# EFFECTS OF LAND-USE CHANGE ON THE ENVIRONMENT IN ATHI-RIVER TOWN

---


**By;**

**Mulwa Purity Ndinda**

**REG NO: C50/81388/2015**


**RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTERS OF ARTS IN ENVIRONMENTAL PLANNING AND MANAGEMENT OF THE UNIVERSITY OF NAIROBI.**

**December 2019**

---

# DECLARATION

This Research Project Paper is my original work and has not been presented for a degree in any University.

SIGNED:

_____DATE: _____

MULWA PURITY NDINDA

{Candidate}

This Project Paper has been submitted for examination with my approval as University Supervisors.

DR. TERESA MBATIA

_____DATE_____

MR. LINCOLIN KARINGI

_____SIGNED:_____

# DEDICATION

I wish to dedicate the project paper to my spouse Douglas Mbilu, son Bill Mbilu and daughter Belissa Nthoki without their compassionate cooperation it would not have made it and in remembrance of my dad, Jones Mulwa who instilled in me the love for books and respect for education.

# ACKNOWLEGDEMENT

I take this opportunity to thank the following people who offered their assistance and contributions in writing this research paper.

I wish to appreciate the inspirational instructions and recommendations from my supervisors Dr. Teresa Mbatia & Mr. Lincolin Karingi. They have given me a deep appreciation of this subject.

I wish like to recognize the cooperation by Subcounty officers of the County Government of Machakos and their insights on the subject of study. I wish appreciate the kindness and assistance given to me by Athi-river township and Athi-river North location residents. They were very generous in their support of my academic pursuits. Jackline in particular; assisted in this research by acting as my "tour guide".

Finally, I wish to appreciate the Chairman of the Department of Geography & Environmental Planning Dr. Wambua and the technicians within the department for their support and encouragement. I could not have completed this research without all of your assistance, tolerance, and enthusiasm.

Thanks to the Almighty God for all of you and His Sufficient Grace.

# ABSTRACT

The way people have used land and exploited its assets in urban regions is a critical predicament as it has changed land cover over time and influenced the effectiveness of the environment. This has decreased the distinctive potential of lands to support both ecosystem and human activity at global scale. These consequences are not localized environmental issues but global ones, as their multiplier consequences cross beyond these urban areas and have become chronic obstacles to achieving goal number eleven of the SDGs; sustainable development to create sustainable cities and communities.

Land-use change is inevitable as urban populations increase in numbers and the urban areas grow in size because of urban sprawl. Consequently, land-use choices made about how this will occur will have effect on the humans dwelling within their homes, neighbourhoods and urban regions and this could have worldwide environmental implications. Urban growth has masked critical human-environmental interaction. This study is primarily based on man-nature interface on an urban environment. The study in particular features the core and sub-urban area of Athi River Ward. The area has numerous industrial developments, high density residential in mixed-use set up which offers the researcher a much broader scope in identifying the environmental consequences of land-use change. Particularly, the study zeroed in on the consequences of land use change as an aspect of urbanization on the environment. It investigated the environmental implications of land uses within the urbanizing Athi-river. It in addition established the relationship between change in land-uses and the urban ecosystem to pick out the constraints and opportunities existing for environmental planning that can be maximised for future sustainable growth of this town. In its recommendations, the study demonstrated how land use planning can play a part in minimizing these consequences. The study was done using secondary data primarily based on literature evaluated and primary data in form of field survey, landsat imagery, administration of questionnaires at one hundred forty households, twenty businesses and fifteen industries and interview schedules for numerous stakeholder institutions.The study revealed that Athiriver town is an unsustainable urban eco-system. Several complicated feedbacks exist between the environment and land-use changes in Athi-river. Improper planning on the utilization of the urban environment, inadequate enforcement/development control and conflicting policies on land-use standards were among the main issues highlighted. The study thus analyses the environmental implications of these issues and gives proposals on ways of reversing this detrimental trends towards achivieng a sustainable urban ecosystem.

# Contents

## List of Figures

# List of Plates



# List of Tables

# ACRONYMS

| | |
|---|---|
| CGN | County Government of Machakos |
| GDP | Gross Domestic Product |
| EPZ | Export Processing Zone |
| HIV/AIDS | Human Immunodeficiency Virus |
| NEMA | National Environment Management Authority |
| MDGS | Millenniun Development Goals |
| NC | Nature Conservancy |
| UN | United Nations |
| UNCHS | United Nations Human Settlement Programme |
| UNFPA | United Nations Fund for Population Activities |
| SDG | Sustainable Development Goals |
| SPSS | Statistical Package for Social Sciences |
| SSA | Sub Saharan Africa |
| VOC | Volatile Organic Compounds |
| WCD | World Commission on Development |
| WRA | Water Resources Authority |

# CHAPTER ONE: INTRODUCTION

## 1.1. Background to the Study Problem

One of the most acknowledged description of sustainability can be tracked down to the 1987 United Nations conference. It recognized sustainable development as that "which meets present needs without compromising the ability of future generations to fulfill their needs"(WCD,1987). The editor of "In Context magazine", Robert Gill man extended this objective inclined definition by pointing out that "sustainability refers to a totally vintage and simple idea (The Golden Rule)...do unto future generations as you would have them do unto you." before the Brundtland commission 1987, "development progress" was symptomatic of industrialization and considered entirely by fiscal operations and growth in GDP. Protection and conservation of the environment seemed to be an impediment to development for many. However, Our common future recognized that "environment or development" as a fallacious paradox. Therefore, attention changed to "environment and development," then ultimately to "environment for development."

The environment can be regarded as the set of conditions that encompass human beings and have an effect on the manner in which they savor life. The two are inseparable even though it was intimated that development is detrimental; even violent to nature (Shiva, 1991). Historical development patterns have again and again not being benevolent to nature. Nonetheless, there are existing possibilities to make future developments sustainable. Degradation of the environment as a result of urbanization raises numerous questions, on what is right or wrong that go beyond monetary dimensions.Urbanization is a revolutionary transition from a rural remote community to a more urbanized one; it is a critical concomitant of industrialization that goes synchronically with the capacity of built-up areas as drivers of economic growth and as adherents of research-based, sociological and high-tech development (Gyabaah,2003). Rapid urban growth finds expression basically in land-use change; that is, the outward growth conurbation, converting key farmland into built-up and industrial uses. Aforementioned includes the increase in density and extent of urban regions that cause the development of multi-storey buildings and sky-craping commercial development in zoned areas. As a social and regional growth, urbanization can be estimated as the transition of a region into an urban area via three social processes; immigration, high rates of natural increase and conversion of peri-urban areas into cities. Generally, urbanization is the proliferation of inhabitants of urban settlemenst leading to the expansion of cities as a result of industrial and economic growths

ultimately resulting in urban- specific changes in expertise, classification of human capital and social behaviours' (Mulwa, 2012).

The world's urban population was 2.4 B in 1990 with 2/3 of this population living in third world nations. By 2025, the urban population will be more than double, to 5.5 billion (UN Estimates) . Ninety (90) % of these prospect growths are going to be aggregated in cities mainly in third world nations (UNCHS, 2002) with nearly half (49%) of Sub-Saharan Africa population been urban by the year 2025 (UN 1996).These urban population growths have been fuelled by massive immigration into urban areas from the countryside; high fertility rates and low mortality rates in urban areas and bias development strategies that advocate for development in these urban areas.

In Kenya, immigration to urban areas is the greatest cause urban populatin growth. It's influenced by circumstances that push people out of the countryside and by circumstances that pull people into urban areas. Kenyan urban population has grown at an alarming rates from 7% in 1960s, 21 % in 1999 to 27% in 2018 (UN) . The magnitude and extent of urbanization vary greatly by region. Athi-river is highly urbanizing town due to its locational advantage of its adjacency to the capital city. As a consequence of uncontrolled urbanization in Athi-river, land-use change has been occurring very rapidly with rapid land-use change.

The study in particular zeroed in on the impacts of land use change as an aspect of urbanization on the environment . It investigated the environmental implications of land uses in the urbanizing Athi-river. It further established the interrelationship between land-use change and the urban ecosystem and sought to identify constraints and opportunities for environmental planning in Athi-river that can be maximised for future sustainable growth of this town. Sustainable growth of any urban areas should provide a comprehensive structure for regulating social development and economic growth even as it provides appropriate and ideal operation of the natural processes of environment over time (Bass, 2006 & World Bank, 2006a). For long-term development to be achieved there should be sustainable utilization of various resources including financial, material, human, social and natural.

## 1.2. Statement of the Research Problem

This growth of urban areas may be an unseen critical human-environmental interaction. The manner in which humans have utilized land and made the most of its supplies in the past years is a perilous predicament (Cieslewicz, 2002) because it has changed land cover and affected the effectiveness of the urban environment. Amidst the unification of farming, advanced technology and the upward thrust of profit-oriented mode of economy the utilization of land and its sources has accelerated dramatically (Kharel,2010). Land use practices have turned out to be so ferocious and widespread in the last two decades that we can see their consequences in form of unplanned development, decline in the quality of environment, loss of key farm lands, degenaration of wetlands, and loss of acquatic life and natural world environments all over the planet (Kharel, 2010). The aforementioned impacts have decreased the distinctive potential of habitats to sustain both ecological systems and human activity worldwide (Kharel, 2010). To this end, these effects are no longer neighborhood environmental problems but issues of global consideration(Houghton,1994). To deal with this sort of issues of global scale, its essemtial for planners, national/local governmental officers and legislators to have precise statistics on ad hoc land use patterns and logical know-how on land-use chages through time (Anderson et. al 1976).

Athi River town was formed as the core of a compact settlement sixty years ago with an urban population of 6,000 people. It has undergone tremendous spatial temporal land-use change in the last fifty years ranging from the industrial, human settlements, urban agriculture, quarrying to the infrastructural land-use changes. Its environs have expanded to cover a vast 693 $Km^2$ at a population of about 60,000 (UN, 2002) compared to the 1999 area of 8.5 $Km^2$ at 6,000 people (GoK, 2001; Koti, 2004). Comparatively, the town's population stood at 137,211 according to 2009 Census report and its projected by CIDP to be 200,041 by 2022 of 241(Km2) density. This can partly be attributed to its growth as a residential/dormitory area due to its proximity to the capital hence deemed a satellite town to the city of Nairobi. As Athi-River's population expands, the demand for services, such as sanitation, supply of water and solid waste collection increases. According to a study done by UN urban profile 2014, More than 50 % of the residents in Athi-river could not access safe drinking water, proper sanitation or sewage facilities. Solid waste collection was poor with more than 50% of the residents throwing their household waste in the open environment while a quarter burnt it. On the same, more than 10 % of the residents relied on the highly polluted Athi River and other nearby rivers and streams for their drinking water. Furthermore, many of Athi-river slums were located

in hazardous areas, close to industries, riverbanks, railway lines and the Nairobi National Park, exposing residents to various health and safety risks.

Urban populations and urban areas will continue to grow in size and numbers therefore land-use decisions made about how this will take place will impact upon the inhabitants of these urban areas and have global environmental consequences.Thus, both rise in and the relocation of the population in Athi-river town will affect the natural urban ecosystem and the functioning between the urban environments and populations. These can cause irreversible adverse effects on the environment in Athi-River and can only be addressed through proper land-use planning.

## 1.3. Research Questions

Therefore, the study aims at answering the following research questions;

1. What is the state of the natural environment in Athi river town?
2. What is the relationship between land-use change in Athi river and the urban ecosystem?
3. What are the existing environmental and land use planning opportunities and constraints in Athi-river town?
4. How can land-use planning play a role in minimizing the effects of land-use change on the environment.

## 1.4. Research Objectives

1. To investigate the state of the natural environment in Athi river town.
2. To establish the relationship between land-use change in Athi river and the urban ecosystem.
3. To identify environmental and land use planning opportunities and constraints in Athi-river town.
4. To recommend how land-use planning can play a role in minimizing the effects of land-use change on the environment.

## 1.5 Hypothesis

**H1** There is a significant relationship between land-use change and the state of the environment in Athi-river town.

## 1.6 Justification of the Study

The united nations Conference on environment and development in Rio de Janeiro,1992' (the, Earth Summit) recognized openly and categorically the importance of environment for social and economic development. Urban areas perform a pivotal role in socio-economic development in all nations because in most cases urbanization culminates from economic growth. People agglomerate in urban areas due to the fact that its where new investments and new employment opportunities are created. Thus, urbanization is a reflection of economic success in different way; its a reflection of the increasing quotient of GDP sparked off by industry and service provision, and the growing quotient of the personnel working in industrial and service provision investments.

Through urbanization, diverse and vibrant economies are built which raise efficacy, create employment opportunities and financial output, offer fundamental services, sustain growth of population and turn into drivers of socio-economic advancement. Thus systematic, and dynamic urban areas are paramount for economic boom and well-being; equally at the local level strong urban economies generate the resources needed for public and private investments in infrastructure, education, health and improved living conditions (UN 2005). Urbanization follows and support economic growth; on one hand, new businesses concentrate in urban areas due to the fact fact they thrive from numerous scale effects for their own enterprises as they gain from all investments within and services and human skilled on site. On the other hand, it's a more inexpensive for governments to provide infrastructural and utility services in urban areas as there are enormous scale effects or closeness in providing infrastructure facilities and services such as pipped water supplies, sanitation facilities, power supply among others.

