experiences 214.26 rainy days (58.7% of the time) and receives about 129.81 millimeters (5.11 inches) of precipitation yearly.

Effect of Pollution on micro-climate (C02 emissions and Urban Heat Island)



- The heavy traffic congestion at the site especially during peak hours results in toxic emissions of CO2 that affect the atmosphere
- More developments without provision of proper micro-climate leads to a steady rise of urban heat

Map 5: Climate

Juja Weather by Month

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Nov	Oct	Dec	Year
Record high °C (°F)	32.01 (89.62)	34.01 (93.22)	32.01 (89.62)	30.01 (86.02)	27.01 (80.62)	27.01 (80.62)	28.01 (82.42)	30.01 (86.02)	30.01 (86.02)	31.01 (87.82)	28.01 (82.42)	29.01 (84.22)	34.01 (93.22)
Average high °C (°F)	26.02 (78.84)	27.27 (81.09)	27.12 (80.82)	25.03 (77.05)	23.31 (73.96)	22.95 (73.31)	23.06 (73.51)	23.85 (74.93)	25.34 (77.61)	25.84 (78.51)	24.56 (76.21)	24.61 (76.3)	24.91 (76.84)
Daily mean °C (°F)	21.41 (70.54)	22.34 (72.21)	22.58 (72.64)	21.24 (70.23)	19.92 (67.86)	19.29 (66.72)	19.2 (66.56)	19.85 (67.73)	21.01 (69.82)	21.75 (71.15)	20.77 (69.39)	20.56 (69.01)	20.83 (69.49)
Average low °C (°F)	14.25 (57.65)	15.01 (59.02)	15.9 (60.62)	15.89 (60.6)	14.71 (58.48)	13.56 (56.41)	13.24 (55.83)	14.14 (57.45)	14.94 (58.89)	15.94 (60.69)	15.53 (59.95)	14.37 (57.87)	14.79 (58.62)
Record low °C (°F)	10.0 (50.0)	11.0 (51.8)	12.0 (53.6)	12.0 (53.6)	10.0 (50.0)	10.0 (50.0)	10.0 (50.0)	11.0 (51.8)	7.0 (44.6)	13.01 (55.42)	12.0 (53.6)	11.0 (51.8)	7.0 (44.6)
Average precipitation mm (inches)	61.14 (2.41)	86.07 (3.39)	130.73 (5.15)	285.8 (11.25)	209.37 (8.24)	140.75 (5.54)	81.44 (3.21)	75.13 (2.96)	80.47 (3.17)	121.26 (4.77)	169.4 (6.67)	116.19 (4.57)	129.81 (5.11)
Average precipitation days (≥ 1.0 mm)	10.55	11.18	18.83	26.28	25.92	21.1	15.65	12.36	13.46	19.28	23.28	16.37	17.86
Average relative humidity (%)	68.71	65.03	67.31	79.61	83.54	79.93	73.9	69.65	66.41	67.0	77.0	77.2	72.94
Mean monthly sunshine hours	11.3	11.35	11.14	10.81	10.88	10.98	11.1	11.29	11.29	11.41	11.08	11.33	11.16

Table 4: Juja Weather by Month

Source: City-Facts

4.5.4.2 Micro-Climate

The increased urbanization in Juja Town has negatively influenced the natural vegetation in the site. Increased developments have also influenced the micro-climate as this has resulted to increased urban heat. The high temperatures especially in January results to depletion of grass, shrubs and trees that help in providing a cooling effect in the site. Depletion of these natural environment negatively affect the micro-climate. Adjacent vegetation along the murram roads such as grass and shrubs are covered by dust and soot. This deteriorates the quality of the urban natural environment and thus a change in the micro-climate.

4.6 Population and Demography

The population is generated according to Kenya Census 2019.

Number of people = Population Density * Study Area

Population Density = 6,291/km^2

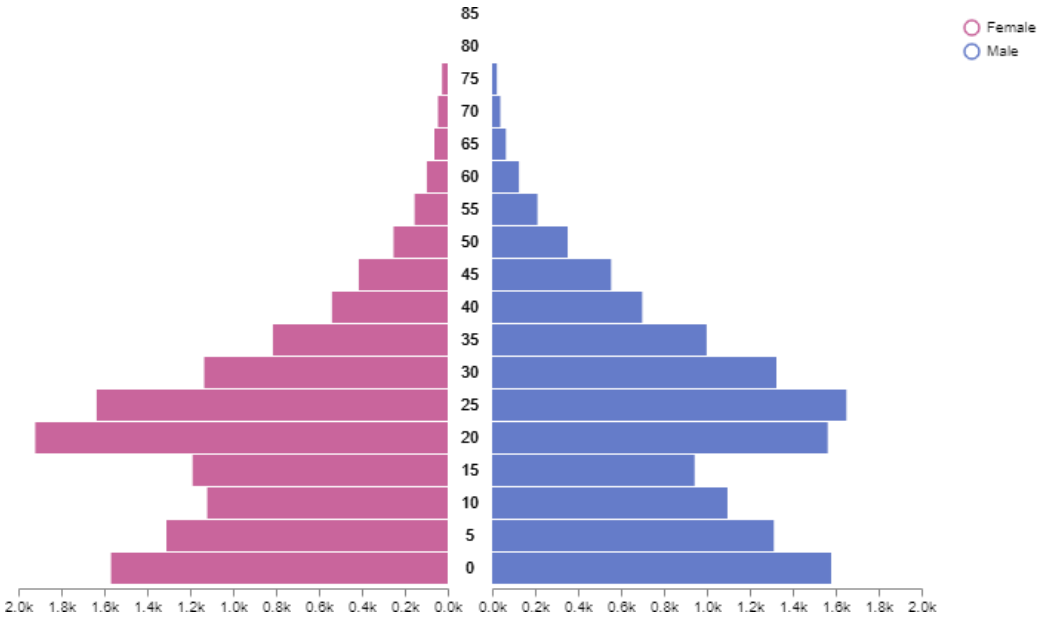
Study Area = 0.56 km^2

Target Population = 6,291*0.56

= 3,523 People

4.6.1 Population Structure

The population structure can be broken down to structure by age and by gender as shown in graph 1 below



Graph 1: Juja Town Population Pyramid

Source: City-Facts

According to census data 2019, women are slightly more than men. The town only registered 12 intersex. Majority of the residents are youth and they are mostly between the age of 20-25 as shown above. This is because majority of the locals are either working or campus students.

4.6.2 Population Density

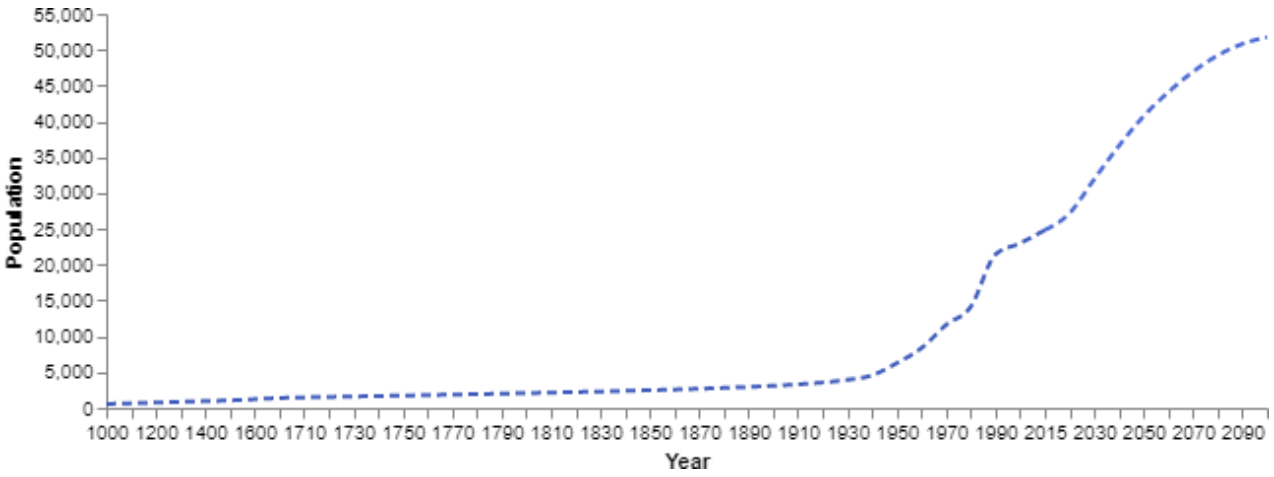
According to the census data 2019, the population density of the town stands at 6,291 per sq km.(2019 Kenya Population and Housing Census: Volume II.)

4.6.3 Population Projection

To calculate population projection;

Pn = Po (1+r/100)n

Where; Po = Current Population r = Growth Rate n = Number of years



Graph 2: Juja Town Population Projection

Source: City-Facts

Current Population = 3523 people

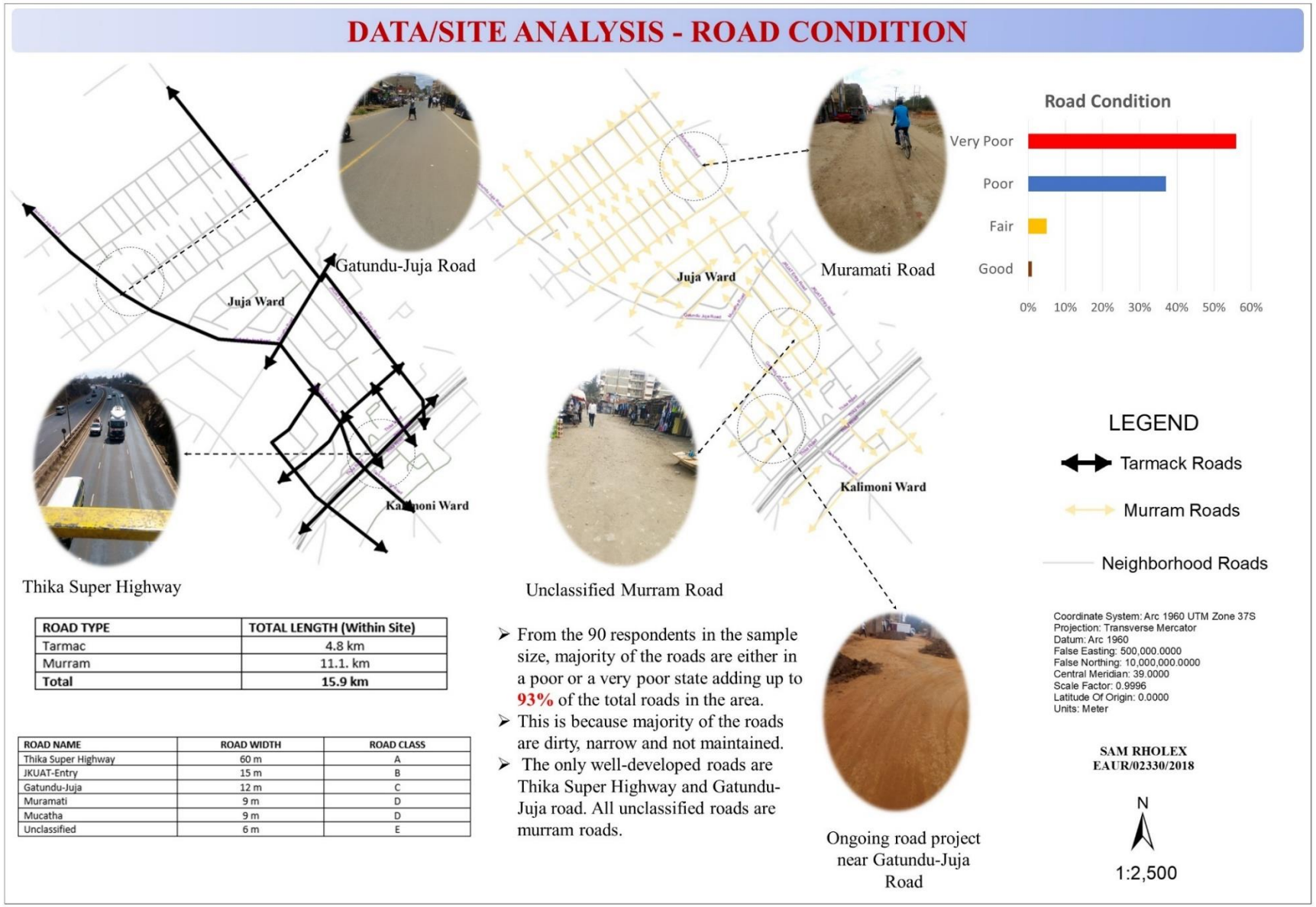
Growth rate = 2.4/100

Population Projection for 10 years (2032) = 4466 people.

4.7 TRANSPORT

4.7.1 Road Condition

Juja town is characterized by undeveloped road networks that are mainly murram roads that are not well constructed. The roads are narrow and majority of informal markets tend to occupy the road reserves. The site has three main tarmac roads, that is, Thika super highway, Mucatha road, Juja Entry Road and Gatundu-Juja road. The total length of the roads in the site is approximately 15.9 km. Approximately 4.8 km of the roads are tarmacked while the remaining 11.1 km are murram roads. This means that more than half of the roads in the site, that is, about 69.9% of the total roads in the site. The murram roads are characterized by large murram particles that hinder fast movement within the site. The type of murram that was used to upgrade the roads were not up to the required standards. Some sections of the roads such as along Muramati road have no drainage pattern. The narrow roads are not up to the required guidelines. The current road width plus the reserves should be 9m, 12m, 15m, 25m, and above according to the physical planning handbook. The buildings and informal markets are eating into the road reserves and wayleaves. See map 6 below.