On the contrary, the growth of urban areas is progressively jeopardized by ecological effects arising from them. Urbanization, suburbanization and re-urbanization are taking place all over the world at alarming rates. There will be about 2 B urbanites by 2030; that is 60% of the world's population leading to a catastrophic destruction of natural resources and ecosystems (The Nature Conservancy, 2008). The growth of urban areas requires more land and resources to support its expansion ultimately leading to modificaton/conversion of land uses causing environmental conundrums such land, water and air pollution, loss of vegetation and biodiversity, urban heat island effects among others (Kharel, 2010). In tandem with the patent ill effects on human health/well-being, these ecological conudrums forthrightly derail socio-economic development. For instance, soil, air and water pollution burden businesses, industries, households as well as public services with extra costs. Eventually cost of

production and operating costs throughout the economy rise due to this inefficient use and depletion of natural resources.

Since worldwide human population is rapidly growing and rural to urban migration is increasing, this urbanization trend will continue to happen at least for another few decades (Kharel, 2010). This pattern of growth will increase land-use and land cover change and exacerbate the ecological conundrums which have already posed threats to our environment and cost our economy billions. For this reason, environmentalist, governments, planning agencies and others should recognize these issues promptly and put environmental perspective into land use planning and decision-making process effectively and without delay (Kharel, 2010). Athi-river town is not unique from these environmental effects and their multiplier effects on its socio-economic development. The study area has several industrial developments, high density residential in mixed-used set up which gives the study a wider scope in identifying the environmental effects of land-use change on the environment in the town and recommend how land use planning can make contributions in mitigating these effects for future sustainable growth of this town.

## 1.7 Delimitations of study/Scope of the Study

This project defines land use change as a major aspect of urbanization which results in deleterious environmental effects. There are extensive urbanization induced environmental problems of numerous scales. For instance, at the local scale we can have issues of air and water quality while global warming and climate change issues are felt at the global scale. This study aimed at investigating land-use & land cover change in Athi-River town and to analyze its relation with the urban environment. This study is limited to Athiriver ward subdivided into two; Athi-river town as the core and its urbanizing outskirts as its the sub-urb.

## 1.8 Operational Definitions

The words urbanization, land-use change, environment and urban ecosystem are widely and interchangeably used in the project paper.

**Environment**

The concept of the environment is fundamental in the discussion of urban areas. In the Ecological Model of growth, Dasmann et al, {1973} recognized that man is part of his environment or ecosystem. The system consists of the physical environment; that is the soil, water, the vegetation and the fauna while man and his society form the built-environment. An

ecosystem must be considered as a whole, with continuous interaction between the environment and living organisms.

**Land-Use Change**

Land-use change is the transformation of land cover and land use. While land cover modification is virtually a change in the character of land cover without undergoing its overall classification (Lambin et al 2003); Land use refers to the manner in which humans employ and exploit land cover for numerous purposes (Lambin et al., 2006). Therefore, I adopt the definition that; land use change as "the exploitation of land cover through its conversion and/or modification over the years generally to serve human needs" (Kharel,2010).

**Urbanization**

Rapid urban growth finds expression basically in the outward growth of the urban corridors, transforming critical farmlands into residential and industrial uses. Ecologically, urban areas are intricate systems that exhibit unique ecological characters, patterns, processes, disturbances and subtle impacts (Mariana,2008).

**Urban Ecosystem**

An ecosystem is a network of living things interacting with nonliving things. For purposes of this study, a city/town is an urban ecosystem which consists of the natural environment and the built environment. Human beings are some of the living things while the buildings, streets, and other structures that humans build are a number of the non-living things.

## 1.9 Organization of the Study

The study is organized into five chapters. Chapter one comprise the introduction. This chapter consist of background to the study, statement of the problem, purpose of the study, objectives of the study, research questions, limitations and delimitations of the study, significance of the study, assumptions of the study, definition of terms and organization of the study.

Chapter two entails systematic identification, location and analysis of documents containing relevant information associated with the research problem being investigated in order to synthesize and summarize the arguments/ ideas presented in the body of literature. It explores man-nature interactions with the environment in urban areas. This chapter looks into various issues relating to urbanization, urban ecosystems, land-use and land cover change, sustainable

urban land-use planning; legal, institutional and socio-economic issues in urban areas, case studies and research gaps among others.

Chapter three covers the understanding of the study area and examination of the environmental implications of land uses within Athi-river town ranging from the industrial, human settlements, urban agriculture, quarrying to the infrastructural uses on natural resources. It comprises the historical background of the area, its geographical location and the demographic, social and economic characteristics.

Chapter four covers the methods used in data collection and analysis. These comprise research design, target population, sample size and sampling procedures, description of research instruments, validity and reliability of instruments, data collection procedures, data analytical techniques and ethical considerations.

Chapter five presents a detailed analysis of findings based on the environmental effects of land-use change on the natural environment. It examines why it's important to understand the relationship between land use change and environment and the existing opportunities for environmental and land use planning. It further looks into roles various institutions can play through land-use planning by demonstrating why and how land use planning could play a vital role in avoiding or at least minimizing the effects of urbanization on environmental resources and hypothesis testing.

Chapter six presents; key findings, conclusion, policy recommendations and recommended areas of further research.

# CHAPTER TWO: LITERATURE REVIEW

## 2.1 Introduction

This entails systematic identification, location and analysis of documents containing relevant information associated with the research problem being investigated in order to synthesize and summarize the arguments/ ideas presented in the body of literature. It explores man-nature interactions at the various components of the environments in urban areas. This chapter looks into various issues relating to urbanization, land-use change, urban ecosystems, land use planning in urban environmental planning; legal, institutional and socio-economic issues in urban areas and case studies among others.

## 2.2 The Concept of Urbanization

Urbanization is simply the revolutionary transition from a rural to an urban community, it's a crucial outcome of industrialization that correlates with the interplay of urban neighborhoods as drivers of growth in the financial system and as adherents of scientific, socio-cultural and technological development (Gyabaah, 2003). Rapid urbananization finds expression basically in the outward expansion of conurbation, converting vital farmlands into industrial and residential uses. Additionally, it leads to the development of multi-storeybuildings and sky-crapper proprietary developments in distinct districts (Gyabaah, 2003). Crucial to the dialogue of urbanization, is the idea of the environment. Generally, environment can be regarded as the set of conditions that encompass human beings and have an effect on the manner in which they savor life. Consequently, one's environment can be examined from an economic, political, social or physical points of view. All these points of view steer indivual decision-making and the well-being of people.

Thriving cities and towns are crucial components of a flourishing domestic wealth (TOU,2016). The aggregation of commercial developments and humanskill resources in urban areas stimulate innovation and advancement in commercial enterprise, science, technology and industry. Access to basic services such as; health, education, public services and socio-cultural activities is effortlessly accessible to people in urban areas than in rural areas. In urban areas, infant survival rates are higher than in rural areas due to better access to healthcare (Mulhollandetal.,2008). The high densities of urban residents make it simpler and much cheaper for the authorities to supply basic goods and services (Brockerhoff, 2000). By virtue of this, the provision of fundamental amenities like clean water and power supply can be met

with lesser expenditure per person. Higher education facilities are set up in major urban areas to develop human capital. Numerous educational courses are at hand, providing learners with variety of choices for their offing careers. A community of people with different personalities, many classes and religions live and work collectively in towns creating higher understanding and unison enabling disintengration of social and cultural drawbacks. Urban areas additionally enjoy developed communication and transport networks (TOU,2016). Such myraid advantages of city lifestyle don't prevail to all; accelerated growth of urbanites and unplanned boom create urban sprawl associated with deleterious economic, social, and environmental effects.

Transformation of the earth's surface to urban land uses is one of the most unrectifiable human inflluences on the natural worl as it hastens the loss of extremely fertile farmlands, influences energy demand, alters the climate, modifies hydrologic and biogeochemical cycles, fragments habitats, and reduces biodiversity (Seto et al., 2011). These effects are seen on multiple levels. Future urbanization will, for instance, pose direct threats to high-value ecosystems: the highest rates of land conversion over the following couple of decades will probably take place in biodiversity hotspots that were quite undisturbed by urban development in 2000 (Seto et al., 2012). Within urban areas, the character of urban growth is also a critical determinant of urban dwellers' vulnerability to environmental stress (Güneralp and Seto, 2008).

Ecological effects of built-up areas reach far beyond the urban regions themselves. In rapidly urbanizing regions, agriculture intensifies on pristine undeveloped land and is likely to expand to new regions, putting strain on land resources (Jiang et al., 2013). Similary, urban areas change precipitation patterns at scales of hundreds of square kilometres (Kaufman et al., 2007). Urban growth will have an effect on global climate as well. Direct loss in flora biomass from regions with high probability of urban growth is likely to contribute approximately 5% of entire emissions from tropical deforestation and land-use change (Seto et al., 2012). The scope and scale of these effects is yet to be exhaustively researched. Despite the fact that many studies have detailed how urbanization influences $CO_2$ emissions and heat budgets, effects on the flow of water, aerosols and nitrogen in the climate system are just starting to be understood (Seto & Shepherd, 2009).

Notwithstanding the fact that urban areas are growing all through the globe, this growth is more pronounced within the third world countries. In this countries the annual increase rate is 1.6% as compared to 0.8% in the developed countries. Africa was the least urbanized continent with only 14.5% of the population in urban areas in 1950; however, through 1988

approximately 35% of it's populace of 749 million people became urban (Gyabaah, 2003). UN urban population prospects imply that the urban populace will increase to 914 M through 2025.

As Gyabaah notes;

"*These developing nations have proven to be the largest challenge to sustainable urban growth. Because of political and financial instability, many third world nations have found it hard to sustain the kind of appropriate growth desired in cities/ urban areas to foster pleasant living environments. The process of urbanization within the developing countries in particular Africa is inexorable and this rapid urbanization offers one of the greatest challenges to human security and sustainable development. In many African nations, urbanization has led to rapid population growth and agglomeration of people and industries in few urban areas such as Accra (Ghana), Lagos (Nigeria), Monrovia (Liberia), Abidjan (Cote d'Ivoire) among others (pg.4). "*

Considering the second 1/2 of the 20th century, the world underwent the most rapid rate of urbanization, mainly in undeveloped nations (Chadchan and Shankar, 2009). Thirty (30) percent of the worldwide populace resided in urban area in 1957, in 2008 it reached 50 percent and it was projected that by the year 2050, 70 percent of this populace will inhabit in cities (United nations, 2007a). Presently, there are 400 plus urban areas with populations of over 1 million people (United nations, 2007b) and within the predictable future, clearly future global's population growth will be housed by the urban areas of third world countries , whose populace is projected to increase from 2.4B in 2007 to 5.3 B in 2050 (United nations, 2007a).

Rapid growth of urban areas substantially accelerates socio-economic development as mega-cities are drivers of economic boom and centres of invention for the world financial systems and the remote areas of their respective countries (De Sherbinin et al., 2007). However, the growth of urban areas has induced multiple environmental issues extending from the neighborhood to the global scales (Kim and Baik, 2005 and Zhao et al., 2006) including; decreased water supply, water and air pollution (Liu and Diamond, 2005 and Shao et al., 2006), creation of micro-climates and escalated energy demands (Zhou et al., 2004 and González et al., 2005), inadequate residential and sanitation facilities and traffic congestion (Jago-on et al., 2009) and a first-rate reduction in natural vegetation production and carbon storage/sequestration (Fang et al., 2003 and Yuan, 2008). For this reason, the understanding and evaluation of land use effects due to present day urban growth have become significant

and several studies have been carried out with the goal of better understanding the impacts and issues associated with urban growth (Foster, 2001, Chen, 2007, Li and Yao, 2009 and Martínez-Zarzoso and Maruotti, 2011).

## 2.3 Urbanization in the Global Perspective

The world's urban population was 2.4 B in 1990, with 2/3 of this population living in third world nations. UN study approximates that it is likely to be more than double, to 5.5 billion current total world population by the year 2025. The source states further that a great deal of this growth would take place in the developing nations -as illustrated in figure 1 below-which will comprise 4.4 billion people or 80 percent of world urban population by the year 2025.

Gowth of urban areas has attained unparalleled magnitudes in extensive regions of the world. More than 1/2 of the global population, about 3.3 B people were anticipated to be residing in cities/towns in 2000 and it is further projected that the population residing in urban areas might grow to 65 % by the year 2020 (UNFPA, 1991). There were only 17 of the world's 25 megacities with populations exceeding 10 million in 2000; including Lagos in Nigeria, Seoul in the Republic of Korea, Buenos Aires among others in the third world nations. Mexico Metropolis had approximately 25 million people, Sao Paulo in Brazil had 22 million, and Bombay and Calcutta in India and Shangai in China each had 15 million (Gyabaah 2003).

"Presently, there are 19 cities with 10 million or more people; 22 cities with 5- 10 million people; 370 towns with 1 to 5 million people; and 433 cities with 0.5 to 1 million people (UNCHS ,2002). Further; 90 % of future population growth will be agglomerated in cities, mainly in developing nations (UNCHS, 2002). Urban centres in Latin america, Asia and Africa are urbanizing swiftly and their populations are anticipated to double by year 2025(Gyabaah, 2003).

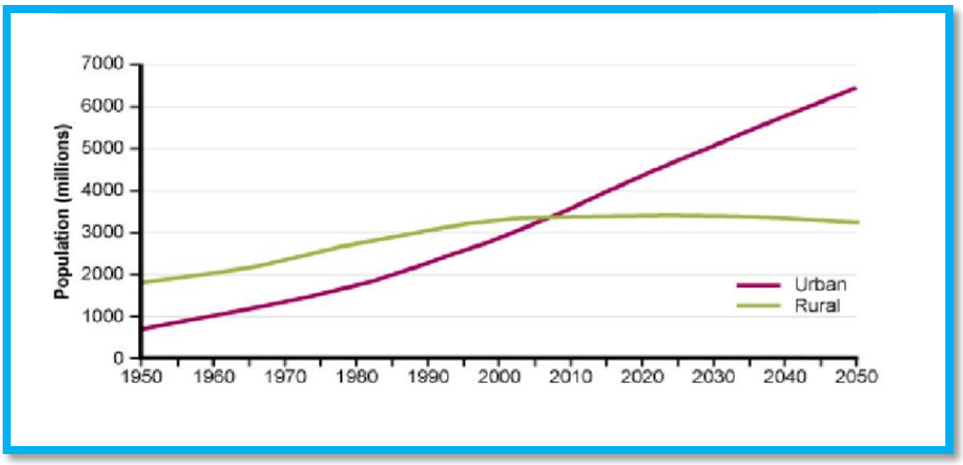



*Figure 1: Urban and rural population of the world, 1950–2050 (UNDESA, 2014).*

### 2.4 Urbanization in Africa

In Africa, built-up areas have outstretched noticeably in inhabitant density and extent. There's inreasing agglomeration of people in a some large urban areas mainly in the capital cities. The least urbanized continent-SSA- is the most swiftly urbanizing part of the world; the United nations anticipated that nearly one-half (49%) it's population will be urban by 2025 (UN, 1996). As mentioned earlier, urbanization has led to conglomeration of people and industries in few urban regions in many African countries due to rapid population growth. These urban growths have been driven by enormous rural-urban migration from rural areas to large cities and urban centres in the notion that these centres offer geater employment opportunities, social facilities and renumerations (Gyabaah 2003). Table 1 below shows the projected urban populations in SSA regions of the years 1950-2025

***Urbanization in Sub-Saharan African Regions (1950-2025)***

| REGION | PERCENTAGE OF POPULATION IN URBAN AREAS | | | |
|---|---|---|---|---|
| | 1950 | 1975 | 1996 | 2025 |
| SUB-SAHARAN AFRICA | 11 | 21 | 32 | 49 |
| EASTERN AFRICA | 5 | 13 | 23 | 48 |
| MIDDLE AFRICA | 14 | 27 | 33 | 50 |
| SOUTHERN AFRICA | 38 | 44 | 48 | 62 |
| WESTERN AFRICA | 10 | 23 | 37 | 56 |

*Table 1: SSA Urbanizn Prospects: The 1996 Revision Annex Tables ( Source: UN)*

## 2.5 Causes of Urbanization in Africa

The primary elements of urban growth in Africa are; rural-urban migration, high natural rate of increase and urban bias development strategies. Movement of people from rural to urban area -immigration- is the most crucial elememt of urbanization in Africa. As urban inhabitants grow rapidly via natural increase (i.e. more births and less deaths), immigration or migration from the remote rural areas to towns/cities is also growing. In many regions of Africa, swift movement of migrants from rural to urban areas and rapid urbanization began in 1960s after most nations got their independence (Khaerl2016). During colonialism era, movement from rural remote areas to urban centres was suppressed via racial segregation legislations in some nations to make certain the safety and security of the white populace in the urban areas. Migration from rural to urban areas was seen as the only way to offer the chance to white collar employment opportunities and better life to the native population. Off late, inadequate key infrastructure and lack of primary services and worsening of the economic standards in the remore rural regions have increased the flow of migrants from these rural to urban regions, consequently increasing urbanization (KhareL, 2016). It's anticipated that with continuity of the modern-day trends, approximately 2 out of 3 West Africans will dwell in urban centres by 2025 (Kharel, 2016).

According to Hnace 19770 & Kasanga & Elvis in 1988;

" *In Kenya, immigration to urban areas is the largest source of urban growth. It's caused by push factors that force people out of the rural areas and by pull factors that draw them into the cities and urban areas. People migrate for several reasons and no single factor acts independently to influence prospective migrants' final decision to move. The harsh socio-economic status, insecurity of tenure and environmental conditions in the rural areas also push the youth out of agriculture in response thus they move to urban areas for non-exiting white –collar jobs. At the same time, the several attractions of the city such as better health and educational facilities improved social life and perceived higher white-collar job opportunities, exerted their own 'pull' on the youth to migrate to the cities and urban centres. For this reason, a unified theory to explain rural-urban migration is unrealistic"*

However, at any point in time, in a given location where there is voluntary movement, a particular factor will be more prominent than others (Gyabaah 2003).

To sum it all; in many countries, immigrants into urban areas are generally influenced by the search for better jobs and income generating opportunities. Thus, the real factors that determine urbanization and conglomeration of people are the same factors that influence the

location of job opportunities including; character and form of industrialization, rate of agricultural sucess, and the communication and transport infrastructure development.

## 2.6 Lessons Learnt from Concept Urbanization

To begin with, the growth of urban areas increases the need for land for housing, urban agriculture and infrastructure uses. Such pressing needs result in elevated pressure on prime agricultural lands, forests and water resources. Secondly, rapid urbanization speeds up land degradation and alters the environment resulting in scarcity of water resouces, soil erosion, and climate change. On the contrast, a flourishing urban centre offers numerous gains and promotes poverty eradication by providing readily available markets for farm produce and manufactured/processed goods, economic resources, create jobs at agricultural and industrial activity districts and opportunities for authorities, politics and centres for academic excellence

On the contrary, the predominant challenges of rapid urban growth and population icrease include:, air and water pollution, environmental degradation in deforestation, soil erosion etc., inadequate housing and overcrowding, insufficient sanitation , climate change, food insecurity, scramble for water and land, vulnerability to higher risks of accidents , poverty and deprivation and environmental disasters. A number of these adverse consequences of urbanization occur in both the rural and peri-urban regions as the case in Athi-River town which is as source of food, construction supplies and wood fuel for the town dwelles. It's critical challenges are; high leves of water pollution, land use and land cover change and land degradation, soil erosion & pollution, insufficient potable water supply, congestion, terrible housing infrastructure, air pollution, inefficient solid waste management system and spread of infectious and parasitic disease.

Its uncommon that thousands and thousands of women and men are actually farming in urban areas to enhance city food security. Many developing countries are food insecure despite practicing urban agriculture. This predicament threatens not only our survival as humans but also to the very capacity of poor African counties to deal with the problems of rapid urban growth, population increase and environmental change considering the countries' low levels of technology and inefficient institutional support..

To sum it all as K. Nsiah-Gyabaah 2003 States;

'' *Despite the fact that Africa has turned out to be synonymous with rapid urbanization, it is neither a crisis nor a tragedy. Urbanization has created a host of new opportunities with new and ill-understood environmental, food and human security issues. Even though urbanization is associated with unemployment, air and water pollution, congestion, overcrowding, social disturbances, crime, ethnic conflicts, environmental degradation, HIV/AIDS and so forth., it however offers opportunities for growth and development of markets for consumer goods and a source human capital for managing natural resources'' pg 25.*

## 2.7. Urban Ecosystem and Development

Urban ecosystem, is any ecological system located within a an urban area or other densely settled area or, in a broader sense, the greater ecological system that makes up an entire metropolitan region (Pickett, 2017). According to Pickett; largest urban ecosystems are presently aggregated in Europe, India, Japan, eastern China, South america, and the united states, commonly on coasts with harbours, along rivers and at intersections of transportation routes. Urban ecosytems consist of the natural environment and the built-environment. They are habitually warmer than other areas sorounding them; have less water infiltration due to the concrete pavements show higher rates and quantities of storm/rain water runoff. Toxins and heavy pollutants from industries and automobiles are highly concentrated in towns.

As Pickett 2017 states;

> "*The massive growth in urban areas speed up the transformation/modification of forests landss, wetlands, deserts, and other bordering biomes into areas committed to residential, industrial, commercial and transportational uses. Swift land transformation can bring about the creation of bare unproductive land which is highly susceptible to land degradation. Similarly, the land conversion process subdivides unexploited rural ecosystems/wild habitats into even-smaller patches and comparatively huge prime habitats are located at the buffer/green belts between the remaining native ecosystems and those which have been modified for human use. Such "edge habitats" inhibit special species—that is, plant & amimal species that can tolerate a narrow variety of environmental conditions. Further, non-urban ecosystems downwind and downstream of urban ecosystems are subjected to high loads of water pollutants, air pollutants and introduced exotic species.Whilst many native species are lost when a natural landscape is modified into an urban one, a few species continue to exist and thrive. Numerous plants, animals and different organisms adapt to the*

*challenges of urban living through changing their behaviour as well as by slightly changing their genetic makeup".*

Despite the fact that numerous similarities exist amongst cities in the world, variations occur due to differences in culture, background history, systems of governance and the effects of the worldwide economic system. A number of the existing variations arise from physiographic conditions including; aridity, topography, natural hazards and the amenities represented by the each city region's distinctive location. Globally, core urban centres have become much less dense as residents move into suburban peripheries; which is likely to be become more denser. Even though urban growth has often been equated to high-quality of life as opposed to people in rural areas, numerous burdens such as agglomeration of urban poverty, environmental inequity and decreased economic opportunity; exist in new urban areas in third world countries as well as ancient post-industrial town centres. This issues can be addressed by way of better planning and by using ecologically conscious urban designs. Increase in "open green space areas" and their more effective distribution throughout the urban landscape can reduce such cases as urban green spaces offer opportunities to enhance the ecological claening of pollutants and moderation of the local climate. Open space additionally provide; shade, the aesthetic benefits of natural scenery and recreational areas for residents.

Athi-river town has been expanding without proper environmental planning. Expansion of the towns infrastructure in terms of urban services has not matched the increase in its population. This has impacted the immediate environment negatively. For instance; visually, the Athi-river riparian system at the heart of this town can be likened to trunk sewer and the color of its waters vary in color from blue-black to brown. In the Ecological model of growth, Dasmann et al, (1973) recognized that man is part of his environment or ecosystem. The system consists of the physical environment, the soil, water, the plant life, the fauna and man and his society. An ecosystem should be considered as a whole, with continuous interplay between the environment and living organisms. At any given time, this implies that the growth of any species is directly or indirectly limited by the environment except human populations who have attained a certain degree of freedom from this rule because of their ability to transform environmental resources for their use. Nevertheless, there are limits as to the variety of human activities that a specific ecosystem can support, called the carrying capacity.

According to Dasmann et al, 1973, carrying capacity has numerous levels starting from optimum to the maximum subsistence level. At optimum density all individuals have a

sufficient supply of all necessities for existence, so that their productivity is at maximum. Consequently, only strong limitations on growth can maintain this optimum density, otherwise a population will move towards the maximum subsistence level with falling productivity and subsequently starvation. Of course carrying capacity isn't always static and in the case of Athi-river; over the years the carrying capacity of the urban ecosystem has been modified by unsustainable human activities in this town and its environs. Any such actions, however, disturbs the existing equilibrium and generally impoverishes the environment with a negative effect on its stability. Within the human timescale this urban ecosystem can be pushed to a "point of no return'" with adverse consequences on the environment. With proper planning and management of urban ecosystems; economic, social and environmental benefits accrue from healthy interactions between human activities and such systems.

**a) Economic Benefits**

The growth of urban areas perform critical role in the development and modernization of under-developed and developing nations and growing attention has been paid to cities and urbanization from scientists and policy makers over the past several decades (Hope, 1986, Zhang and Song, 2003 and Siciliano, 2012). Rapid urbanization has significantly improved economic and social development and global cities are engines of economic boom and centers of innovation for the worldwide economic system and the hinterlands of their respective countries(DeSherbinin et al., 2007).

**b) Social Benefits**

The growth of urban areas/cities can make contributions to sustainable development if it's planned well. Cities agglomerate socio-economic activities and neighbourhoods close together with the cost per person of providing basic services like piped water, roads and sewage treatment been lower than in the rural rural areas. Authorities can increase the efficiency and and habitability of urban areas by making great investment in public transport, sources of clean energy and by planning beforehand for urban growth such that they're capable of offering basic services when populations expand due to urbanization.

**b) Environmental Benefits**

In line with UN, urban growth in the context of environmental planning provides environmental sustainability by;

a. Promoting regeneration and appropriate use of buildings, land and infrastructure for example through rehabilitation of abandoned resources.
b. Conservation of environment and historic cultural assets such as wetlands.
c. Deal with and mitigate potential environmental disasters such as heatwaves, floods and pollution.
d. Protection and enhancement of regions of recreation and cultural assets.
e. Promoting use of renewable and clean energy.
f. Encourage efficiency use of energy in the layout and design of development.

## 2.8 Urbanization, Poverty and Environment

The level of poverty in urban areas of many nations is some thing that lawmakers cannot afford to disregard as they have done previously (S. Uttara etal,2012). In Kenya, between about 60% the country's urban population live in abject poverty. Urbanization rate is soo high such that it's projected to reach 50 % urban by 2020 with 1/2 of all Kenya's desolate population residing in urban areas. In this regard, there is absolute confidence that abject poverty itself is swiftly urbanizing as well in Kenya. Furthermore, this proportion of the urban residents in the most deplorable class is also on increase with the gap between the haves and have-nots rapidly expanding. Whilst a few urban residents have experienced improved status due to incredible ranks of economic boom in past few years, destitution has intensified for the majority of the poor in urban areas who've turned out to be ensnared in retrogressive ascends of distress and vulnerability. Progressively, these extreme disparities in towns have adverse consequences on economic development, human security and stability. These extreme disparities and abject povery and have disastrous social corollaries when combined with bad governance and tribal antagonism, as the 2007 post-election violence in urban informal settlements made it all too clear.