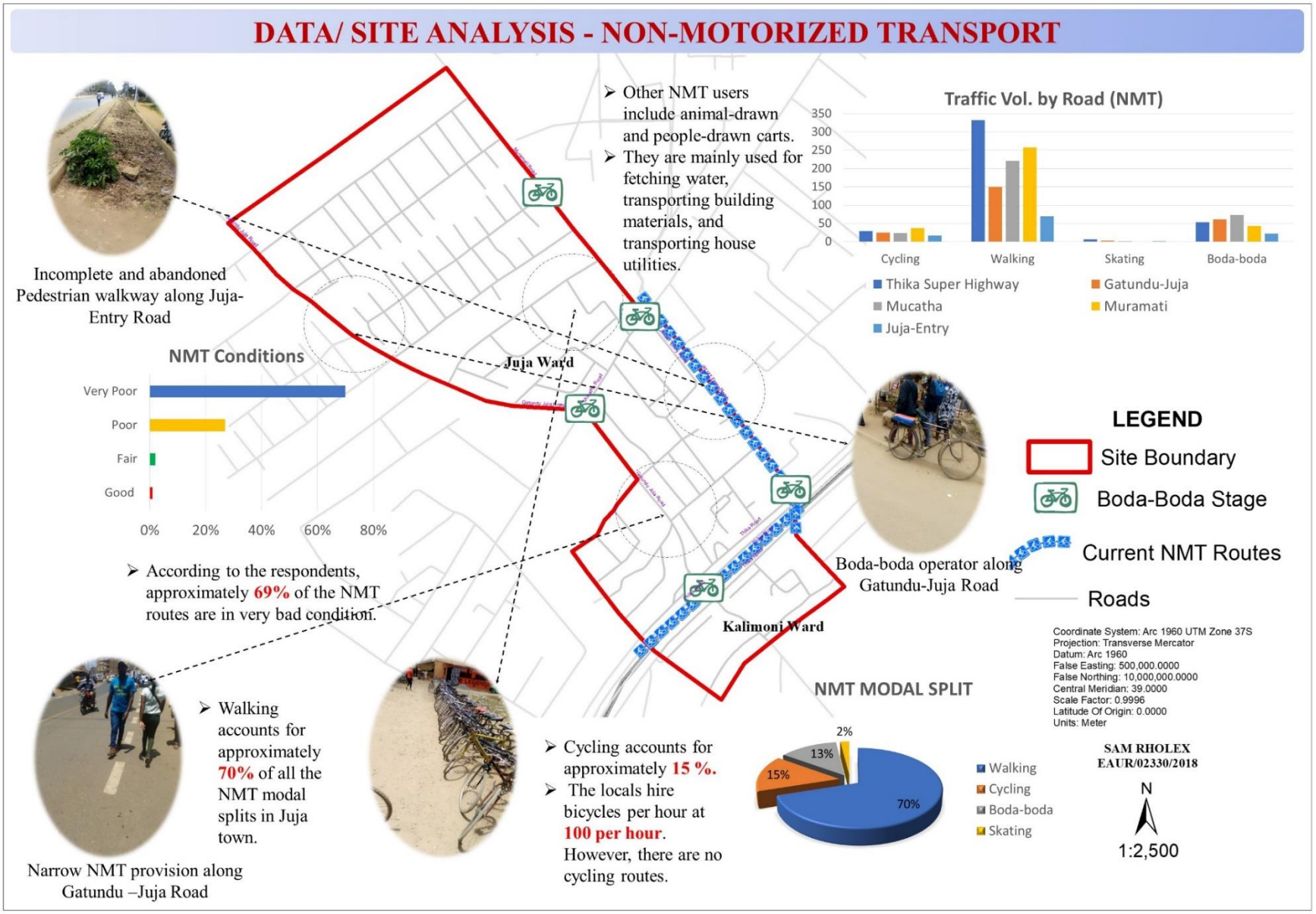
Map 6: Road Condition

4.7.2 Non-Motorized Transport

Juja has an interesting business of boda-boda operators. This is the main means of transport for quick access to short distances as it is affordable. However, the sector is note well provided for as there are no elaborate NMT routes in the site.

There are only two NMT routes in the site and that is along Thika Super Highway and JKUAT Entry Road. The total NMT length is approximately 1km. There are only five main boda-boda shades that also double up as their stage. Most of the boda-boda operators are forced to park along roads or on junctions. Walking accounts for the largest modal share in the transport means.

The site has grown immensely over the years and the number of pedestrians has significantly increased. However, there has been little efforts to try and provide pedestrian walkways through the town. As majority of the residents are youths, and students, they tend to walk from one place to the other. This has significantly resulted to conflicts between the pedestrians, cyclists and motorists. Other non-motorized transport includes animal drawn carts and “mkokoteni”. The locals use these NMT mainly for fetching water, when transferring building materials for short distances and when moving out from one house to a new rental house, especially for the students.



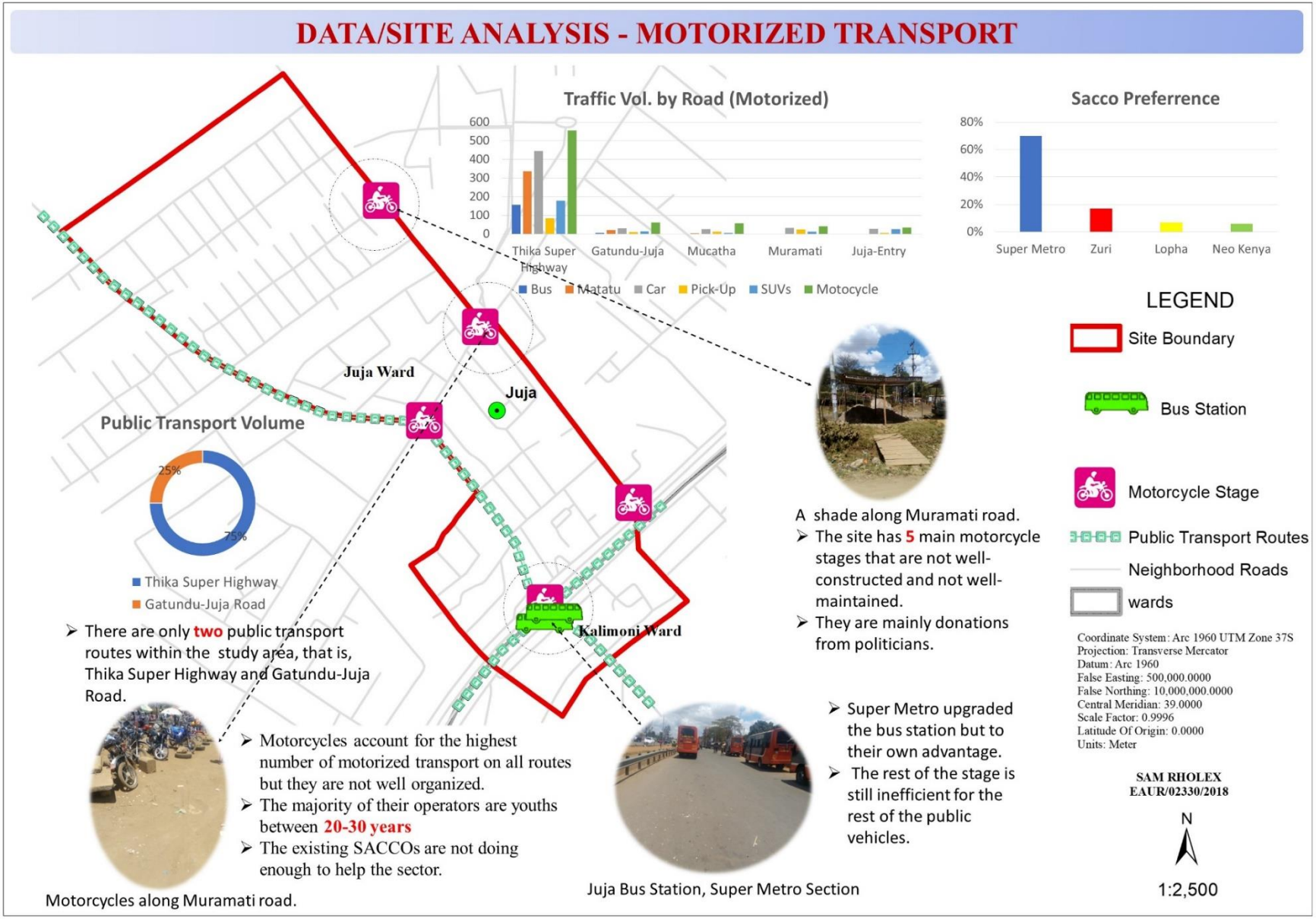
Map 7: Non-Motorized Transport

4.7.3 Motorized Transport

Juja town is served by various means of transport. Public transport serves most of the residents because a majority of the residents are either low income or middle-income earners. The town also serves as a “bedroom” for majority of the workers in Nairobi CBD and they mostly prefer public transport (PuT). However, according to the checklist tally, private transport (PrT) account for majority of the vehicle fleet. This overdependency in private cars results into traffic congestion, increase in black carbon emission, green gas emissions, and a rise particulate matter.

The site is serviced by various saccos that help in public transportation. These saccos include Super Metro, Zuri, and Lopha. Super Metro is the most preferred Sacco due to its efficiency. However, the residents often make long queues waiting for the public vehicles. This is due to the high population of people commuting to and from the CBD especially during peak hours. The public vehicles only operate on two routes in the site, Thika Super Highway and Gatundu-Juja Road. The other roads are mainly access roads and are serviced by private vehicles.

Motorcycles account for the majority of motorized transport in the town. The motorists are mainly youths of between 20-30 years. The age bracket can be attributed to high unemployment rates among the youths resulting to a majority of them taking loans to purchase the motorcycles on installments. Though there are many motorcycles, the sector has many hiccups and there are mainly challenges such as pedestrian and vehicular conflicts and inadequate stages. The site has one main bus stage that is not enough to accommodate all the vehicles. Although, Super Metro upgraded their parking stage, there is still inadequate space. The allocated spot is not enough for all the public vehicles. This results to traffic jams and accidents in the area. See map 8 below.



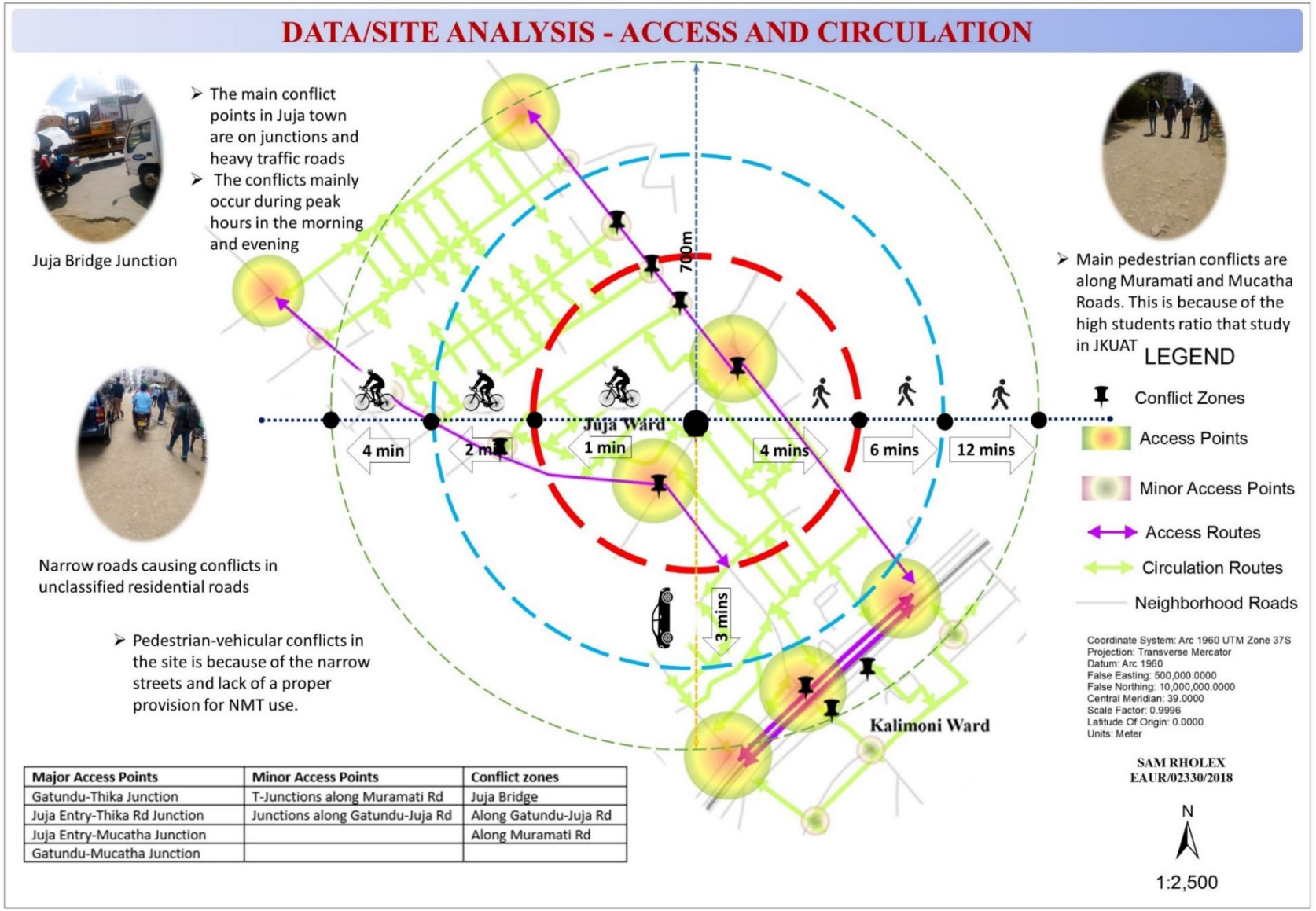
Map 8: Motorized Transport

4.7.4 Access and Circulation

The study area has seven main access points, that is, along Thika super highway, Junction between Thika Super highway and Gatundu-Juja Road, Junction between Mucatha Road and JKUAT entry road, junction between Mucatha Road and Gatundu-Juja road and at the entry of Muramati road. The murram roads in the site makes it hard to connect from one place to the other. The high population also creates more conflicts within the site, especially along Muramati road and Mucatha road as they have a lot of commercial activities along them.