With the upsurge in poverty in urban areas in the foregoing years, people living in urban areas are confronted with restraints very extraordinary in contrast to those of their non-urban peers. For instance, urban residents spend higher rates for housing and transportation while searching for scarce employment opportunities and they too cope with deplorable sanitation amenities. Further, the poor in urban areas pay higher rate for urban land even in cases where the land is not serviced. Most poor people in urban areas do not have affordability access to conventional land markets in surburb regions. Inflow of poor people into the cities/urban areas over the years, inefficient planning and lack of job opportunities cause elevated distution in our urban areas (World Financial Institution, 1997). These disparate frameworks on exploitation of

resources result in the poor been denied right to access natural resources for their livelihood. For this reason, there has been no consideration of the resource needs of the urban poor consequently pushing them into ecologically fragile environments such as riparian zones; overly exploiting them for their subsistence and the market.

In the research by Brockerhoff and Brennan in1998 on urban poverty in third world regions they asserted that the well-being of urban dwellers in third world nations is determined by the rate of land-use change, treatment of waste water and solid waste and the release of pollutants into the air/water/soil. Possibly some of the utmost defectiveness in many towns/cities is in the management and dumping of household and industrial wastes. The quantity and accumulation of contaminats leaking into lands and rivers rise from inappropriately managed landfills and sanitation sites. In the long run, conditions such as these can have deleterious effects on the environment and further contribute to poor health and outbreak of diseases. In several cities all around the third world's water resources are being duelled over among cities' (household, industrial uses) and the rural folks agricultural uses. At the same time, the quality and quantity of theses water resources continues to decrease with the increase in size of these cities.

## 2.9 Urbanization Effects on the Various Components of the Environment

In a research paper done by S Uttara et al published in the International Journal of Research in Engineering & Applied Sciences in 2012 the following urbanization effects on the various components of the environment were identified and are sumarized below;

### A) Impacts on the atmosphere and climate

Materials like concrete, asphalt, bricks and many others found in urban areas take in and reflect energy differently from vegetation and soil causing heast Islands thus urban areas continue to be warmer in the nights when the rural areas have already cooled down. Land-use activities emit a wide variety of effluents into the environment such as carbon dioxide, carbon monoxide, ozone, sulfur oxides, nitrogen oxides, lead and many other pollutants that change the air quality. On the same, towns frequently receive more rain than the surrounding geographicalregion due to the fact that dust particles heavily accumulated in urban atmosphere can provoke the condensation of water vapor into rain droplets.

### B) Impacts on the lithosphere and land resources

Rapid development in urban areas can bring about vast volumes of soil erosion and sedimentation in stream channels while toxic wastes are often spread-out across urban areas or

accumulated in industrial areas or waste dump sites. Heavy metal pollutants from Lead- based emulsions used on buildings is one of the extensively dispersed toxins that ends up into soil through been buried in large quantities of waste in the ground at municipal and industrial landfills.

### C) Impacts on hydrosphere and water resources

In urban areas naturally occuring vegetation and pristine lands are replaced with; tarmack concrete, brick and other different impervious surfaces. Thus when it rains water is less likely to infiltrate into the soils and instead it forms surface runoff and flows directly into water streams and river channels with higher and faster high point flows fluctuating watercourses that have developed over centuries under pristine environmental set-up. Frequent flood occurences is a major problem in urban areas for as they urbanize water streams try to hold up with these transformations. The quality of water is degraded with time due to urbanization that in the long run causes increased siltation there by also rising the quantity of pollutants in surface run-off.

### D) Impacts on biosphere

The top-dressing fertlizer spread across gardens & urban farms find its way into water streams where it enhances the mushrooming of plant life at the disadvantage of acquatic life, while the organic waste dumped into streams increases boi-oxygen demand as it decomposes resulting in extinction of some plant and animal species. With such a trend, native species are driven out out of urban areas and new habitats created for some native and non-native species. Urban areas too create habitats for some species considered pests such as; pigeons, sparrows, rats, mice, flies and mosquitoes. Urbanization has, for instance, eliminated many bat colonies in caves, but has provided sites such as bridges for these species to nest.

## 2.10 Urbanization Effects on Human Health & Social Development

It is ordinary for 1/2 of a urban residents to dwell in shack unpleasant settlements where sanitation and safety conditions are lousy. Toddler and infant death rates are 10-20 (WHO) times what they ought to be. The high densities of people, industries, automobiles and their wastes produce disastrous health in cities and urban areas such as dysentery, diarrhoea, respiratory/air ssociated deaths and traffic accident deaths. Life in urban areas is terrible, unpleasant, brutal and short-lived when there's no good governance as suggested by Thomas Hobbes suggested in 1651.

In contrast, most built-up countries often have high-ranking life expectancies. The countries with high ranking life expectancies are substantially urbanized; while countries with the low life expectancy are to a great extent rural. This is true as in some cases large towns have emerged with high-ranking life expectancies and low infant and child mortality rates. Therefore megacities do not need to be noxious regions. Certainly, they perhaps ought to be amongst the globes most refreshing regions. Take for instance the urbanites of a major Brazilian metropolis-of Porto Alegre who have an evarage a life expectancy level that is high-ranking than most cities in Europe and North America. In Tunis-North Africa the life expectancy level is more than thirty (30) years higher than several other African urban areas. On that note, it's key to ask the "why" this question. For sure a totally sizable portion of the answer comes from the fact that people from destitute class do not have enormous health punition. Possibly the most self-confident critical indicator of an excellent urban governance system is the difference in life expectancy between it's haves and have-not social groups. Cities with average life expectancies are provided with access to portable water in sufficient amounts and proper sanitation and basic goods with majority dwelling in permanent houses in land secure areas. Such government systems have reaped big from high population aggregation. Agglomeration of humans, manufacturing and solid/ liquid wastes without a proper system of government is a disaster to the well-being of the urban residents. However, this agglomeration of urbanites, high level production and waste generatiom reduces cost per person for different infrastructure facilities and utility services to generate the first-class well-being as urban conglomeration reduces the cost of raising charge/taxes to pay off infrastructure facilities and utility services; it also lowers the cost of enforcing pollution control and occupational and environmental health policies.

The aggregation in urban areas advance transparency in cooperation between governing authorities and citizens promoting social development. Some of the most exceptional models of collaborative, dynamic and resposible systems of governance have come from urban areas in the last 3 decades. Once more to Brazilian metropolis-Porto Alegre- the megacity city that furthered the groundbreaking of participative appropriation of resources where every citizens was aware of authorities budgetary sizes and its expenditure and ought to help in setting right the community's peferences for funding . On the same, in Mumbai and other urban areas in India; there are outstanding confederations formed between departments of the governing body and the alliances of low-income groups promoting the delivery of community services such as police stations, community-managed toilets and washing facilities.

## 2.11 Land-Use Change

Land use is a the outscome of biophysical and socio-economic phenomenas which are determined by geographic region, scope and topical use ' (Briassoulis, 2000; Lambin et al., 2001; Lesschen, Verburg & Staal, 2005; Meyer & Turner, 1992; Turner et al., 1995). Therefore, land use change can forthrightly be defined as the change in land cover and land use. Land cover is the natural character of stretch of land inclusive of both physical resources (farmlands, hills/mountains, flora, different tpes of soil, biodiversity resources, water resources) and the built envrionemnt/structures (buildings, pavements) (Meyer, 1995). Land cover change commonly takes place in binary forms; that is, either by land cover modification or land cover coversion (Lambin et al 2006). Land cover transformation is a recast in the overall categorization of land cover by complete substitution of one form of land cover by another form caused by alteration in urban expanse, growth of farming land or deforestation. Whereas, land cover modification is forthrightly an alteration in the nature of land cover devoid of going through its complete categorization (Lambin et al 2003) land use is the manner in which people make use of and harness land cover for numerous purposes (Meyer, 1995 & Lambin et al., 2006) including agriculture, mining, residential, industrial or even recreation.

There are numerous aspects of land-use transformation/modification. Determining these aspects calls for some expertise on the land utilization and decision making process as this process is controlled by numerous factors (Lambin et al., 2006). Numerous scholars and researchers have pointed out imminent and underlying aspects of land use transformation/modification to comprehend the land utilization decision making process. The imminent drivers of land use transformation/modification contain instantaneous and on the spot human actions on existing land cover at neighborhood setting including personal farmlands, neighborhoods, or zones (Lambin et al., 2006, Ojima et al 1994). The fundamental aspects of land transformation/modification are the basic forces that change either one or more imminent aspects and act at localized or even global scale (Lambin et al., 2006). A couple of the explained most often given forces include; technological, financial, political, institutional, demographic and cultural forces (Geist et al., 2006). These fundamental causes/basic forces are also the drivers of urban growth which correspondingly is the driving force of land-use transformation/modification in Athi-river.

## 2.12 Land-Use & Land Cover Change and the Environment

The global population is growing, but the land realm is currently fixed. Therefore; with every additional populace there arises a want to make extra change to the global environment. The

effects of these change can be either adverse or gainful. For instance, it is estimated that the globe is depleting 15M Ha of tropical woodland land yearly, a depletion that has deleterious impact on biodiversity. Simultaneously, lots of this cleared land is converted into farmimg land to nourish our increasing population-an advantageous effect (UN,2005). In the last 3 decades since the United nations conference on the Human environment in Stockholm in 1972 concerted efforts have been made to recognize the confines of the planets bountiful assets and actions have been taken to hold and sustain these assets.

Global population now stands at 7.7 billion people (IPC 2018). Whilst worldwide resources were adequate to upkeep the globes's human populace collectively before industrial revolution, distinct groups or even entire communites at times attained ecological limits for specific resources and a number of them got extinct as a result unsustainable land use practices. With intensifying globalization of cultures in current centuries, resource degradation has been globalized causing current environmental issues to become a problem for the whole world instead of for distinct specific groups. Despite the fact that anticipated ecological limits can occasionally be conquered, it has never been made viable to have unlimited supplies of natural assets or repositories for waste not even by advanced science or technology (Casagrande et al 1999). Relative projections placed global populace at 8.3 M by 2025 hoping that it will stabilize at roughly 10M -11M by the end of the century (UN 2004).

In the present; the earth planet is the only habitation we have, with each number added to the current population, a decrease occurs in our habitation space. Therefore, there is scarcity in land but an escalating demand to nourish more people putting pressure on already limited land resources excarbating changes in the environment.( Lund et al 2000). Humans have supreme capacity in the utilization the natural resources. However, they have caused fundamental modifications within the natural ecosystems, particularly in current years including:

I. 1/2 the global wetlands were depleted over the past century (UN 2004);
II. Illegal Logging and modification/transformation of land have reduce vegetationt cover by atleast 20& or as much as 50% (UN 2004)
III. Almost 70% of the globe's marine fish stocks are either over-fished or being fished at the ecologigal limit (UN 2004) among others.

Urbanization, crop farming, land clearing, tree planting and rehabilitation of wetlands are some of the activities classified as land uses or how people utilize or exploit land. The intensity of land use is the stretch to which land or it's resources have been put into use. It's a measure

of the extend and level of development, a true picture of the outcomes brought about by that development (Planning Department 2001). Land-use intensity as a measure of activity can range from very low ( the undisturbed wild lands) to intermediate (a managed forest ecosystem) to very high (urban and industrial se-up) (Lebel et al 1998). In global land use change perspective , land-use intensity is a critical feature in assessing change and its impact (Berka et al. 1995). It is determined by the spatial demands of a specific land-use activity, in relation to open green space, demands for infrastructure and ecological impacts. Framework for determining land-use intensity (UN 2005) normally include:Type of land-use activity, Period of use, Existing number living or non-living things that pre-occupy the land at agiven time and the size land in question.

Globally, human impact on the environment is substantially and growing. Landsat Satellite imagery reveal detailed startling signs how humans haved impacted on the landscape overtime. Generally, urbanization is the agglomeration of people as a result movement and redistribution processes (Geruson et.al 1977). This implies the location and relocation of people on space and resources & industries in the landscape. The growth of urban areas causes increase in dense settlements. The aggregation of urban areas and their suburbs linked economically and socially constitutes a system called a metropolitan area or region (Geruson et. al 1977). This definition is incomplete as it leaves out the ecological linkage of urban areas which is one of the predomint linkages of exploitation that has created the system itself. Urban areas are results of capitalism which promotes diffusion of habitat and activities based on economic functioning and administrative activities (Rustow1977). Further; urban areas "reduce the importance of the physical environment in the determination of the system of functional and social relations, abolishes the distinction between rural and urban, and places in the forefront of the space/society dynamics and the historical conjuncture of the social relations that constitute its basis" ( Rostow, 1977). Thus environmental planners cannot ignore the link between land-use change and urbanization which alter the natural environment system-ecosystem.

Expansion of urban areas has often encroached into prime farmlands resulting in the conversion of nearly 1 235 526 acres of arable land annually (UN2005). Built-up areas covered about 2-4% of the earth's surface according to Wiebe 2003. Due to this, several researchers then argued that undisturbed lands lost to urban developmemts will not affect global food security in the foreseeable future (Rosegrant et al. 2001). However, expansion of urban areas often takes highly productive farmlands out of production, inceasing the need to use marginal lands for farming and pasture production. The most deleterious effect of urbanization is its impact on

the environment; urban areas use 75% of the world's natural resources and produce equal quantities of waste, adversely affecting the health of local and global environments (Giradet 1995). In late 1990s, urban residents in developed nations produced from 300-800 kg of waste per person per annum (UN, 2005). While badly run cities/towns can be gravious challenges for a nation, a good governed city/town can promote national prosperity. Planned cities can reap on high population densities to reduce resource use and energy consumption and GHGs emissions. Numerous urban areas have invested huge chunks of money in recycling and composting waste-management programs to reduce environmental pollution while others have maintained large areas of productive agricultural land amid highways and high-rises (Harrison 2001).