The site has 14 junctions that help in navigating through the site. Some of these junctions such as Thika-Gatundu junction experience serious vehicular conflicts. These conflicts catalyze traffic congestion especially during evening hours. Traffic congestion results in serious environmental impacts such CO_2 emissions, and rise in the levels of particulate matter that results in serious health problems such as asthma. Traffic congestion also slows movement within the site and the process more fuel consumption that also affects the urban environment.

Walking across the longest stretch, that is, along Gatundu-Juja Road takes approximately 25 mins, cycling takes approximately 10 mins and driving takes approximately 4 mins. See map 9 below.



Major Access Points	Minor Access Points	Conflict zones
Gatundu-Thika Junction	T-Junctions along Muramati Rd	Juja Bridge
Juja Entry-Thika Rd Junction	Junctions along Gatundu-Juja Rd	Along Gatundu-Juja Rd
Juja Entry-Mucatha Junction		Along Muramati Rd
Gatundu-Mucatha Junction		

Map 9: Access and Circulation

4.7.5 Connectivity and Linkages

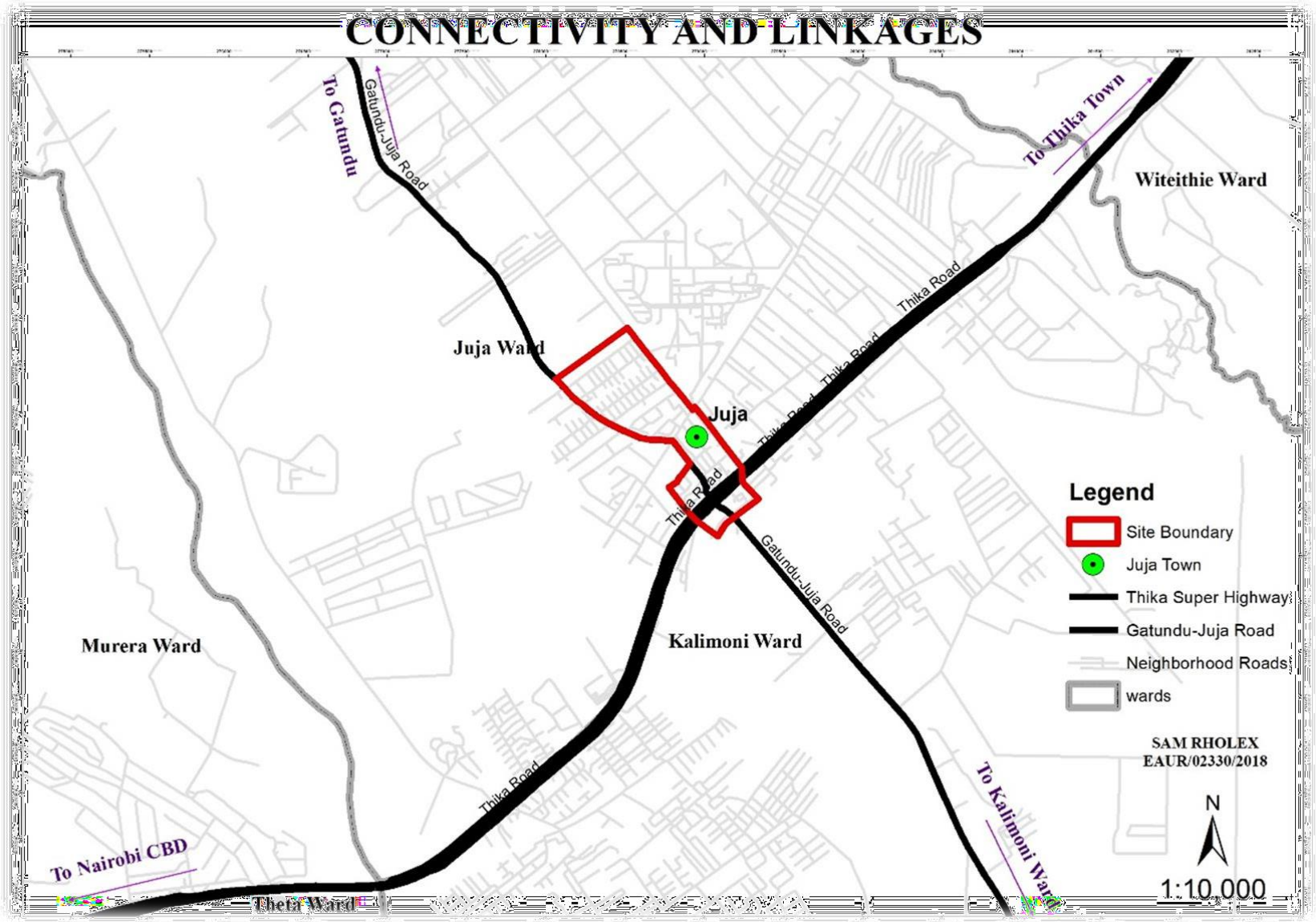
Juja town has two main roads that connects it to other towns outside the site. Thika super highway connects it to Nairobi CBD and Thika town whereas Gatundu-Juja road connects it to Gatundu to the north and Kalimoni ward to the south.

Major towns that connect to the site include Nairobi City and Thika town. The site serves as a "bedroom" to the workers who commute to and from the CBD on a daily basis.

The town also serves as a residential block for people and students such as Mount Kenya University students that reside in the town.

Some of the near institutes include Kenyatta University (KU), Mount Kenya University (MKU), Zetech, and Kenya School of Accounting (KCA). The site also serves these students with residential accommodations.

Map 10: Connectivity and Linkages

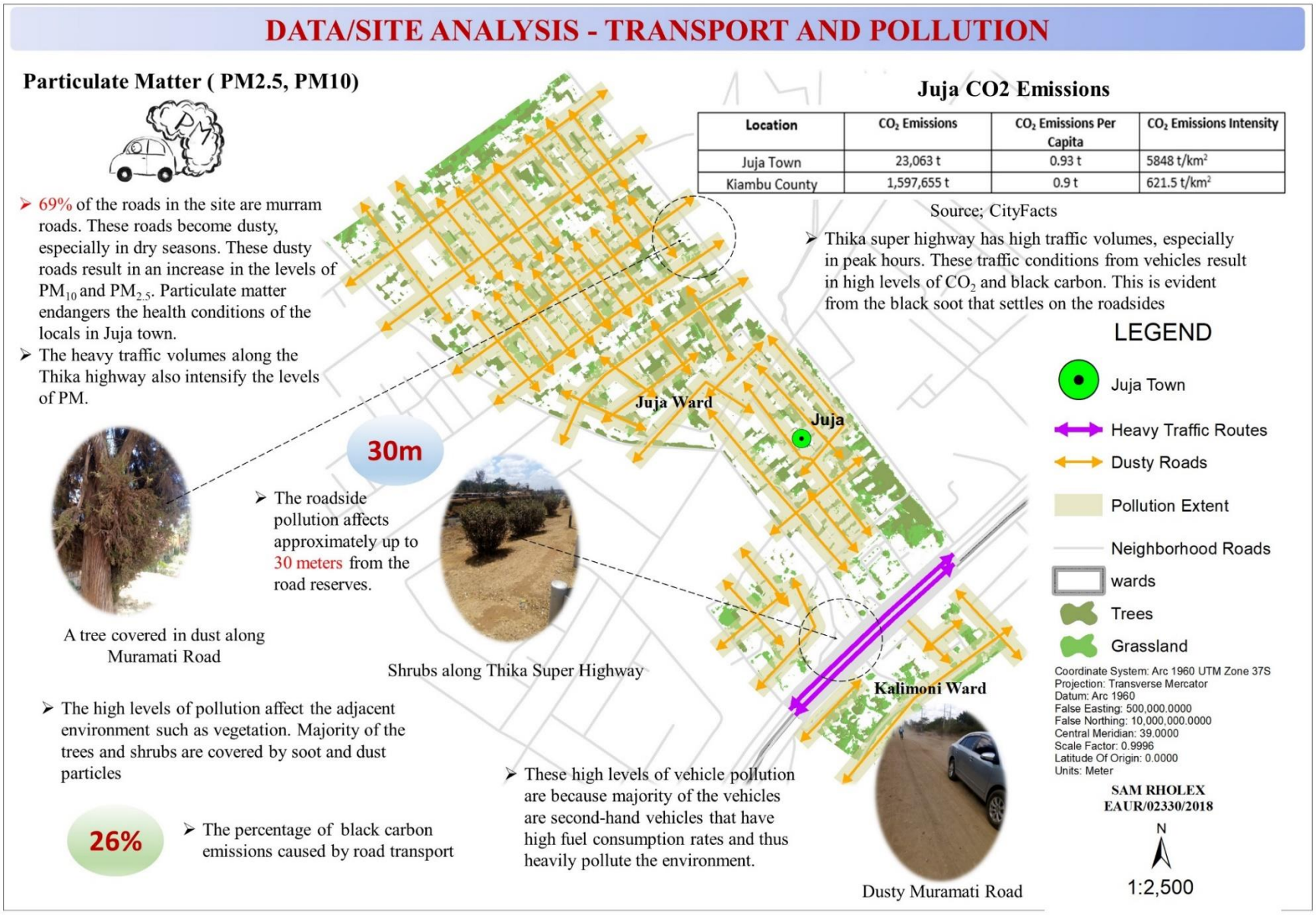


4.7.6 Transport and Pollution

Transport sector in Juja town has been given little focus and this has resulted to serious environmental pollution that affect the urban environment. Some of this transport-related pollution problems include green gases emissions such as CO_2 emissions, Black carbon emissions, and rise in the levels of particulate matter. 69% of the roads in the site are murram roads.

These roads become dusty especially in dry seasons and due to the high population in the area, the dust from pedestrians and private vehicles become intense. These dusty roads result to the increase in the levels of PM_{10} and $PM_{2.5}$. Particulate matter endangers the health conditions of the locals in Juja town. Thika super highway has high traffic volumes especially in the peak hours. This traffic conditions from vehicles results to high levels of CO_2 and black carbon. This is evident from the black soot that settle on the road sides.

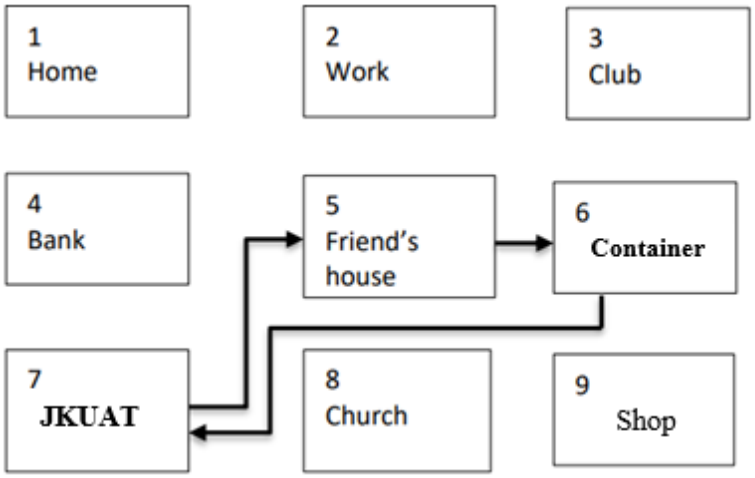
The high pollution levels in the area can have micro effects such as urban heat and macro effects such as global warming leading to climate change. These high levels of vehicle pollution are because majority of the vehicles are second hand vehicles that have high fuel consumption rates and thus heavily pollute the environment. The road-side pollution affects approximately up to 30 meters into the residential and commercial land uses.



Map 11: Transport and Pollution

4.7.7 Trip Distribution

Trip distribution analysis was done through the origin destination model matrix. A three-day survey was conducted at different junctions that included Juja Entry-Mucatha junction, Gatundu-Mucatha junction, Gatundu-Thika junction, and Juja Entry-Thika Road. A checklist was also filled along major roads that include Muramati road, Mucatha road and along the access roads within the residential zones. From the survey, we analyzed the preferred routes, reasons for journey occupation and the modes and means of travel.



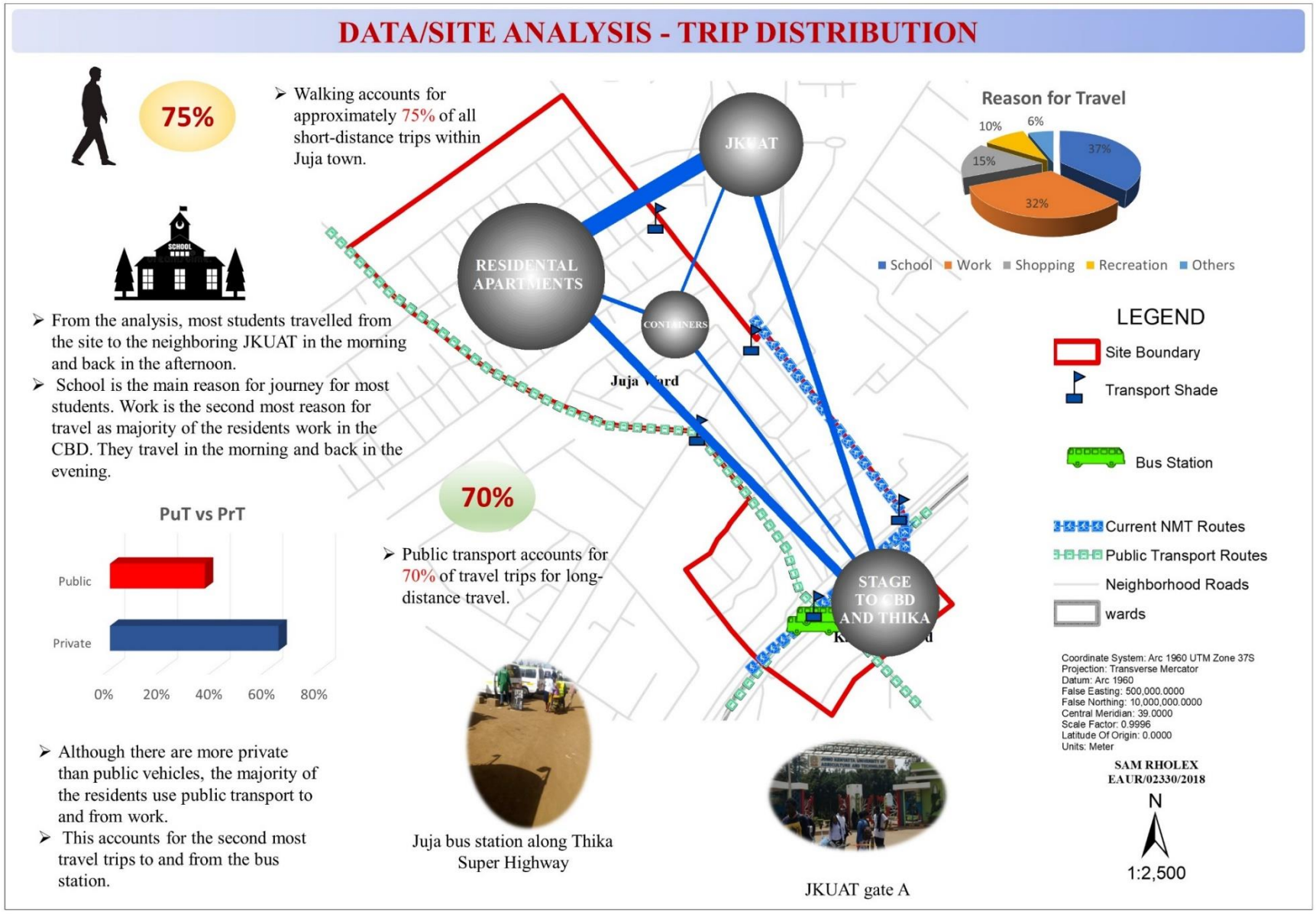
Demand Matrix

From Origin \ To destination	1	2	3	4	5	6	7	8
1								
2								
3								
4								
5						1		
6							1	
7					1			
8								

Trip No.	Origin Zone	Destination Zone	Trip Leg No.	Means of Transport
1	7	5	1.1	Walking
			1.2	Bus
			1.3	Walking
2	5	6	2.1	Bodaboda
3	6	7	3.1	Walking
			3.2	Bus
			3.3	Walking

Table 5: Trip Distribution Table

Source: Author



Map 12: Trip Distribution

4.7.8 Transport and Urbanization

Juja town has rapidly urbanized over the past few decades. The rapid urbanization can be attributed to the opening of JKUAT that led to the fast population growth in the area. With the population projected to grow, Juja town is expected to densify and even grow spatially. The current urbanization is characterized by new high rise residential buildings, new commercial activities and new public and private institutions.

Real estate in form of high-rise buildings is the most lucrative investment in the area and there are many current ongoing building projects. Unchecked rapid urbanization in the area has led to neglect of the transport sector. Buildings are occupying wayleaves that are meant for infrastructural developments related to the road networks such as drainage patterns and sewer lines. This has resulted to narrow murram roads within the residential apartments. The roads are not maintained and are not adequate to sustain the rapid urbanizing Juja town. This has resulted to conflicts and traffic and pedestrian congestion along the roads.

4.8 POLICIES, LEGAL AND INSTITUTIONAL FRAMEWORK

4.8.1 Policy Frameworks

4.8.1.1 Integrated National Transport Policy (2009)

The policy notes that urban areas are characterized by an inadequate supply of public transport and stiff competition for limited road space among motorists, pedestrians, and cyclists. The policy proposes strict parking policies, access restrictions for private cars, and road pricing to enhance traffic demand management. The policy recognizes the important role of NMT and public transport in responding to mobility needs for low-income groups. The policy emphasizes the need to integrate NMT into the planning, design, development, and implementation of road infrastructure and calls for efficient, professionally operated public transport

4.8.1.2 National Climate Change Action Plan (2018-2022)

Objective 7b includes the following goals: promote efficient, safe, and affordable public transport, construct at least 150 km of NMT within urban areas, and pilot electric and hybrid vehicles. It further emphasizes the need for climate-resilient transport infrastructure that can withstand extreme weather events such as floods.

4.8.2 Legal Frameworks

4.8.2.1 Physical And Land Use Planning Act (2019)

Makes provision for the planning, use, regulation, and development of land. Transport has been identified as part of various development plans, and hence transport systems should be analyzed and developed to cater to future demand

4.8.2.2 Urban Areas And Cities Act (2011)

Provides for the classification, governance, and management of urban areas and cities; the criteria of establishing urban areas; and the principle of governance and participation of residents. Parking, traffic control, public transport, and street lighting are listed as requirements for classification of an area to be a city or a municipality

4.8.2.3 Physical Planning Handbook

Provides guidelines and minimum standards for physical planning, including planning for transport infrastructure. The handbook calls for dedicated pedestrian and bicycle facilities and adequate landscaping.

4.8.2.4 Constitution Of Kenya(CoK) 2010

COK establishes the devolved system of governance and the formation of county governments. The fourth schedule, Part II, mandates County Governments with: planning, development, and maintenance of county roads; street lighting; traffic; and parking. Functions under the national government include the construction and operation of national trunk roads and the formulation of standards for road construction. Article 39 (1) guarantees all Kenyan citizens the right to freedom of movement, and Article 42 guarantees the right to a clean and healthy environment. All public offices are mandated to respond to the needs of vulnerable members of society, including women, the aged, children, persons with disabilities, and minority /marginalized communities.

4.8.2.5 County Governments Act (2012)

According to this Act, counties must create a five-year County Integrated Development Plan, which serves as the foundation for sectoral plans. According to the Act, the Department of Roads, Transport, and Public Utilities must create sectoral plans for the next ten years, including a mobility plan and guidelines for managing and budgeting for the transportation systems under their control.

4.8.2.6 Highway Code

The Highway Code provides recommendations for how drivers, cyclists, and pedestrians should utilize the roadways. The Code specifies where pedestrians should cross the street. They are not allowed to cross the highway. Helmets and reflective gear are suggested for cyclists. All users are required under the code to abide by traffic signs and signals.

4.8.2.7 Kenya Roads Act (2012)

Establishes KeNHA, KURA, and KeRRA and stipulates their functions. Provides road classification, management, construction, and maintenance of public roads in Kenya.

4.8.2.8 National Motorcycle Regulations (2014)

Regulates the operation of two and three-wheeler vehicles in Kenya. The regulation mandates two-wheeler riders to have a valid license, carry one passenger at a time, have protective gear (i.e., helmet and reflective jacket), and observe all traffic rules.

4.8.2.9 Climate Change Act Of 2016

Provides a framework for regulation to enable a better response to climate change. Additionally, it offers ways to accomplish low-carbon development. The usage of renewable energy is encouraged across all sectors, including transport.

4.8.2.10 Environmental Management And Coordination Act

Establishes the National Environment Management Authority (NEMA) and legal framework for the management of the environment and lists all major roads among projects to undergo environmental impact assessment before construction.

4.8.3 Institutional Frameworks

4.8.3.1 The Ministry of Transport, Infrastructure, Housing, Urban Development, and Public Works (MOTIHUD-PW)

Responsible for setting standards for road design and overall transport strategy. According to the Kenya Roads Act of 2007, the three road authorities—Kenya National Highways Authority (KeNHA), Kenya Urban Roads Authority (KURA), and Kenya Rural Roads Authority (KeRRA)—are in charge of managing, developing, rehabilitating, and maintaining roads.

4.8.3.2 KENYA ROADS BOARD (KRB)

Oversees the road network and coordinates its development, rehabilitation, and maintenance by administering the Fuel Levy.

4.8.2.3 NATIONAL CONSTRUCTION AUTHORITY (NCA)

Controls the construction sector and plans for its growth, including but not limited to categorizing and registering road contractors.

4.8.2.4 THE NATIONAL TRANSPORT AND SAFETY AUTHORITY (NTSA)

Responsible for coordinating the activities of the road transport departments and overseeing the road transport sector to reduce the number of fatalities caused by car accidents. A National Road Safety Action Plan must be created and implemented by the authority.

4.8.2.5 THE COUNTY GOVERNMENT

Has the mandate of preparing a sectoral plan to guide the sustainable development of the county. Through the department of transport, the county oversees the implementation of county roads; the preparation of plans and policies; and budget preparation and approval.

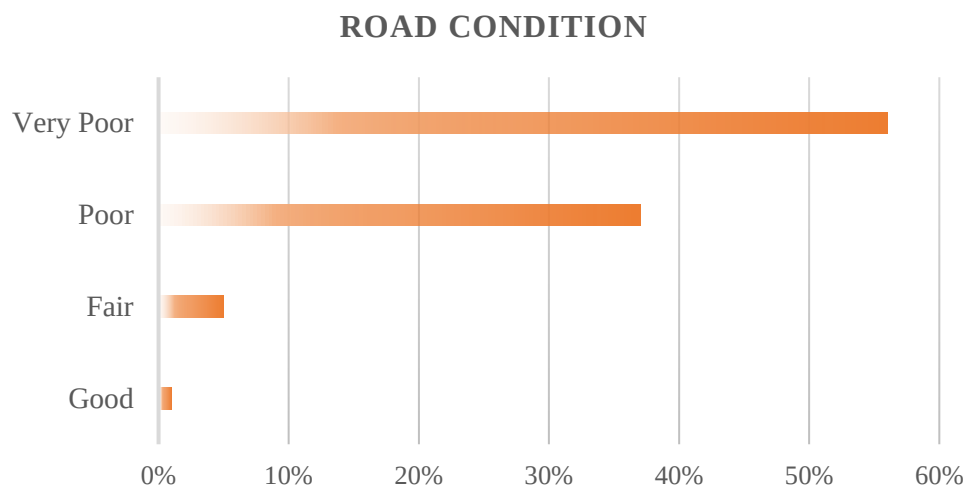
CHAPTER FIVE – DATA ANALYSIS AND DISCUSSION

5.1 INTRODUCTION

This chapter presents and discusses the data that were gathered through questionnaires, direct observation, key informant interviews, pictures, and mapping. The data included, among others, frequency of responses, length of the trip, destination, mode of transportation, main public transport saccos and NMT amenities that were available.

5.2 ROAD CONDITION

From the 90 respondents in the sample size, majority of the roads are either in a poor or a very poor state adding up to 93% of the total roads in the area. This is because majority of the roads are dirty, narrow and not maintained. The only well-developed roads are Thika Super Highway and Gatundu-Juja road. All unclassified roads are murram roads. Graph 3 below shows the road conditions as per the local residents response.



Graph 3: Road Condition

ROAD TYPE	TOTAL LENGTH (Within Site)
Tarmac	4.8 km
Murram	11.1. km
Total	**15.9 km**

Table 6: Road Type and Length

Source: Author

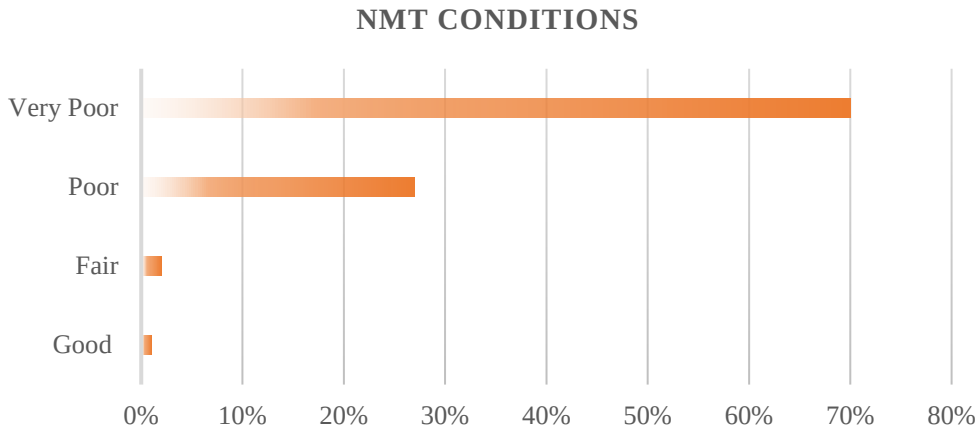
ROAD NAME	ROAD WIDTH	ROAD CLASS
Thika Super Highway	60 m	A
JKUAT-Entry	15 m	B
Gatundu-Juja	12 m	C
Muramati	9 m	D
Mucatha	9 m	D
Unclassified	6 m	E

Table 7: Road Width and Classification

Source: Author

5.3 NMT ROUTES CONDITION

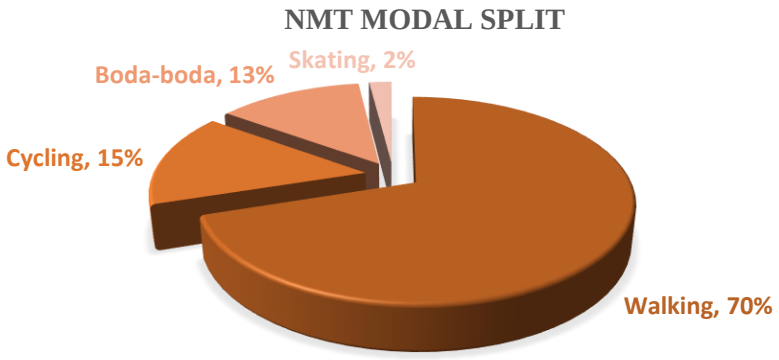
The NMT routes available in the site are inadequate and not well maintained. Existing NMT route along Juja-Entry Road has been abandoned before completion. Majority of the NMT users such as Boda-boda riders advocate for better routes to reduce accidents. According to the respondents, approximately **69%** of the NMT routes are in very bad condition. Graph 4 below summarizes the NMT conditions as per the local residents response.