## 2.13 Land-use Planning Framework

The land-use planning framework constitute information on policy, legislation and institutions that guide in the land use planning activities. They help in organization of land and buildings thereon to the desired standards. Most of these legislations and policies link directly or indirectly to the six priority issues in Kenya's efforts towards achieving the Millennium Development Goals i.e. security, increased employment, gender equity, water, health, sanitation, environment and infrastructure development whose scope has been widened into the Sustainable Development Goals (SDGs) adopted after MDGs in 2015. Reviewed documents give guidelines on environment related matters. These include;

### 2.13.1 Legislations

Since the coming into effect of the 2010 Kenyan constitution, on 8th August 2010 it has been adopted in practice and massive reforms are expected. As environmental planners and key decision makers we are supposed to adopt, accommodate and integrate these reforms in planning. The new constitution acts as a guide to the form of governance of our country for sustainable development to be achieved. Cap 2 Sec 42, highlights that every individual in Kenya has the right to a clean and healthy environment. The Constitution further under Article 67 establishes a constitutional office NLC to handle land issues. Other land-use planning laws reviewed anchored on the constitution include; Land Act 2012,The Physical Planning Act 2012, County Government Act 1996, Urban Areas and Cities Act 2012, Community Land Act 2016, Trust Land Act, Environmental Management and Coordination Act 1999, Forest Act 2005, Water Act 2002, Mining and Minerals Act Cap 306, Agriculture Act 1995, Wildlife Conservation and Management Act Cap.376 and the Public Health Act {Cap 242}.

### 2.13.2 Policies

Vision 2030 is the main policy in Kenya which is National development strategy that covers the period 2008 -2030. Its major aim is to transform Kenya into a newly industrializing middle income country providing high quality of life to all its citizens by year 2030. Its major goals are to: economically improve the prosperity of all Kenyans, socially build a just and cohesive society and politically to realize a democratic political system founded on issue-based politics that respects the rule of law and prospects the rights and freedom of every individual in the Kenyan society. Environmentally this Kenyan vision aims at achieving at least 10% forest cover by the year 2030. Other policies reviewed on land-use planning include, Water Policy 1999, Forestry Policy, 2014 and the Land Policy, 2017.

### 2.13.3 Institutions

This covers the institutions responsible for environmental management in Kenya. EMCA, 1999 sets out the institutions that are necessary for the provision and enforcement of the Act. Some of these institutions include; Ministry of Land, National Environmental Council {NEC}, National Environment Management Authority {NEMA} , Public Complaints Committee {PCC} National Environmental Tribunal {NET} , Provincial and District Environment Committee, Environmental Planning Committees, the Standards and Enforcement Review Committee and the Courts

### 2.13.4 Gaps in Literature

Despite the fact that the environment provides multiple purposes and amenities that promote value for people and are important for their sustenance, people have barred the continuity and significance of ecological services in a rush to celebrate urban fantasy (Committee on Assessing and Valuing the services of Aquatic and associated Terrestiral Ecosystems, national research Council, 2004). Van der Ryn & Cowan (2007) articulated the issue of of expanding disengagement between humans and natural world as:

"[*we] live in interpenetrating worlds. the first is the living world [natural world], which has been formed in an evolutionary crucible over a period of 4 billion years. the second one is the world of roads and urban areas, farms and artefacts [human designed world], that human beings were designing for themselves over the last few millennia"* .

Proliferation and opulence of man-kind shaped world has developed from the detriment of natural assets of the world. Sim Van Der Ryn and Stuart Cowan assert that the;

"*designed mess we've made of our neighborhoods, cities, and ecosystems owes a great deal to the dearth of a coherent philosophy, vision, and practice of design that is grounded in a rich know-how of ecology".*

A massive gap exists between natural world and man-made world further distancing human beings from the nature.

"*To link up this gap and connect people with living world, an environmental approach is required in the planning practice (Van der Ryn et.al 2007). Ryn et al proposes that we should practice preservation, renewal and guardianship approches into planning and decision making process.*

While growth of urban areas isn't the only determinant of ecological degeneration, it undeniably controls decision making process. This results in the degradation of both natural and built environments. Nowadays, most 'detrimental' urbanization is experienced in destitute developing countries whose financial and socio-political frameworks cannot sustain huge immigration people into urban areas from rural areas. To restrain deleterious consequences of urban growth, policymakers ought to master how to offset the demands of both the countryside and urban areas not having to compromise either. Some of the issues that call for concerted deliberation by the governments, authorities, the non-state-run sector, indigenous communities, civil institutions and development confederations are: insufficient housing, upgrading of informal settlements and land tenure regularization, joblessness, laxness, crime, scarcity of portable water, improper sanitation, lack of efficient transport system, environmental degeneration, poverty and so forth.proper and effifiecnt land-use planning ought to be put in place to predict future development and control it over the years. Developments in urban areas must be habituated with an aura of accountability and mindfulness for both natural and built environment.

Locally a lot of studies have been done in Athi-river town and other satellite towns for example; on the industrialization of these towns & power relations in mediating, environmental attitudes of residents of among others but none has captured land-use change as an aspect of urbanization and its effects on the environment for purposes of planning and decision making . The research aims to partly fill this research gap.

## 2.14 Theoretical and Conceptual Frameworks

### 2.14.1 Theoretical Framework

Ecological Model of growth, Dasmann et al, (1973) recognized that man is part of his environment or ecosystem. The system consists of the physical environment, the soil, water, the vegetation, the fauna and man and his society. An ecosystem must be considered as a whole, with continuous interaction between the environment and living organisms. At any given time, this implies that the growth of any species is directly or indirectly, limited by the environment except human populations who have attained a certain degree of freedom from this rule because of their ability to convert environmental resources for their use. Nevertheless, there are limits as to the number of human activities that a particular ecosystem can support, called the Carrying Capacity. According to Dasmann et al, 1973, Carrying Capacity has several levels ranging from optimum to the maximum subsistence level. At optimum density all individuals have a sufficient supply of all essentials for existence, so that their productivity is at maximum. Therefore, only strong limitations on growth can then maintain this optimum density, otherwise a population will move towards the maximum subsistence level with falling productivity, and finally starvation.

Of course carrying capacity is not static and in the case of Athi-river, over the years the carrying capacity of the urban ecosystem has been modified by unsustainable land use activities within this town and it's adjoining environs. Any such actions, however, disturbs the existing equilibrium and generally impoverishes the environmental resources, with negative effects on its stability. Within the human timescale this ecosystem can be pushed to a "point of no return"" with adverse effects on the natural environment. With proper environmental planning and management of urban ecosystems; economic, social and environmental benefits accrue from the healthy interplay between human activities and such systems. The natural environment in urban areas is a fundamental aspect in shaping the wellbeing of residents and the impacts of the built-up area on the larger environment. Numerous environment driven challenges in Athi-River town include lack of/inadequate water supply and insufficient sanitation, improper solid waste management and high levels of industrial pollution. Regrettably, abating these conundrums and correcting their consequences on the population is quite exorbitant.

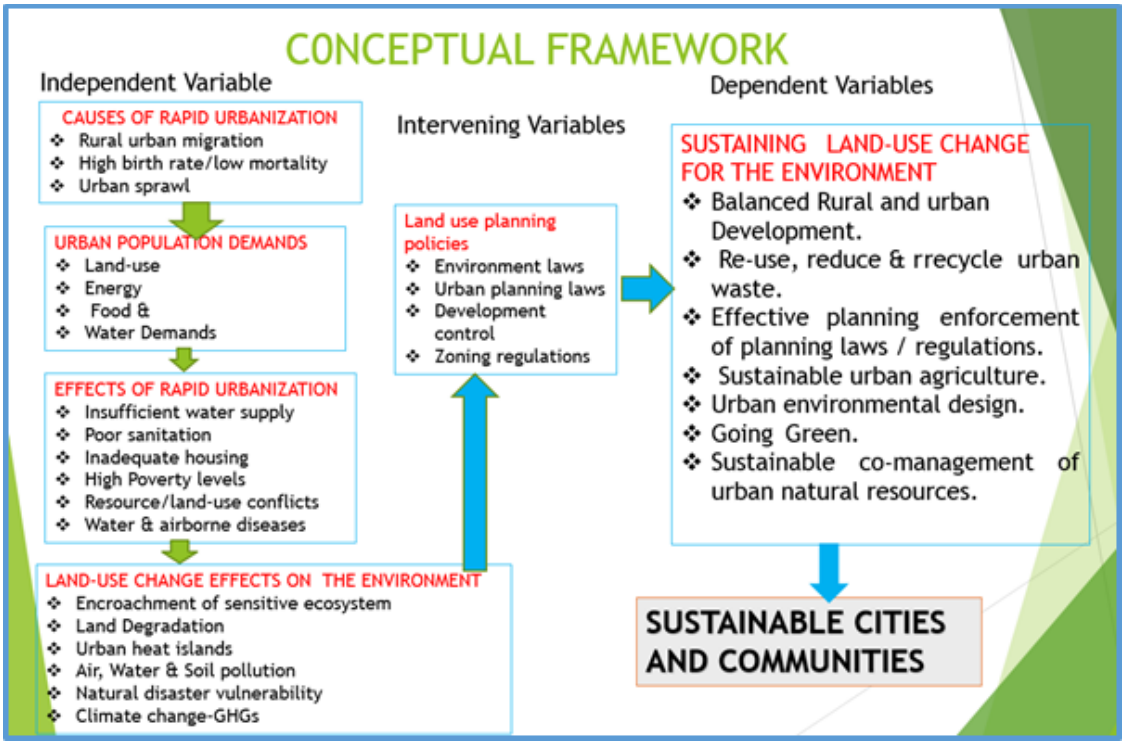
Urban growth arises from immigration into the cities/towns and the high fertility levels of the urban population. Urban fertility rates in urban areas in SSA are 1.5 kids lower than in the countryside; in developed countries like Latin America the discrepancy is nearly 2 kids. Such urbanization is caused by countryside inhabitants' thirstness for the privileges that

citoties/towns offer. Such privileges include; higher chances to receive better education, improved health care services and others services such cinema halls, gymnasiums and discotheques. The poor in urban areas have less chance for better education than urban non-poor, but they still have a higher chance than people in rural areas. Though urbanization gives populations better opportunities, it is also possible to conglomerate some ecological consequences on space.

### 2.14.2 Conceptual Framework.

Guided by Dasman's Ecological model of growth the researcher conceptualized a model where all land use and environmental planning efforts are geared towards achieving sustainable cities and communities such that both environment conservation / protection and developmemnt are balanced as illustrated below. According to UN 2015, Sustainable cities and communities endevour to; meet urbanization demands, meet industrialization demands, meet demands for rural and agricultural sectors, protection of lands under natural resources, protection of lands under ecosystem services, meet miming sector demands, meet transport sector demands, protection of social interests and livelihood aspect, protection of heritage sites and regulation of land use shifts from one use to another.

Figure 2: Conceptual Framework (Source; Author 2019 & some bits borrowed from UN)



# CHAPTER THREE: STUDY AREA

## 3.1 Introduction

Athi-river town centre under study is placed about 25km in the south east outskirts of the city of Nairobi in Machakos County. The town is named after a physical feature-Athi-River, which passes through it. It's also called Mavoko. This part of peri-urban Nairobi is located at the junction of the Nairobi-Mombasa road, the country's principal highway and Namanga road which is part of the great North road which connects Cape town to Cairo. It is also the confluence of River Athi and the Mombasa-Kisumu railway line making the town a node of transport and communication (Koti, 2004). The area was identified for this study as it was considered as forming a unique geographical space for academic and realistic scrutiny for three reasons. First, the area is a transitionary area between the truly urban Nairobi city and a clearly countryside area of Machakos County subsequently experiencing rapid socio-economic transformation and environmental challenges (UN-HABITAT, 2006). Secondly, the study area poses new institutional concerns for socio-ecological planning and vulnerability appraisal resulting from the intertwined nature of the rural/urban peculiarities; the residents" heavy dependence on and exploitation of the natural resources (Eakin et al, 2010). Lastly, being at the formative stages of development, the area is a place with a prospective for beneficial change because of the livelihood diversification plus access to services and information that would shape the residents" environmental adaptation (Ricci, 2011). The town hosts Mavoko Sub-County headquarters which is part of Athi River Ward of Machakos County. The ward covers an area of 693 km$^2$.. The Ward is host to two administrative sub-locations: Athi-river North and Athi-river Township. It has a total population of 137,211 (2009 census) and is highly industrialised with six cement factories located in its vicinity. With increasing densities on this town, high rate of industrialisation, urban transport and infrastructure developments there is likely to be increasing environmental consequences on the numerous components of the environment. Studies on the weather-related, geographic and ecological outcomes of this rapid urbanization in Athi-river town have not been conducted. This study will be limited to Athi River Ward as indicated in the maps below. The figures 3& 4 below show the study area in the national and regional contexts and diverse land-uses within Athi-river town.