Graph 4: NMT Conditions

Source: Author

Walking accounts for approximately **70%** of all the NMT modal splits in Juja town. Cycling accounts for approximately **15 %.** The locals hire bicycles at KES. **100 per hour**. However, there are no cycling routes.



Pie Chart 1: NMT Modal Split

Source: Author

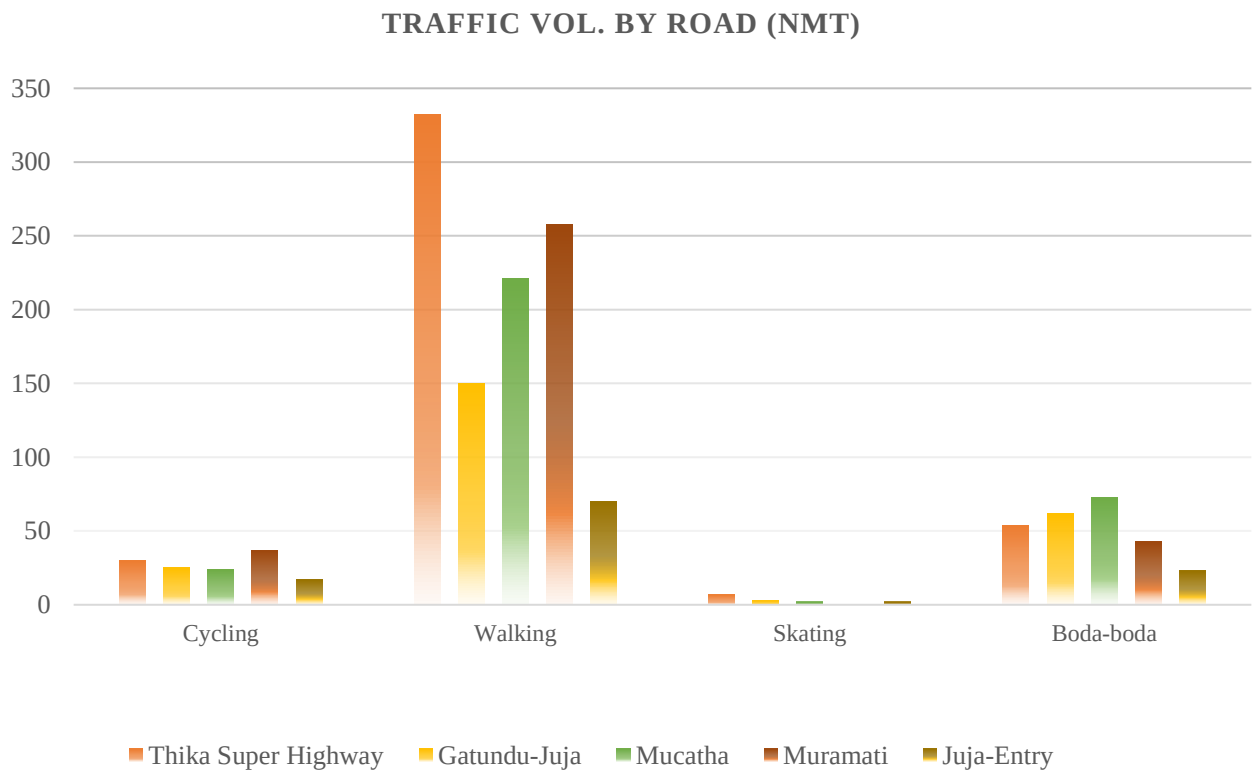
Other NMT users include animal-drawn and people-drawn carts. They are mainly used for fetching water, transporting building materials, and transporting house utilities.

5.4 TRAFFIC VOLUME

5.4.1 Volume by Road (Non-Motorized Transport)

From the survey conducted on non-motorized transport, Walking accounts for the highest percentage, approximately 70% of the modal share. This is mainly because the walking accounts for all the last and first travel means. Skating is the lowest used form of NMT because there are no good routes for skating within Juja town.

Juja town also embrace boda-boda services but they are not well catered for in terms of proper lanes and shades. Majority of the residents also higher bicycles per hour @100. This encourages NMT use but the undeveloped routes discourage the business. Graph 5 below shows the NMT traffic volume by road.

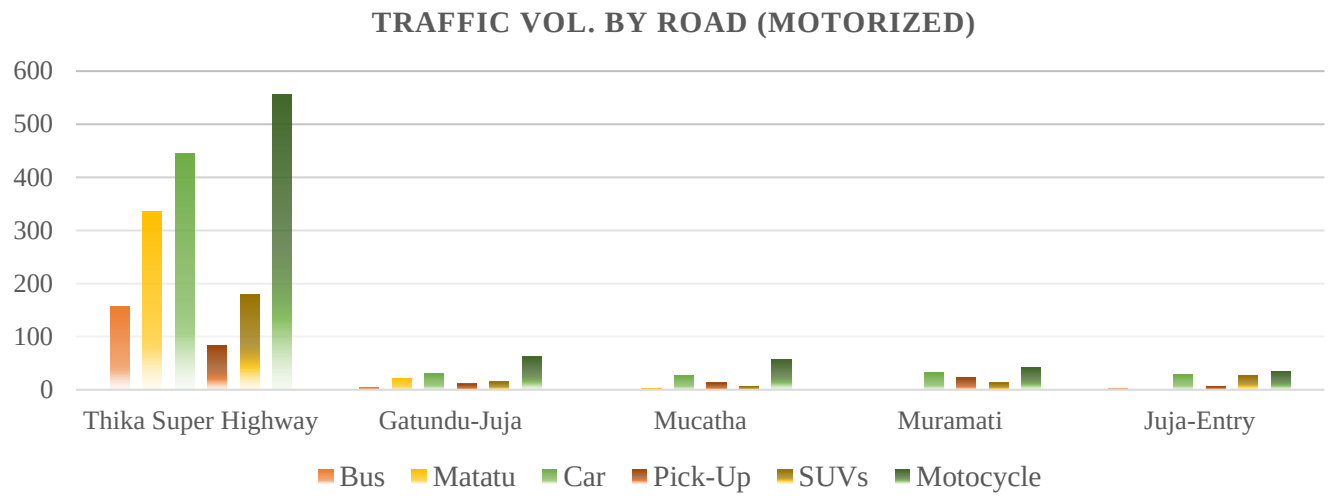


Graph 5: NMT Traffic Volume by Road

Source: Author

5.4.2 Volume by Road Type (Motorized Transport)

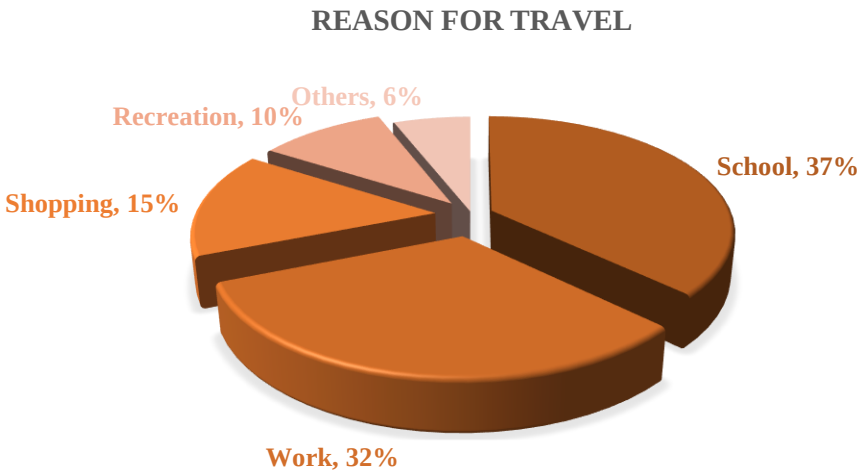
From the transport survey conducted for 5 days, it was evident that Thika Super Highway has the highest traffic volume especially during peak hours. The other main roads within Juja town experience a medium traffic flow across the day. There are only **two** public transport routes within the study area, that is, Thika Super Highway and Gatundu-Juja Road. Motorcycles account for the highest percentage of motorized transport in Juja Town followed by private cars. See graph 6 below.



Graph 6: Motorized Traffic Vol. By Road

5.5 REASON FOR TRAVEL

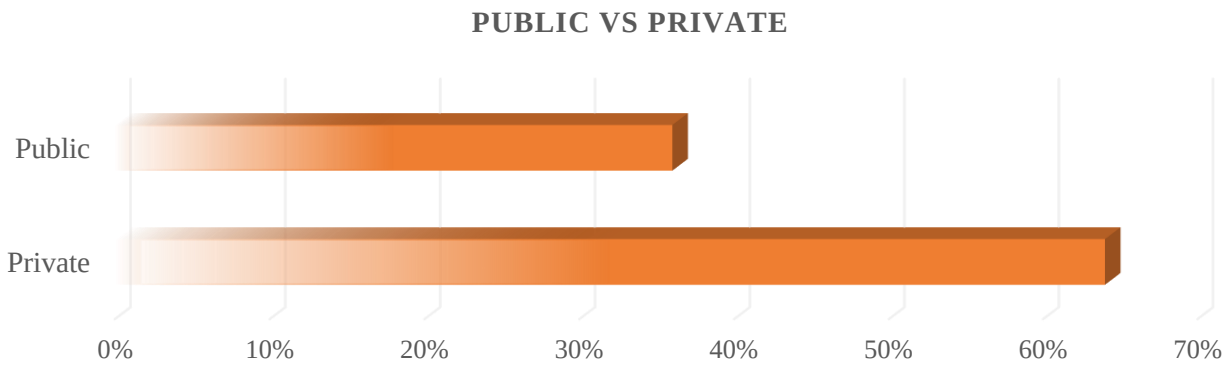
Majority of the population in the area is between the age of 20-30 years. From this data, majority of the locals are either students or working within or outside Juja town. From the primary data collected from travel distribution, majority of the people travel either to school or to work, accounting for 37% and 32% respectively. See Pie chart 2 below.



Pie Chart 2: Reasons for Travel

5.6 PUBLIC VS PRIVATE TRANSPORT

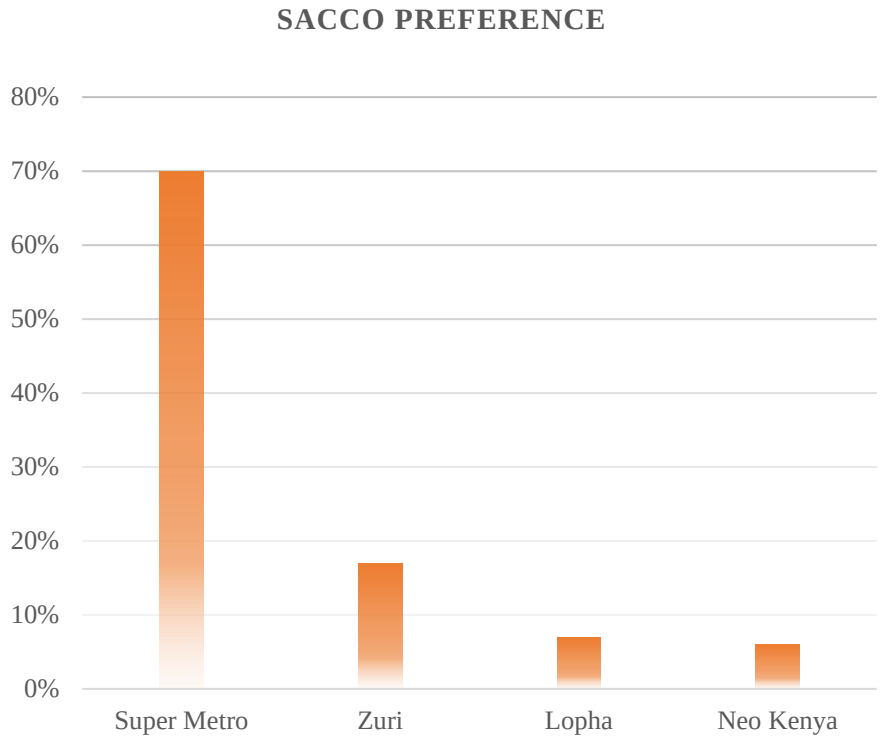
From the transport survey conducted, PrT accounts for more vehicles at approximately 64% while PuT is at approximately 36%. This means that private vehicles cause more traffic jam than public vehicles. It was also observed that public transport serves more people and therefore has a higher percentage in terms of passengers. See graph 7 below.



Graph 7: PuT vs PrT

5.7 PUBLIC TRANSPORT SACCOS

Super Metro is the most preferred Sacco for the passengers because of better services in terms of payments, and vehicle conditions. There is need to improve other saccos for better public transport.



Graph 8: Sacco Preference

5.8 EMPLOYMENT

5.8 1 Employment Ratio by Respondent

Majority of the respondents were self-employed within Juja Town. The type of businesses were transport-related such as Boda-boda riding, car washing and mechanics. There is also a rise in unemployment amongst the youth as mentioned by the planning officer. There is need to have better transport routes to boost economic activities and in the long run reduce unemployment.

5.8.2 Place of Employment by Respondent

Majority of the respondents work within Juja Town, accounting for **42%.** However, it is important to note that a significant proportion, **33%,** work in the Nairobi CBD and they commute on a daily basis. It is critical to upgrade the transport routes in a sustainable manner for a fast and safe connectivity and circulation within Juja Town.

5.9 EDUCATION LEVEL

Majority of the residents have either completed or in the higher learning institutions, accounting for **60%.** This is because majority of the residents are students from Jomo Kenyatta University of Science and Technology (JKUAT).

5.10 SUMMARY OF FINDINGS

Juja Town experiences serious road transport issues such as undeveloped, congestion and narrow roads that affect the urban environment in terms of air quality. Juja Town residents heavily rely on public transport for long distances and non-motorized transport for short distances. However, both motorized and non-motorized routes are undeveloped.

Thika Super Highway accounts for the highest traffic volume while Juja-Entry Road accounts for the lowest traffic volume. There are more private, 64%, than public vehicles, 36%, in Juja Town. Majority of the residents travel to school and work, accounting for 37% and 33% respectively. Majority of the residents are self-employed and work within Juja Town. However, a significant amount accounting for 33% work in the Nairobi CBD.

This transport issues can easily be addressed and mitigated through proper transport planning. With the help of government parastatals such as KURA, NEMA and KenNHA, private investors and NGOs, Juja town can be transformed into sustainable town for the current and future generations.

CHAPTER SIX – CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

This chapter seeks to come up with conclusions through the synthesis of the issues in the study area. This chapter also analyses possible solutions to the problems through concepts, vision statements, proposals and strategies that are mapped in the structure plan and master plan.

6.2 SWOT ANALYSIS

STRENGTHS	
Thika Super Highway	The highway acts as the major connection and linkage between Juja town, Nairobi CBD and Thika town. The highway helps the locals working away from the site to commute daily to their places of work
Gatundu-Juja Road	The road connects the site to Kalimoni ward and to Gatundu. It also serves as a major circulation route across the site
Bike Hiring	Bike hiring @100 per hour encourages the locals, especially students to use non-motorized transport within Juja town
Terrain	Juja town is has a fairly sloping terrain that helps in the natural draining of surface runoff
WEAKNESSES	
Undeveloped Roads	69% of the roads are murram roads and this affects the circulation within the town especially during rainy seasons. The roads are also narrow and the reserves are occupied by informal markets.
Poor Drainage	There is no provision for proper drainage patterns along the roads and this results in stagnant waters that turn into sewages.
Congestion	Pedestrian congestion especially along muramati road and vehicular congestion on Thika Super Highway slows down circulation
Pollution	Air pollution from vehicles and dust particles from murram roads affect Juja town's urban environment
OPPORTUNITIES	
JKUAT	The institution is the main attraction point to the study area as majority of the residents are students and staff members of the university

Juja Police Station	The police station provides security within Juja town
Thirika River	The adjacent river to the west side of the site provides water for the locals and also helps in draining the surface runoff from the roads
THREATS	
Pollution	Road pollution such as CO_2 emissions and Particulate Matter from vehicles affect the town
Undeveloped Roads	The adjacent neighborhoods are characterized by murram roads that are undeveloped and affects the connection to site

Table 8: SWOT Analysis

6.3 CONCEPT, VISION AND STRATEGIES

6.3.1 Concept New Urbanism Concept

The concept has two main principles associated with transport planning, that is, walkability and connectivity. Most locations must be accessible on foot in 10 min or less from home or work. Streets must be designed with pedestrians in mind, and in some instances, they must be completely car-free. Traffic is spread out by a linked street grid, which also makes walking easier. Walking is made enjoyable by a high-quality pedestrian network, a public realm, and a hierarchy of tiny streets, boulevards, and lanes. (Scheepers_BJ_Chapter_3, n.d.)

Key Principles of New Urbanism

- **Walkability;** Communities should be able to meet all basic needs and have the majority of their infrastructure and facilities within walking distance of the residential zones.
- **Connectivity;** This implies that there must be a network of connected roads and streets that reduce traffic issues and give citizens a way to go from one area to another.
- **Environmentally Friendly**; The idea of walkability, when everything is within ten minutes of walking distance, is to reduce the usage of automobiles and other forms of transportation that harm the environment. A better public transportation system, more bicycle use, and a reduction in the use of conventional fuels is of most priority.

6.3.2 Vision

Vision Statement;

"An Integrated Road network that incorporates both motorized and non-motorized transport for a sustainable urban environment"

6.3.3 Proposals and Strategies

STRATEGIES	PROJECTS
1. Incorporation of car-free neighborhoods	❖ Upgrading of the residential roads from murram to bitumen and carbro ❖ Converting the existing roads bound within Mucatha, Muramati and Gatundu-Juja road into complete cycling and walking lanes. ❖ Provision of bicycle parking spaces along the NMT routes ❖ New NMT policy formulations
2. Reduction of air pollution caused by vehicles	❖ Incorporation of photocatalytic materials on paving and parking carbros that help in air purification ❖ Provision of CO_2 car exhaust filter for all vehicles that trap black carbon and the carbon is turned into ink ❖ Planting of more trees along road networks ❖ Providing transport planning policies such as carbon taxing and traffic pricing
3. Improvement of Public Transport	❖ Introduction of new public transport policies such as buying and destroying of old vehicles by the government and strong fines on unroadworthy vehicles. ❖ Introduction of Intelligent transport systems that includes electric vehicles that will reduce energy consumption rates of public vehicles ❖ Introduction of double decker buses
4. Improvement of all NMT routes	❖ Provision of new and upgraded routes ❖ Pedestrian friendly routes complete with seats, shades and dustbins ❖ Provision of enough bollards along NMT routes
5. Improved connectivity within Juja Town	❖ Construction of two new residential/access roads that cut across the site, parallel with Muramati road
6. Upgrading of security within Juja Town	❖ Upgrading and erection of new traffic and street lights

Table 9: Proposals and Strategies

ILUSTRATIONS

Plate 4: Car-free neighborhood

Plate 5: Bicycle Parking along NMT Routes

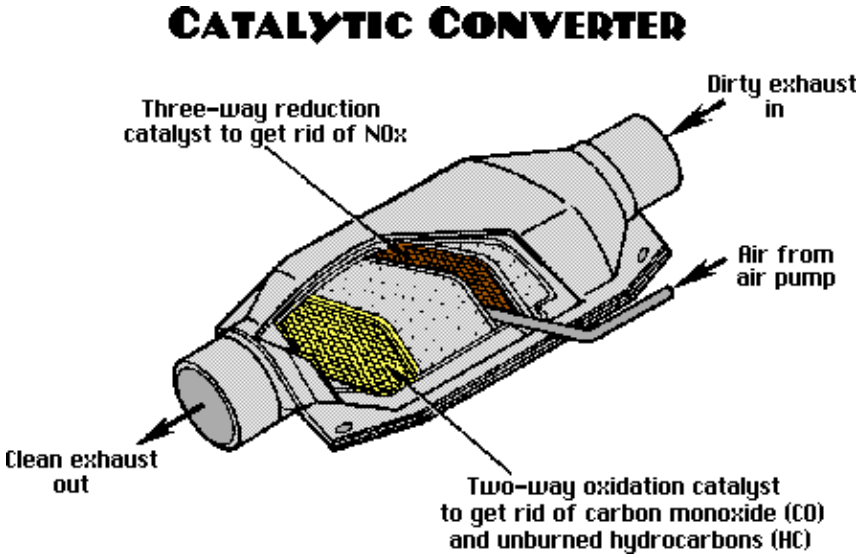


Plate 6: Catalytic converter

Source: ScienceDirect

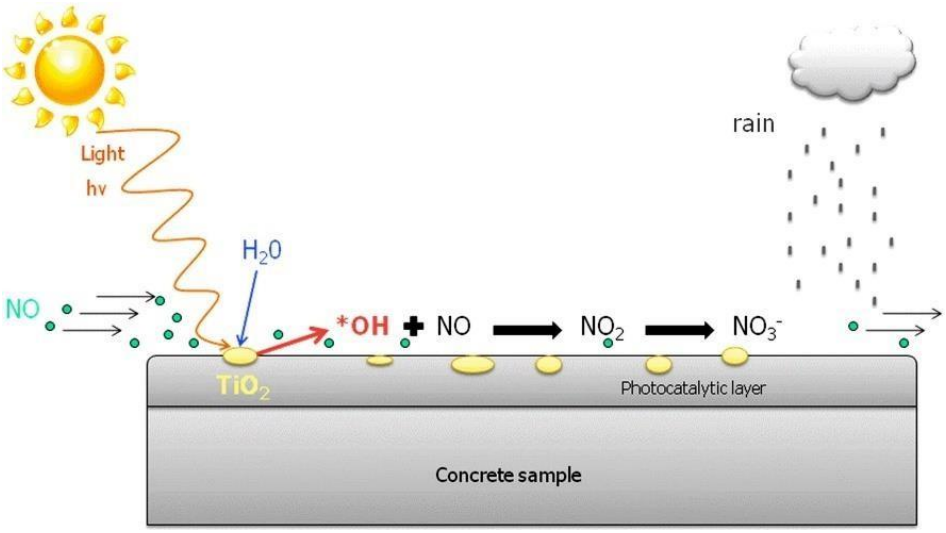


Plate 7: Air Purification Process

Source: ScienceDirect

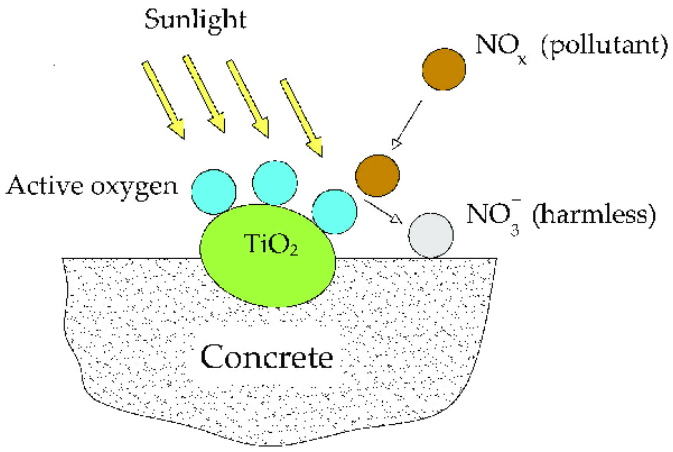
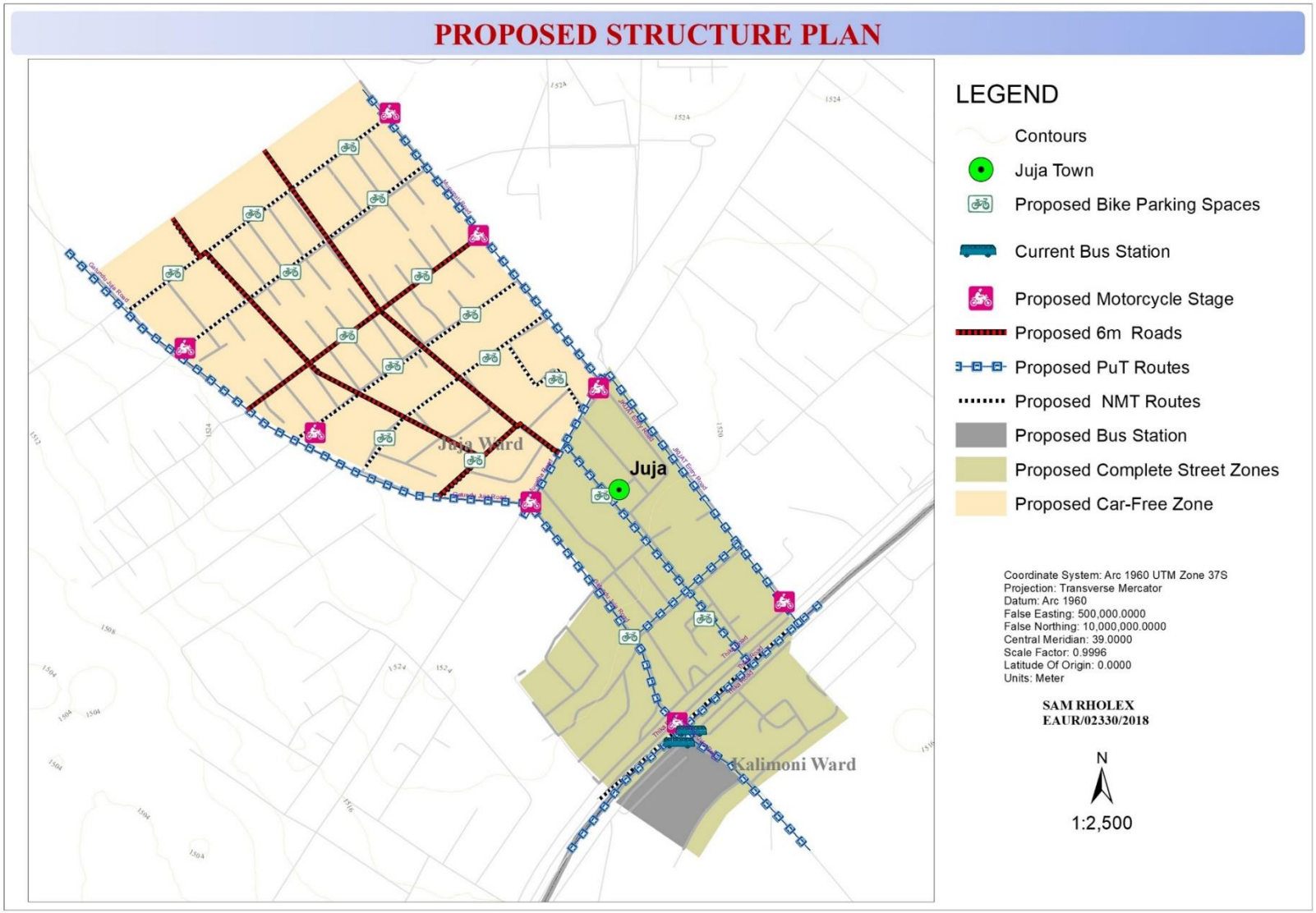