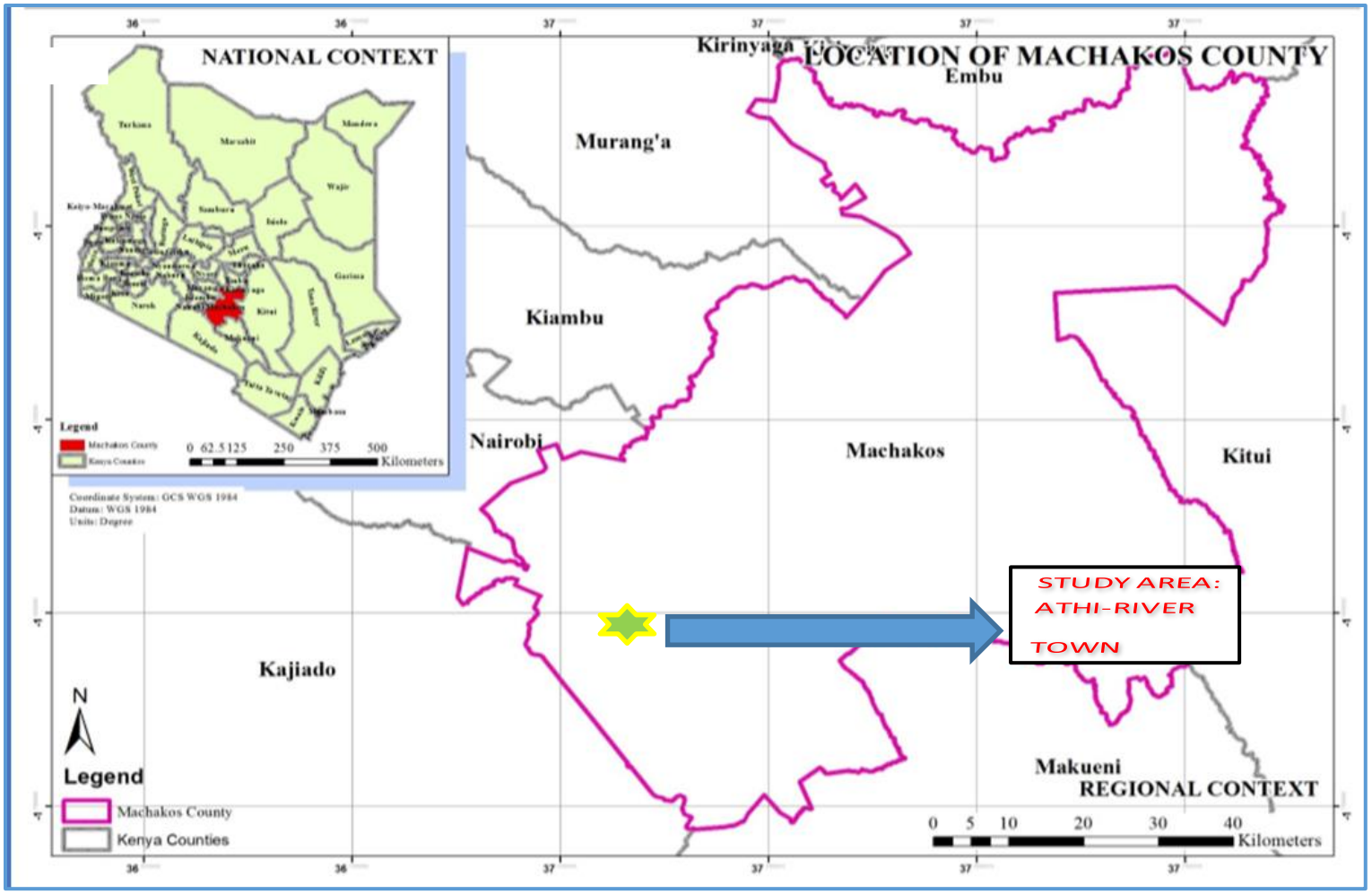



*Figure 3: Athi-river in the National & Regional Context ( Adopted from Machakos CIDP 2017)*

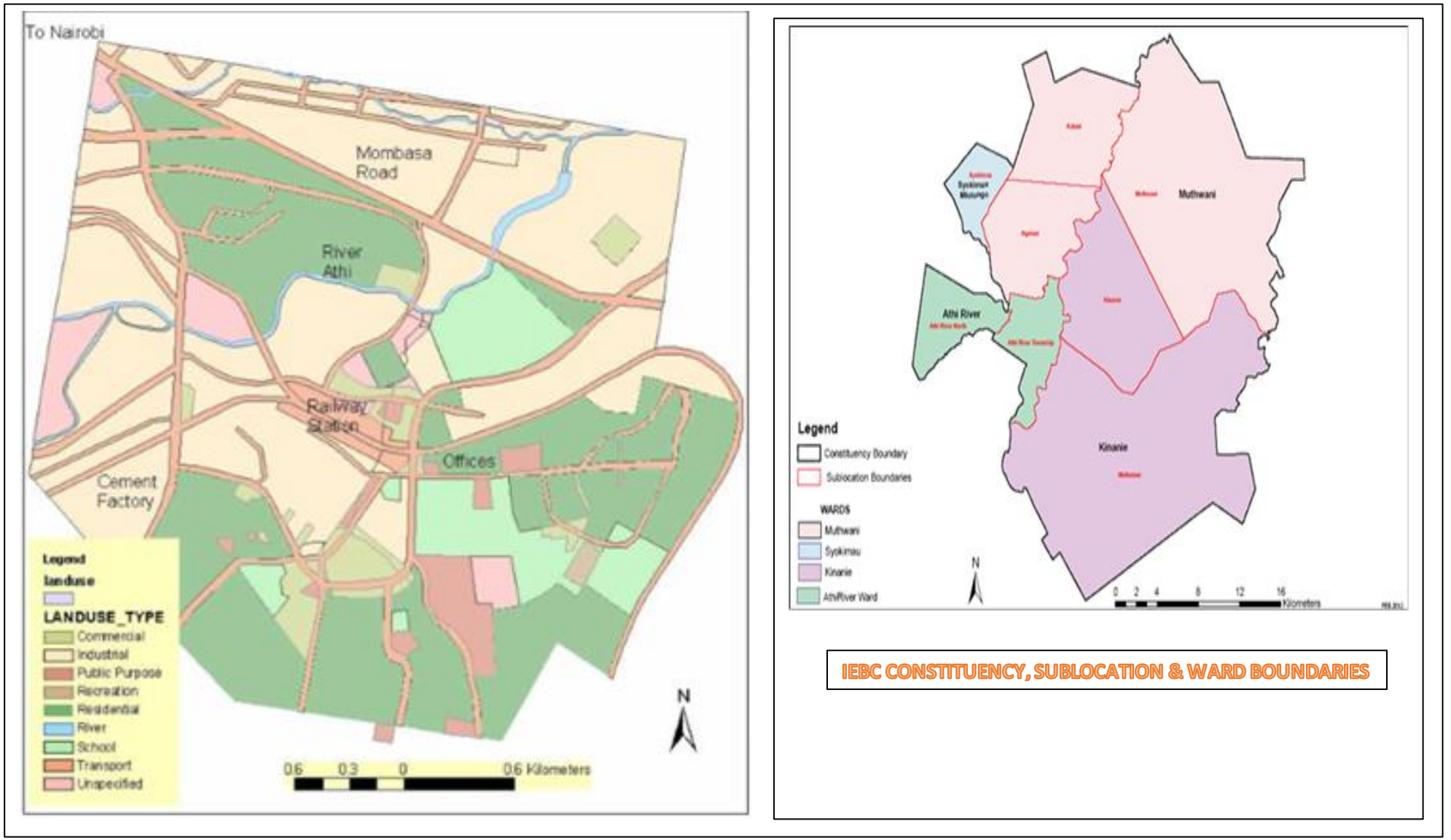



*Figure 4: Land Use Map of Athi-river Town (Source; Koti 2004)*

## 3.2 Historical Background of the Study Area

Athi-River town is one of the urban areas developed early in Kenya as per our urbanization history. It's existence was born through trade, with its first primary commercial facilities being concentrated at the old town area next to the railway station (Mireri, 1992). It started off as a local native Council in 1940 and later became an African District Council in 1974; later curved out from the County Council of Masaku and was elevated to an Urban Council then upgraded to a Town Council in 1987 and to a Municipal Council status in 1993. As a service provider, the council operated under the local government Act and the urban areas Act. Under the new devolved system of governance Athi-river town is under the jurisdiction of Mavoko Sub-county in Machakos County. The County government of Machakos has the core mandate of ensuring the planning and approval for all development activities within its area of jurisdiction.

By 1969 the population of the town stood at 5,343 in comparison with 582 in 1948. The rapid rise in population by over 800 percent between 1948/69 is attributed particularly to the establishment of K.M.C. (1953) and East African Portland (1957). Before the establishment of these two industries the town was serving simply as a rural centre with railway station and some shops. These industries attracted massive population through providing higher employment opportunities. Between 1969/79 the population virtually doubled from 5,343 to 10,012, which can be attributed to the proliferation in the number of industries. In the 1970s, 8 greater industries were set up creating more opportunities which attracted immigrants leave alone population growth because of natural increase.

Between 1979/89 the population of the town nearly doubled rising to approximately 20,000 (1989) from 10,012 (1979) people. The populace doubled in a decade, which can be attributed specifically to immigrants and partially to natural population increase. The population growth can be linked to the increase of old and new industries presenting more job opportunities. In the 1980s 12 more industries were set up, which opened up more opportunities for employment. The 1991 population was estimated by Mangat and Patel consultants to be about 21,000 people. Between 1990/91, 7 new industries were set up. A study carried out by Mireri in 1992 indicated that eight extra industrial premises were under construction, which have attracted even a larger population for employment and other related activities. This trend of industrial development and population growth has persisted to date with the urban population projected to be 200,041 by the year 2022 according the Machakos County Intergrated development Plan.

## 3.3 Natural Environment

### 3.3.1 Physiography & Hydrogeology

The rock classification of Athi river encompasses numerous geological sequences. The volcanic rocks within the area are represented by upper Athi series which include sediments and Lake Beds, Athi Tuffs and Kapiti phonolite. The thickness of these volcanics varies but normally decreases in the direction of the south and southeast as they reach the limit of the lava flows ( Koti 2004).

Beneath the volcanics are the undifferentiated crystalline rocks of the mozambique belt that is the Basements nexus of rocks consisting mainly of gneisses and schists. These are shallow seated and have been encountered by several of the numerous boreholes drilled in the study area. Geaverts, 1964, classify the sequence as all the sediments and tuffs lying between the Nairobi and the Kapiti phonolite. The regional hydrogeology suggests that the most significant aquifer system of the project area is the upper Athi sequence aquifer nexus. Athi-river falls within the upper Athi River catchment with a major physical feature -Athi-river-which cuts across the study area. The quality and quantity of water in the Athi River is highly influenced by residential, industrial and commercial land uses mainly in Mavoko where numerous noxious effluents are released into it.

### 3.3.2 Topography, Climate, vegetation and Soils

The area is of flat gently undulating terrain lying at 1500m to the east and 1530m towards the west altitudes. The study area is located within the upper Athi River catchments. The average annual rainfall in Machakos county ranges from barely over 1000 mm in some highlands to slightly below 500 mm in low lying south and south east parts of the county. The rainfall in the area has a bimodal pattern with rainy seasons occurring from March to may and November to December. The study area has a potential for agricultural activities.

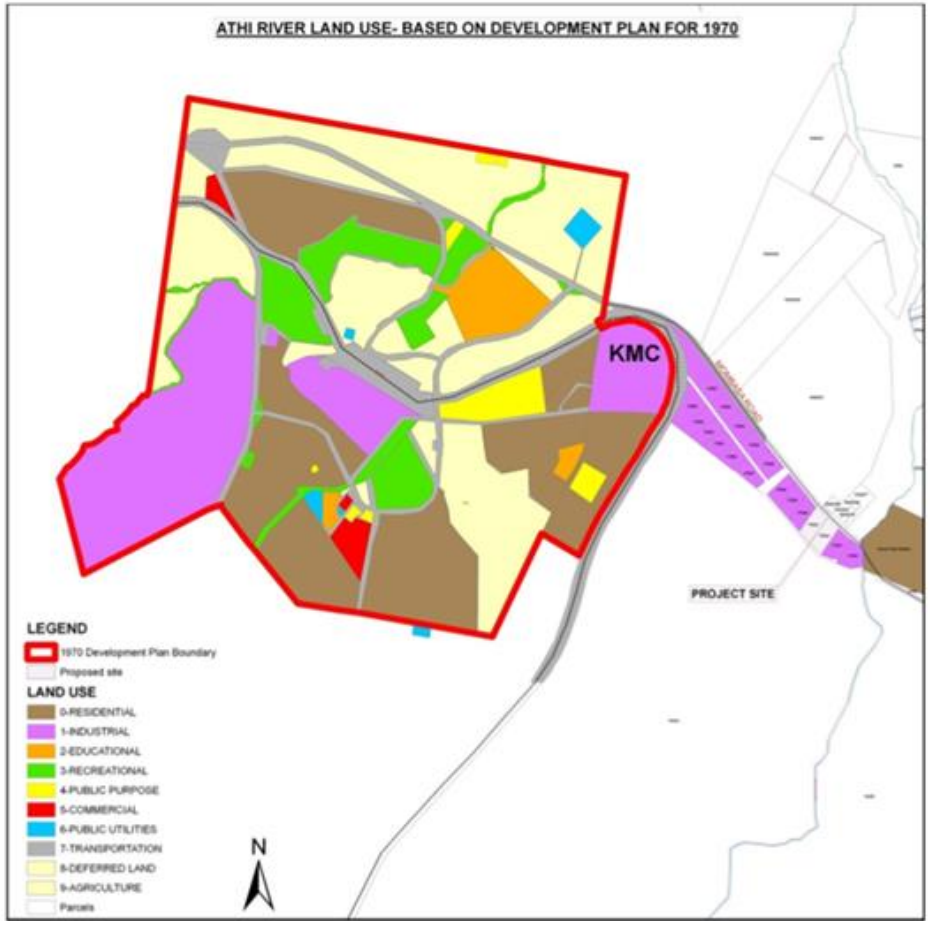
Athi-river Ward falls under the agro-climatic zone V-4; a semi-arid zone, with annual rainfall amounting to 450 – 900mm. Primary vegetation within the Athi-Kapiti ecosystem are the grass plain dominated by Cynodon, Themeda, Cypress, and Digitaria species; Dry forest, Olea africana, Croton dichogamus, Brachylaena hutchinsii, and Calodendrum; Riverine forest/valley forest, Acacia xanthophloea, Euphorbia candelabrum, Apodytes dimidiata, Canthium schimperiana, Elaeodendron buchananii, Ficus eriocarpa, Aspilia mossambicensis, Rhus natalensis, and Newtonia species (KPLC, 2011). Generally, the area is of bushland cover with plant growth potential being low to medium. The study area lies in a mainly dark-grey

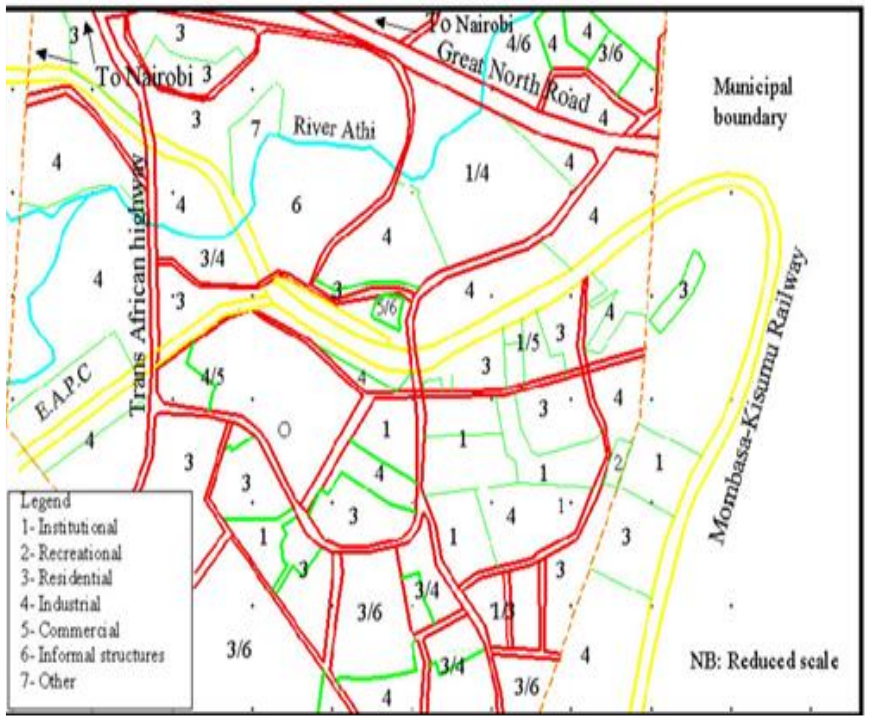
black cotton soil whose stratificatio varies. They have low infiltration rate and low permeability that is capable of significantly upholding any released contaminants to the groundwater (KPLC, 2011) due to their poor drainage nature.

## 3.4 Man made/Built Environment

### 3.4.1 Land use/ Human Settlement

Land-use activities in Athi-river is classified into 9 land-uses including; residential, commercial, industrial, recreational, educational, public purpose and public utility (Koti 2004). These land uses as per the Athi River Development Plan prepared in 1970 and the Physical Planning Map of 1998 are captured in the figures 5 & 6 below. The figures below show various land-uses in Athi-river and histotrical land-use changes in Athi- river ward respectively.




**ATHI RIVER TOWN PHYSICAL PLANNING MAP 1998**

*Figure 5: Land Use Maps (Source, Machakos County Archives)*

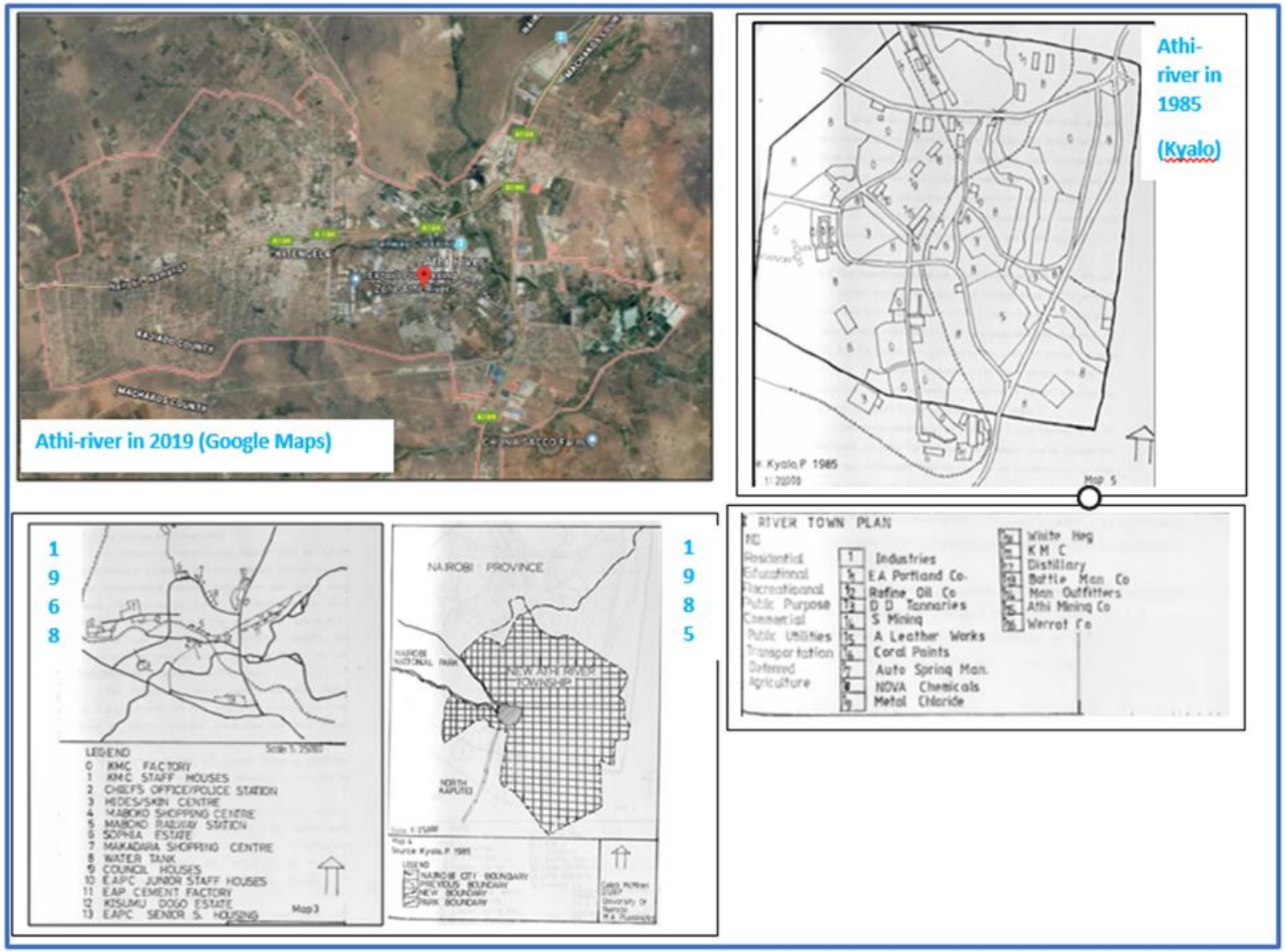



**Figure 6: Historical Land-use Change (Source Google Map; accesed in Oct 2019)**

### 3.4.2. Social and Micro-Economic Characteristics

This presents the social & economic outline of Athi-river by analysing the demographic tendencies and economic characteristics from reviewed literature. Athi River division (now Sub-county) in 2008 had the least population density in comparison to other divisions neigbhoring it. Due to its closeness to the city of Nairobi, the town is growing swiftly with new residential, industrial and commercial developments upcoming. Its present day population stands at 137,211 with CIDP projections of 200,041 people by 2025.

The poor within Athi River on average earn between Kshs 3,000 and Kshs 5,000 per month (UN 2006). Social well-being tracking surveys undertaken by others social researchers in 1994 and 1997 for the then Machakos district; indicated that 68.7% of the population lived below the poverty line in 1994 and 63. 3% of the population lived below the poverty line in 1997. On the same, exercise undertaken in 2000 indicated that 66.2% of the population lived below the poverty line. The national labor force absorption capacity (ability of the economy to provide employment) in 2007 was 44%; in the then Machakos district it was 33% and in Mavoko it was 28%.

Provision of housing is a common challange in both countryside and urban areas in Kenya. Corresponding to the Ministry of lands and urban development, the country currently has a demand of 200,000 new medium and low cost houses annually. Regrettably, these houses can't be accommodateds in the city as the land rates are exceedingly expensive. Subsequently metropolitan areas such as Athi-river, Kitengela and many others house these people that work in the city in thousands. The completion of the dual carriage way- Mombasa road and its proximity to Syokimau SGR & JKIA-airport, Athi-river town provides a perfect area for investors to build inexpensive residentials for people who work in the city. Field observation noted that numerous private developers have built residential estates in Athi-river with major estates like NHC-Stone Athi, Parkside and Green-Park Estates within Athi-river Ward.

## 3.5 Conclusion

As Athi-river's population expands, the demand for services, such as portable water, sanitation facilities and solid waste collection increases. Acording to urban profile study carried out by UN in 2014, more than 50% of the residents in Athi-river did not have access to safe drinking water, sanitation or sewage facilities and waste collection was terrible with more than 50 percent of the residents throwing their household waste in the open environment while 1 / 4 burnt it. More than 10 percent of the residents were dependent on the highly polluted Athi River and other nearby rivers and streams for their drinking water. Moreover, lots of Athi-river slums

are located in hazardous areas, close to industries, riverbanks, railway lines and the Nairobi national Park, exposing residents to diverse health and safety risks.

Such a degraded urban eco-system undermines development and threatens future development progress. The growing urban population of Athi-river against a backdrop of scarcity of natural resources like land for development has intensified this problem. This study examined why it's key to appreciate the interplay between urban ecosystems and land-use changes as well the subsequent consequences arising from this interplay. The study also demonstrated how land use planning can perform a vital role in mitigating these consequences guided by the town's existing opportunities and constraints.

# CHAPTER FOUR: RESEARCH METHODOLOGY

## 4.1 Introduction

This section covers the data collection and analysis methods. The main methods used in collection of information were literature review which involved the collection of information from secondary sources that is; in libraries, documentation centres and internet sources. This was then be followed by a reconnaissance visit, base map preparation, stakeholder and consultative meetings, data collection, data analysis and recommendations on the best urban environment practices.

## 4.2 Study Research Design

The research commenced by sectioning the study area in two study sections; the highy urbanised densely populated core and the suburb areas of Athi-river Ward with low density. Each areas was recognized by the name of the river crosscutting it; that is Athi-river location in the core and Mto-mawe/Stoni Athi area. Both sections had a about 60,000–100,000 likely to be interviewed within the legal adult age standards i.e 18yr plus from both genders. Respondents were picked out randomly from each of the two sections of the ward with the aim of eliminating partiality on gender and profession.

A piloting study of the questionnaires was carried out using 10 student participants from the University of Nairobi, Department of Geography & Environmental studiesand 10 residents from Athi-River. Other than the responses by the family heads, extra data was collected from the business community, industries and key informant (resident associations & clergy). Interviews were carried out daily for 5 days from 9am to 4pm.