Plate 8: Air Purification Description

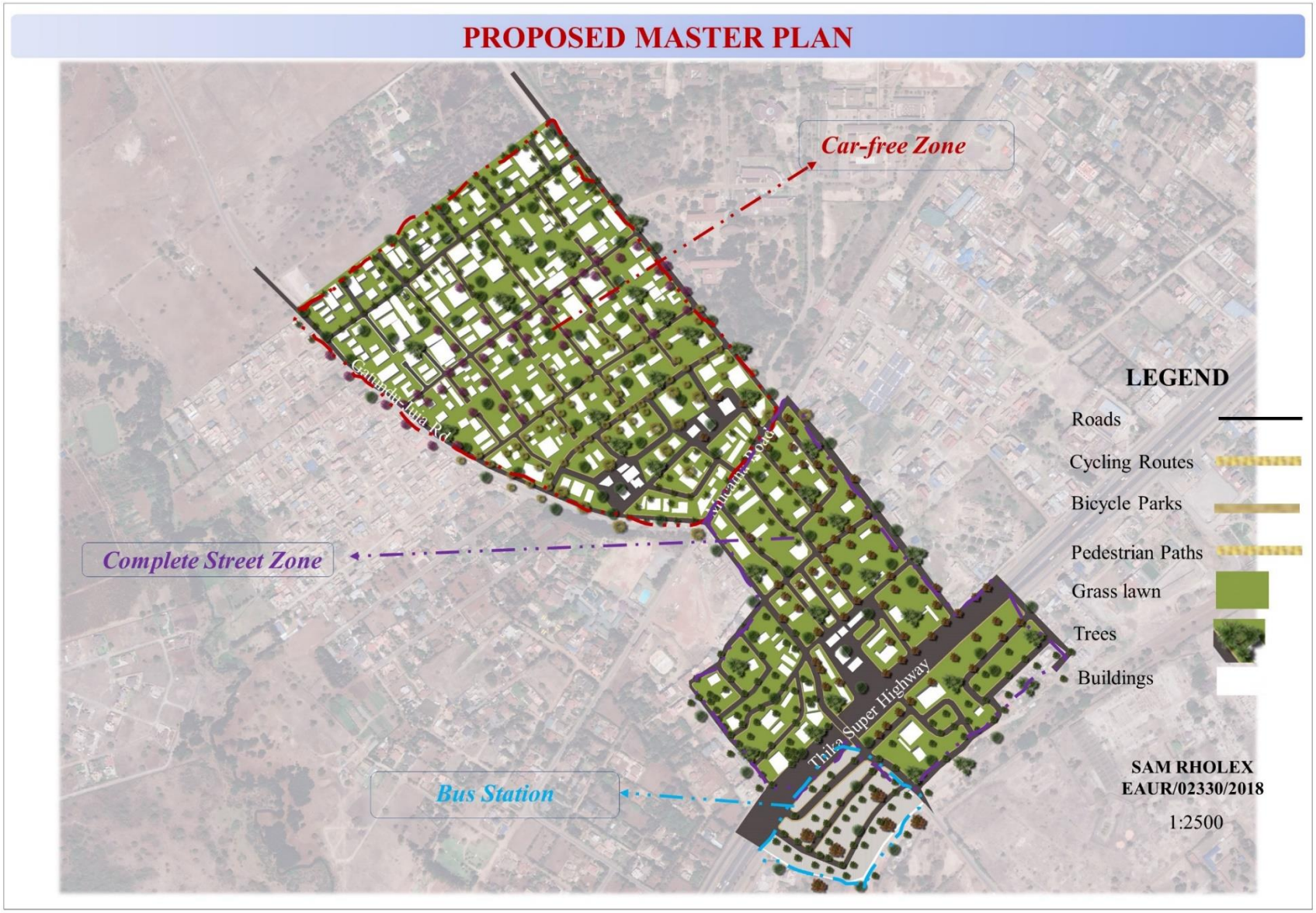
Source: ScienceDirect

6.4 PROPOSED STRUCTURE PLAN



Map 13: Proposed Structure Plan

6.5 PROPOSED MASTER PLAN



Map 14: Proposed Master Plan

The master plan shows details of how the proposals are to be implemented in the ground. The main proposals have been identified in the zones above.

Some of the cross sections and perspectives of the master plan include;

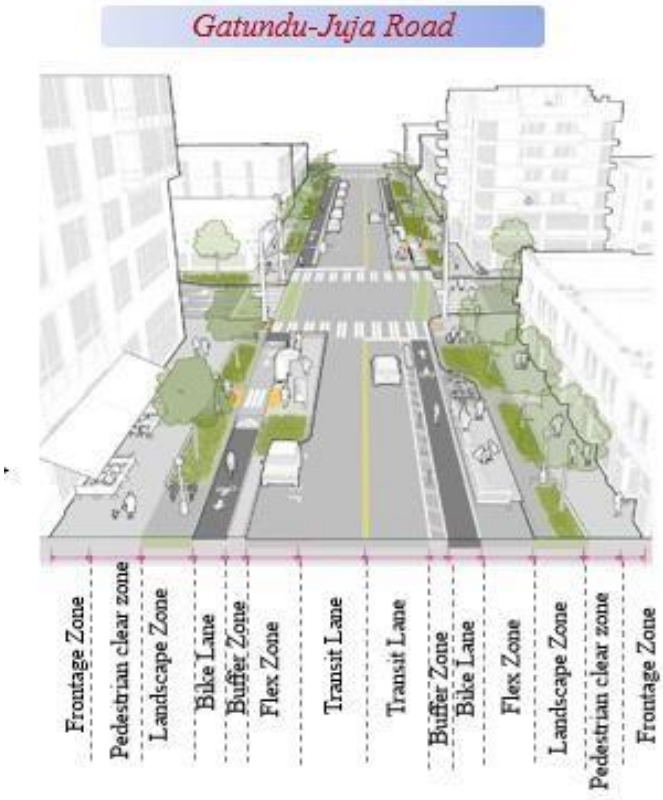
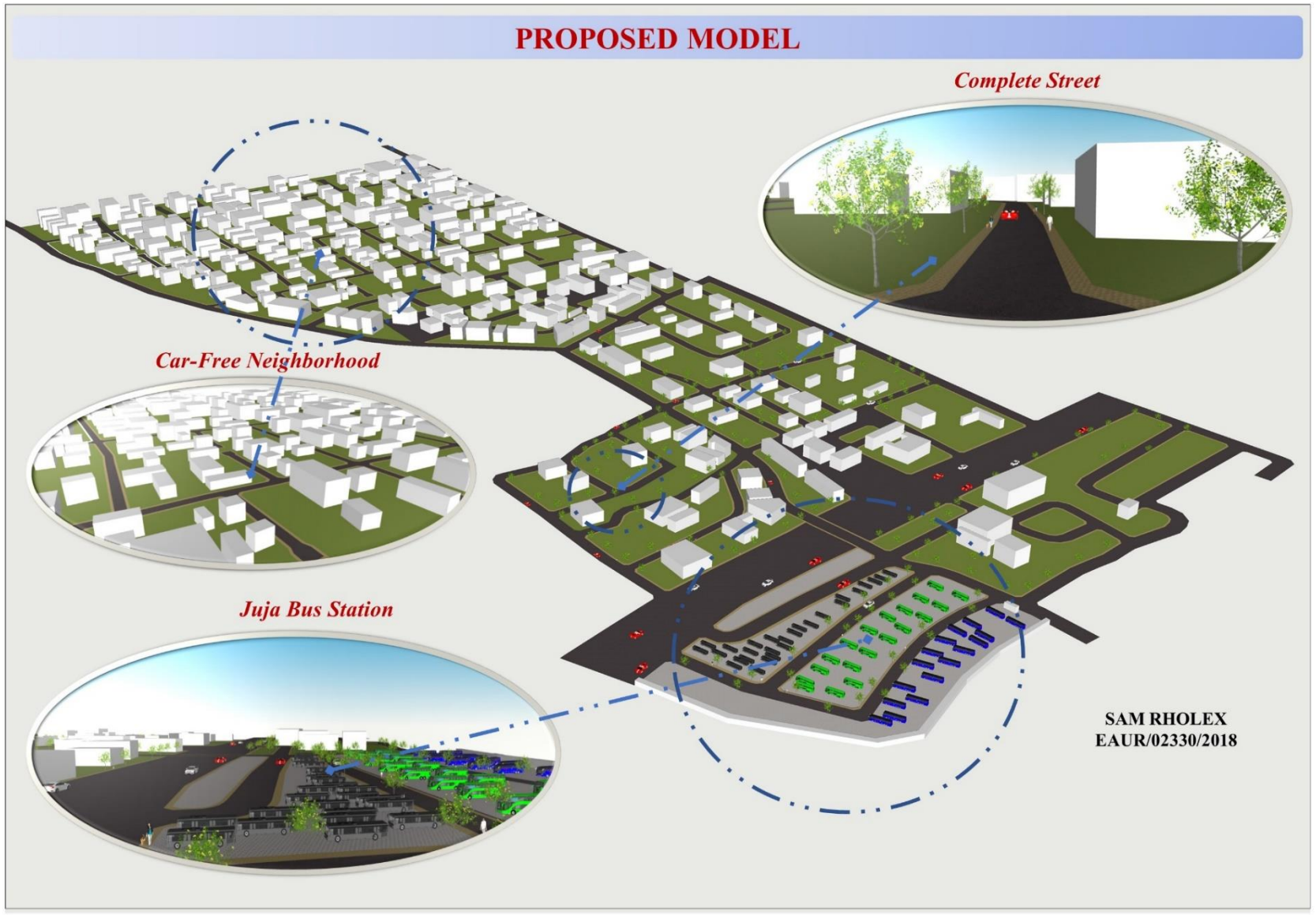


Plate 9: Master Plan Sections

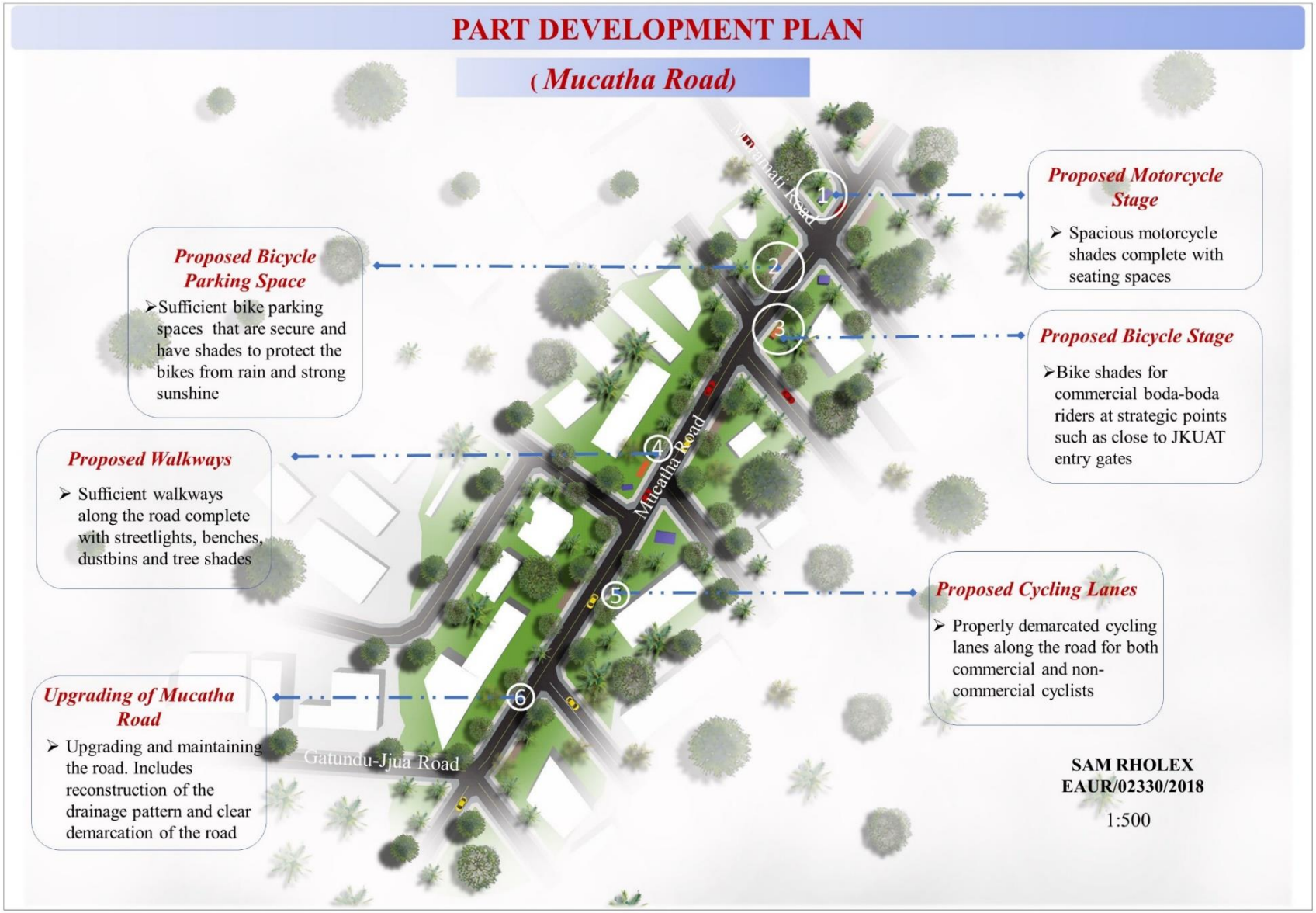
Source: Author

6.6 MASTER PLAN MODEL



Map 15: Master Plan Model

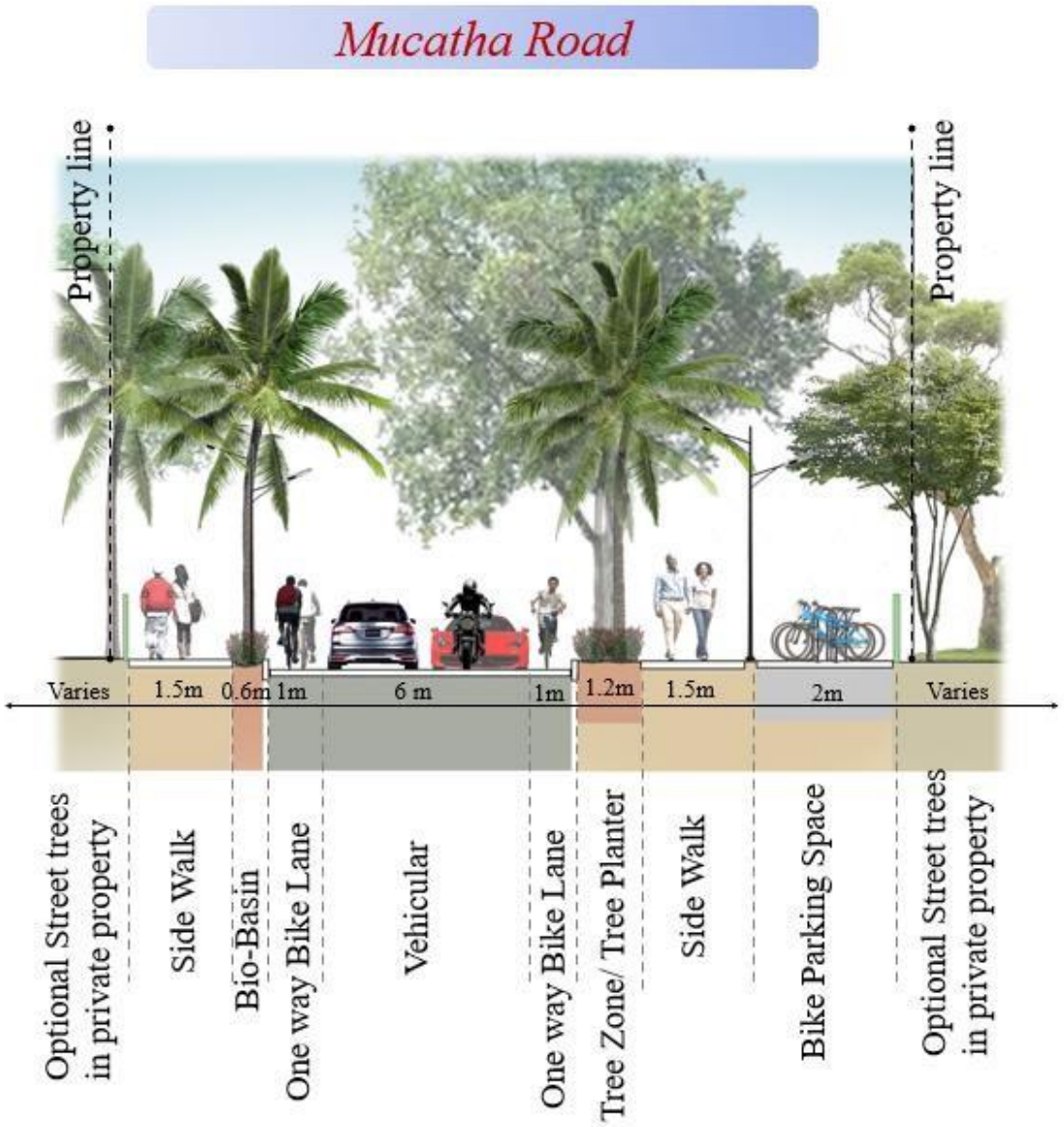
6.7 PART DEVELOPMENT PLAN



Map 16: Part Development Plan

Part Development Plan was from Mucatha road and it shows details of how the complete street zone is proposed.

Part Development Plan Cross section;



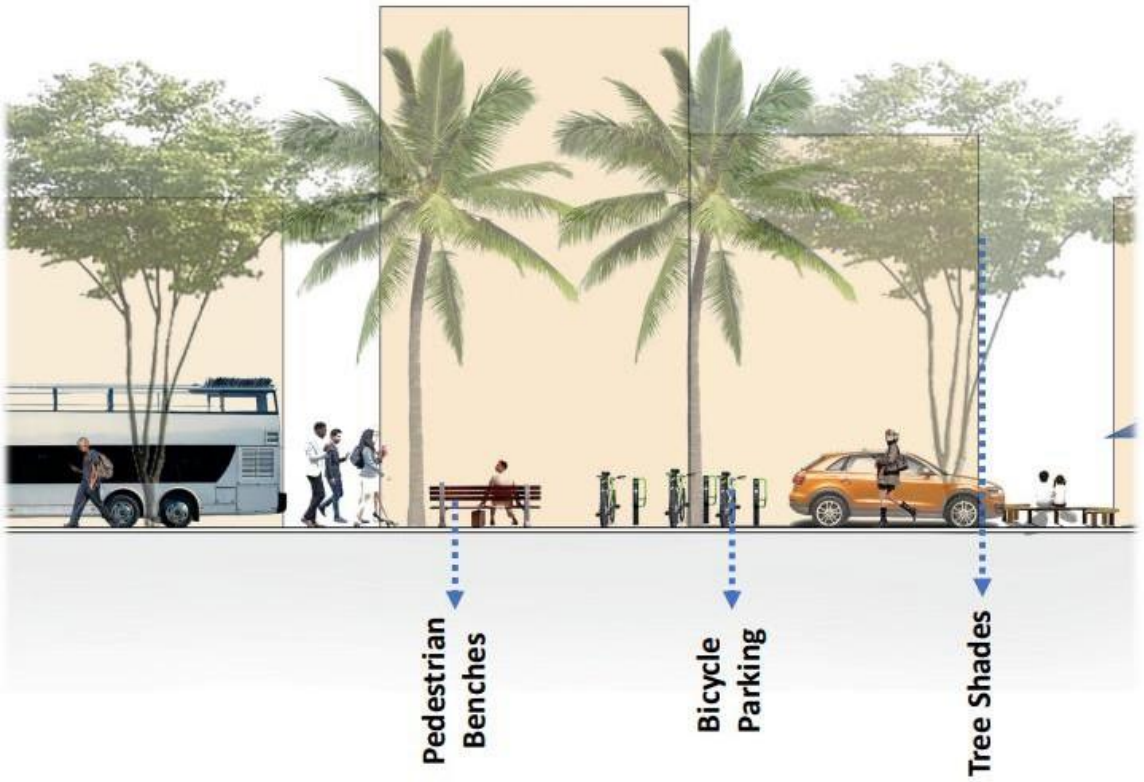


Plate 10: PDP Cross Sections

Source: Author

6.8 POLICY ACTION AND JUSTIFICATION

6.8.1 Sustainable Development Goals

One of the seventeen sustainable development goals includes having sustainable cities and communities that provide a quality clean environment. Car free zones will reduce pollution in Juja town and therefore providing a cleaner environment

6.8.2 Agenda 2063

Vision 2063 on Africa we want, identifies that although Africa produces just about 5% of the global carbon emissions, there is a need to address the rise in carbon emissions and global climate change Provision of a car free zone will reduce carbon emissions in Juja town

6.8.3 Vision 2030

Kenya's goal under Vision 2030 is to become a middle-income industrialized nation that offers all of its residents a good quality of life. Through 2030, various models are used to estimate carbon dioxide emissions from burning fossil fuels that could lead to long-term environmental deterioration

6.9 IMPLEMENTATION MATRIX

STRATEGIES	PROJECTS	DURATION (Years)	TERM	AMOUNT (millions)	FINANCER	ACTOR
Incorporation of car-free neighborhoods	❖ Upgrading of the residential roads from murram to bitumen and carbro	5-10	Long Term	50	World Bank	KURA
	❖ Converting the existing roads bound within Mucatha, Muramati and Gatundu-Juja road into cycling and walking lanes.	3-5	Short Term	40	International Development Association	KURA
	❖ Provision of bicycle parking spaces along the NMT routes	2-3	Short Term	20	World Bank	KURA
	❖ New NMT policy formulations	1-2	Short Term	5	National Government	Planning Department
Reduction of air pollution caused by vehicles	❖ Incorporation of photocatalytic materials on paving and parking carbros that help in air purification	3-7	Long Term	50	World Bank	KeRRA and KURA
	❖ Provision of CO_2 car exhaust filter for all vehicles to trap black carbon through by laws	2-5	Short Term	30	International Development Association	NEMA
	❖ Planting of more trees along road networks	2-5	Short Term	15	County Government	Forestry Dept.

	❖ Providing transport planning policies such as carbon taxing and traffic pricing	1-2	Short Term	8	National Government	Planning Dept.
Improvement of Public Transport	❖ Introduction of new public transport policies such as buying and destroying of old vehicles by the government and strong fines on unroadworthy vehicles	2-5	Short Term	12	National Govt.	Planning Dept.
	❖ Introduction of Intelligent transport systems that includes electric vehicles that will reduce energy consumption rates of public vehicles	5-10	Long Term	50	World Bank	NTSA
	❖ Introduction of double decker buses	2-5	Short Term	20	National Govt.	NaMAT A
Improvement of all NMT routes	❖ Provision of new and upgraded routes	1-3	Short Term		National Govt.	KURA and KeRRA
	❖ Pedestrian friendly routes complete with seats, shades and dustbins	3-7	Long Term		National Govt.	KURA and KeRRA

Table 10: Implementation Matrix

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APPENDICES

APPENDIX 1: Questionnaire

TECHNICAL UNIVERSITY OF KENYA SCHOOL OF ARCHITECTURE AND SPATIAL PLANNING

DEPARTMENT OF SPATIAL PLANNING AND DESIGN

A STUDY ON THE NEGATIVE TRANSPORT ISSUES AFFECTING THE URBANENVIRONMENT, A CASE STUDY OF JUJA TOWN.

The information you provide will be treated with utmost confidentiality and will be used foreducational purpose only.

SECTION A: Interviewer

Name of the interviewer……..

Date…….

Location……..

Code…….

SECTION B: Respondent's Background details

Name of the respondent (optional)……

1.1 Age: ……..years

1.2 Gender: Male ☐ Female ☐

1.3 Marital status: Single ☐ Married ☐ Widow/widower ☐

SECTION C: Transportation

2.1 Main Means of Transport

Walking	
Cycling	
Public transport	
Private transport	
Boda-boda	
Motorcycle	

2.2 Main reason for travel

School	
Work	
Recreation	
Shopping	
Others	

2.3 What is the average travel cost per day?

…… ……

2.4 What are your main travel destinations across the day? (e.g house-school-shoppinghouse)

…… …….

2.5 What is the preferred Sacco to travel in? (e.g Zuri, Super Metro)

…… ……

2.6 NMT Conditions (walking and cycling lanes)

Good	
Fair	
Poor	
Very Poor	

2.7 Road Conditions

Good	
Fair	
Poor	
Very Poor	

SECTION D: Health

3.3 Do you have any respiratory disease?

…… ……

3.2 If any, specify ……

SECTION E: Education level

4.1 Highest level of education:

None ☐ Primary school dropout ☐ Completed primary ☐ Secondary school ☐

Tertiary;

Certificate ☐ Diploma ☐ Degree ☐ Post Graduate ☐

SECTION F: Employment

5.1 Employment:

Unemployed ☐ Government ☐ Private organization ☐ Parastatal organization

☐ Self-employed (Specify): …….

☐ Other (specify): ……

1.6 If employed, place of employment?

☐ Within the Juja town

☐ Thika town

☐ City Centre (Nairobi, CBD)

☐ Other areas within Nairobi and Kiambu (Specify)……..……

☐ Other areas outside the region (Specify)……..……

SECTION F: Recommendations

17. What do you suggest the National and County Government (Nairobi Metropolitan Service) can do to improve the transport within Juja town?

a)…….……..

b)……..

c)……..

d) ……

19. According to you, who are the key players within the transport sectors, and what can they do to help mitigate the transport problems?

a)…….……..

b)……..

c) ……..……

TECHNICAL UNIVERSITY OF KENYA

SCHOOL OF ARCHITECTURE AND SPATIAL PLANNING

DEPARTMENT OF SPATIAL PLANNING AND DESIGN

A STUDY ON THE NEGATIVE TRANSPORT ISSUES AFFECTING THE URBAN ENVIRONMENT, A CASE STUDY OF JUJA TOWN.

1. Juja Town Planner

Date	
Respondent's name	
Designation	

a) What are the guidelines provided for development control and are they being adhered to?

b) What are the guidelines for the enforcement of building standards?

c) What are the current regulations in place to help develop transportation land use?

d) Are there any ongoing or future projects on transport?

e) What are the political hurdles that town planners are facing in Juja town.

2. KURA/ KeNHA/ KERRA Official

Date	
Respondent's name	
Designation	

a) What current road projects are existing in Juja town?

b) What are the goals of these projects?

c) What are the emerging issues facing road transport?

d) What do you think the ministry should do to help have a sustainable transport system in Juja town?

3. NEMA official

Date	
Respondent's name	
Designation	

a) What are the existing laws that govern transport-related pollution?

b) What is the current trend of pollution in Juja town?

c) What can be done to help in reducing transport-related pollution?

4. Public Health Officer

Date	
Respondent's name	
Designation	

a) What are the levels of respiratory diseases in Juja town?

b) What has been the trend in respiratory infections in the last few years?

c) What can be done to mitigate transport problems that result in respiratory infections?

APPENDIX 3: Transport Survey

TECHNICAL UNIVERSITY OF KENYA

SCHOOL OF ARCHITECTURE AND SPATIAL PLANNING

DEPARTMENT OF SPATIAL PLANNING AND DESIGN

A STUDY ON THE NEGATIVE TRANSPORT ISSUES AFFECTING THE URBAN ENVIRONMENT, A CASE STUDY OF JUJA TOWN.

Transport Survey

1.1 Survey along Gatundu-Juja Road

Type of Transport	**Number Seen**	
	Morning (8-9 am)	Evening (4-5 pm)
Cycling		
Private		
Public		

1.2 Survey along Thika Super Highway

Type of Transport	**Number Seen**	
	Morning (8-9 am)	Evening (4-5 pm)
Cycling		
Private		
Public		

1.3 Survey along Marimati Road

Type of Transport	**Number Seen**	
	Morning (8-9 am)	Evening (4-5 pm)
Cycling		
Private		
Public		

1.4 Survey along Mucatha Road

Type of Transport	**Number Seen**	
	Morning (8-9 am)	Evening (4-5 pm)
Cycling		
Private		
Public		

1.5 Survey along Juja-Entry Road

Type of Transport	**Number Seen**	
	Morning (8-9 am)	Evening (4-5 pm)
Cycling		
Private		
Public		