## 4.3 Data Need Matrix

The data needs matrix table below is an outline of the approach used in collection of data, its analysis and the expected outcome.

| Research Questions | Research Objective | Types Of Data | Data Sources | Data Collection | Data Analysis | Presentation | Expected Outcome |
|---|---|---|---|---|---|---|---|
| What is the state of the natural environment in Athi river town? | **To investigate the state of the natural environment in Athi river town** | Qualitative/ Quantitative data; Inventory of Historical land-uses in Athi-River. . | Secondary sources (Government publications ns, thesis, conference papers, books, abstracts, periodical scholarly journals etc.) & primary data sources. | Observation, interviews, focus group discussions and photography ng & GPS | GIS mapping Descriptive Analysi/ Assessment of the state of the natural environment. | Charts, graphic s, maps, imagery etc. | A detailed analysis on how land-use change has affected the environment in Athi river with major focus on the dominant land-uses and their respective effects on the environment. |
| What is the relationship between | **To establish the relationship** | Assessment | G.O.K publications, thesis, conference papers, | Observation, | GIS mapping | Charts, graphic | A comprehensive |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **land-use change in Athi river town and the urban ecosystem?** | **between land-use change in Athi river and the urban ecosystem?** | of the urban land-use activities in Athi river and their respective social, economic & environmental implications to determine their sustainability from ecosystem perspective. | books, periodical scholarly journals etc.) & Field Survey | Interviews, fucos group discussion & photography ng & GPS | SPSS Descriptive Analysis | s, maps, imagery Descriptive Notes etc. | assessment of the relationship between the land-use activities Athi River and their respective implication on the natural & built environment. |
| **What are the existing environmental and land use planning opportunities & Constraints in Athi-river town** | **To identify environmental and land use planning opportunities &constraints in Athi-river town.** | Determination of the major environmental resources in Athi-river for better planning and utilization of the same resources. | Field Survey, Mapping & Relevant Publication n | Opinion Polls, Observation, interviews, photography ng & GPS | Mapping Descriptive Analysis | Maps and Models of utilization on of natural resource by various urban land-uses activities | Land use Maps, Zoning Sketches |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **What is the relationship between land-use change in Athi river and the urban ecosystem?** | **To reccomend how land-use planning play a role in minimizing the effects of land-use change on the environment** | Highlight the importance of proper environmenntal planning on natural resource use | Mapping & Relevant Publication n | Observation, interviews, reviewed literature | Mapping Descriptive Analysis | Maps and Models of utilization on of natural resource by various urban land-uses activities | Descriptive analysis on importance of proper environmental planning on the use of natural resources. |

*Table 2: Data Needs Matrix (Source; Author 2019)*

## 4.4 Population Study & Sampling Methods

Sampling involved selecting a representative group of the total population of the Athi-River town. Sampling helped in saving time and costs as well as reducing bias. The study targeted; heads of household, Business community, Industries, local governance and religious leaders as well as officials of the local residents' associations. The study used both quantitative and qualitative research approaches to generate data for the purposes of describing the demographic characteristics (gender, age, marital status and length of stay in the study area); and socio-economic characteristics (education level, sources of livelihood, range of monthly income, place of work, land tenure and form of residence ownership). This design enabled the collection of data on land-use change effects on the environment in Athi-river town; what natural resources are available, their utilization both sustainable and unsustainable, land-use /resource use conflicts & land-use planning); and to explore the relation between the population and socio-economic characteristics of urbanization and their respective effects on the environment.

The study adopted John Eng (2003)'s formula for calculating representative random sample size of unknown population size because of the swiftly changing population of the study area, for a confidence level around a proportion as shown;

$$N = \frac{4z\alpha 2/2\ p\ (1-p)}{D2}$$

where:

n = the sample size

z = the standard normal deviate relating to the 95% degree of confidence set at 1.96

p = an estimate of the proportion of people falling into the group in which we are interested in the population

d = the acceptable proportion of error

In this study p = 0.5. (selecting 50% provided the most reasonable prediction of the random sample size). Confidence interval of 95% could be estimated to be within 10% of the actual value. The random sample size was then given by way of:

$n = 4 \times 1.962 \times \text{zero}.5(1 - 0.5)$

0.12

n=99.99

N=100

This formula gives a number that is an estimate of the absolute minimum, making it important to have extra respondents to atone for loss during follow-up or other causes of attrition. John Eng (2003) and Botsch (2011) recommends an addition of 10% of sample size to atone for persons that the researcher is unable to contact; and further 30% to compensate for non-response. Thus, the sample size for the study was 140 households distributed across the two locations in Athi river ward in equal proportions.

This study also used non-probability sampling methods to identify interviewees and participants in the Focus Group Discussions and the business community while purposive sampling was used to select key informants; religious leaders and residents association officials that participated in the study. According to a study done on Mavoko Urban Sector Profile done in 2004, there are about 60 industrial developments within this town. Purposive sampling was used to identify the industries to interview with major interest on the environment section of the administration. Only 15 of these were interviewed in proportion of 3 mining &minerals industries, 3 agriculture industries and 3 industrial manufacturing industries with only one industry interviewed as per their spatial distribution at core, semi-periphery and the periphery of the urban centre respectively. Primary and secondary sources of were relied on to gather both qualitative and quantitative data. The collection techniques used included;

## 4.5 Secondary data collection

Literature review preceded collection of primary data and involved the process of reading books, journals, magazines among others in search of ideas on sustainable environmental planning in urban areas. The researcher first identied the types of documents available and relevant to the study area, before securing authority for their access. Guided by the Evaluation Review (2009), relevant documents were compiled and summarised, indicating the type of document reviewed and the way to reference each document. Some of the documents included; policy documents, acts of parliament, journals and publications on urbanization, urban ecosystem, urbanization and poverty/social development, concepts and theories on land-use and environmental planning for development. Land use-change as result of anthropogenic

activities can be objectively measured as it can be seen from space using satellite imagery as the evidence for this change is not easily seen on landscapes. This study primaryly used GIS Landsat Data on landuse covers to illustrate the transformation/ conversion of numerous land uses in Athi-river over a period about 20yrs.

## 4.6 Primary Data Collection

From the area of study, primary data was gathered by observation use of a checklist, administering of questionnaires at household, business, industry and institutional level and key informant interviews with the planning officers at the Ministry of Environment, County Government of Machakos and NEMA offices. The survey methods used were within the resources available and at the same time met the specified requirements and standards covering collection, interpretation, organization, compilation and presentation of information in a readily understandable form. They are all discussed below;

1. ***Observation***; entailed direct observation and was done in two ways at reconnaissance and during field work using observation checklist. Tools such as cameras and measuring equipment's were used to record observations such as urban waste disposal methods, blocked drainage, human activities such as urban agriculture, visible industrial emissions such as smoke.
2. ***Questionnaire***; semi-structured closed and open questionnaires were administered to respondents directly. Respondents were household heads or spouses, County Government of Machakos development control officer & environment officer, Industries managing officer, MEMRI, Ministry of Lands and the NEMA who are the major stakeholders responsible for the management of Urban environments.
3. ***Interviews***; these involved face to face interviews with the key informants such as the resident association representatives where an interview guide was used.
4. ***Participatory methods***; Involved stakeholders being involved in problem identification, collecting data and analysis of the same. Here focus group discussions were used where the community met with a focus of identifying the environmental problems associated with urbanization of this town and their appropriate solutions. Two focus groups discussions were held; one for the youth and one for women who are the major drivers in environmental change to attain sustainability.
5. ***Surveys***; spatial surveys helped create a picture of natural resources and socio-economic infrastructure available in the community were done through sketch maps.

## 4.7 Data Analysis

Preparation of data involved activities to input, store, retrieve and analyze the collected data. This entailed data editing, coding, inputting and validating. Here software's such as SPSS, Excel and GIS were highly relied on to facilitate the interpretation of the collected data. The data was be analysed through comparison of Landsat TM images of the years 1984-2019 to ascertain temporal and spatial land cover changes in that period of 20yrs to validate the alternative hypothesis.

# CHAPTER FIVE: RESULTS AND DISCUSSION

## 5.1 Overview

This section presents a detailed interpretation of findings based on land-use change and sustainability of these land-uses with reference to their social, economic and environmental effects. It further looks into roles various institutions can play and demonstrates why land use planning can help mitigating the effects of land-ise change on the environment.

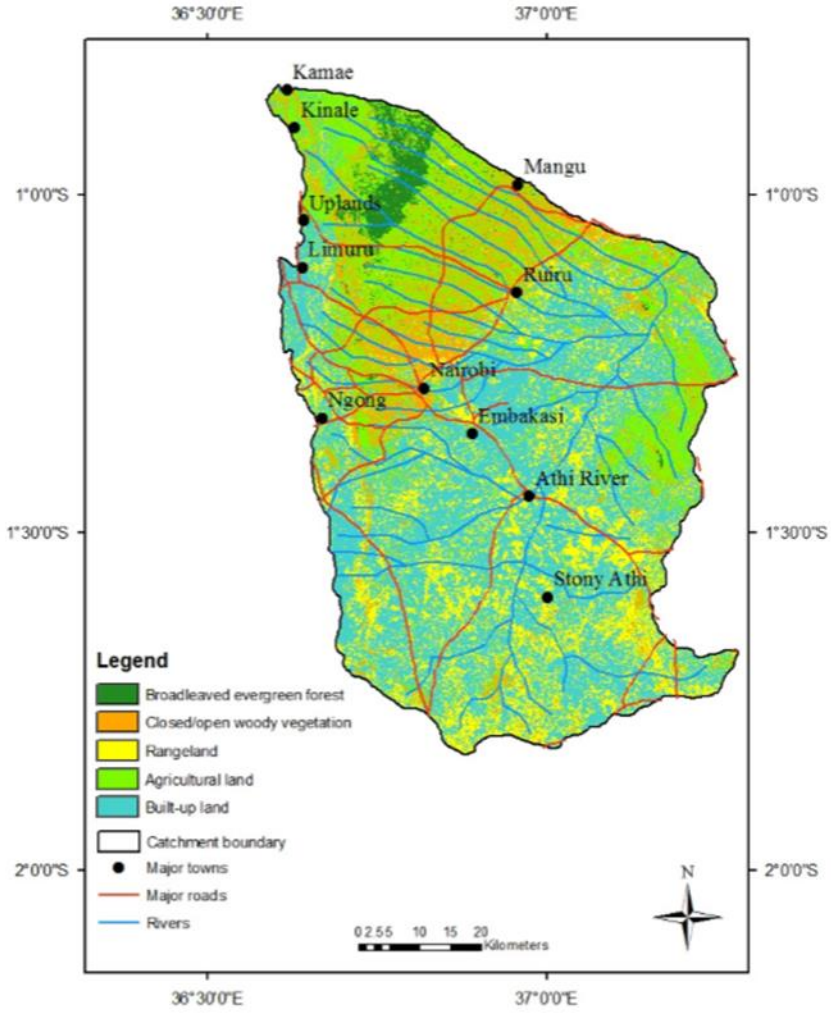
## 5.2 Existing Situation; The state of the natural environment in Athi river town.

From field observations, it can be confirmed that in the years , settlements pattern of the areas has taken linear form with most developmemts oncentrated along the major roads -Mombasa Road and Namanga road-as well along the minor roads. Existing situation looked at the past spatial-temporal land cover changes in Athi-river.

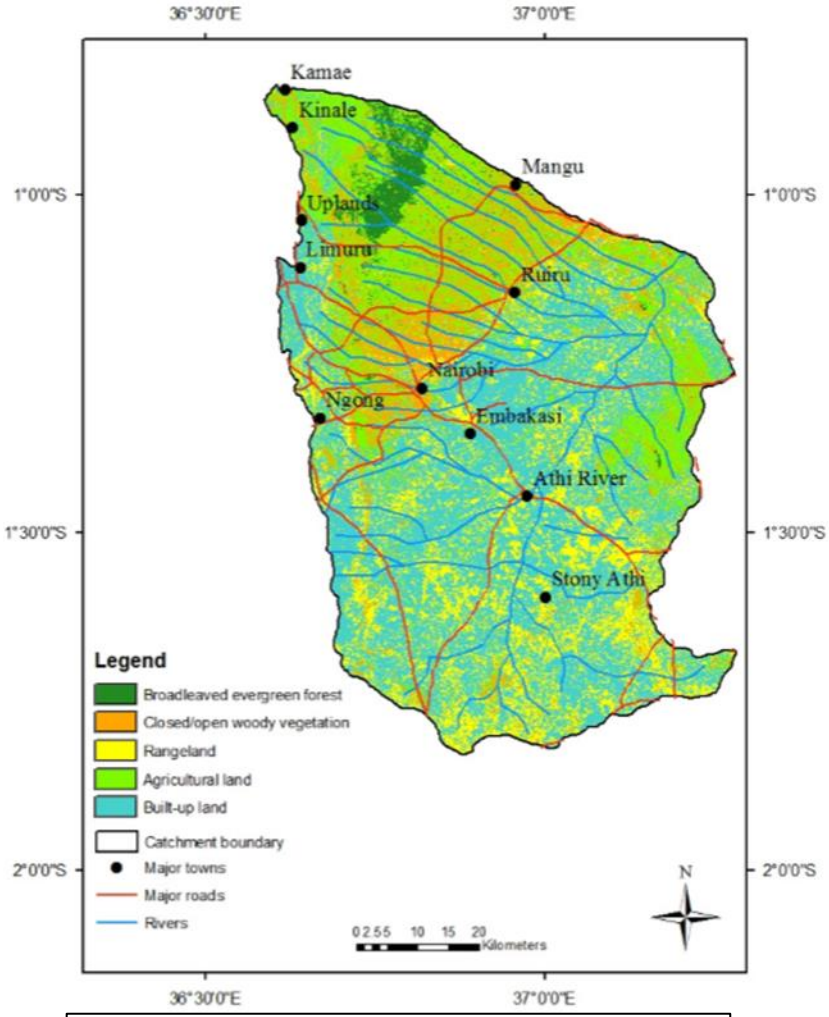
Both secondary and primary data were heavily relied on to analyse this objective. From reviewed literature it was very clear that Athi-river towm is located within the larger Upper Athi River Catchment area; one of the drainage basins that has undergone swift land cover transformation/conversion as a result of changes in land use activities and pressure from inceasing populations (Lambretchts et al., 2003). Some land cover patterns of the study were obtained from reviewed literature from Elias 2013 which had been mapped using Landsat Thematic Mapper images captured in the period December 1984 to February 2000. The images were chosen of the years 1984 , 2000 and 2010. From the reviewed literature 5 significant land cover classses were demarcated in the entire Athi drainage basin area including, the evergreen forest, woody vegetation and rangeland . Land cover changes in the catchment area were as illustrated in the figure 6 in page 58 & 59 respectively ( Source; Ketana S.J et.al 2016)

From the LANDSAT images its clear that agricultural use and built-up uses increased from 1984 to 2010. On the contrary, the forested land, rangeland and woody vegetations diminished in the period 1984 and 2010. Predicted land cover type maps indicated a likely increase in both the built-up and agricultural covers in the period 2010 and 2030 .

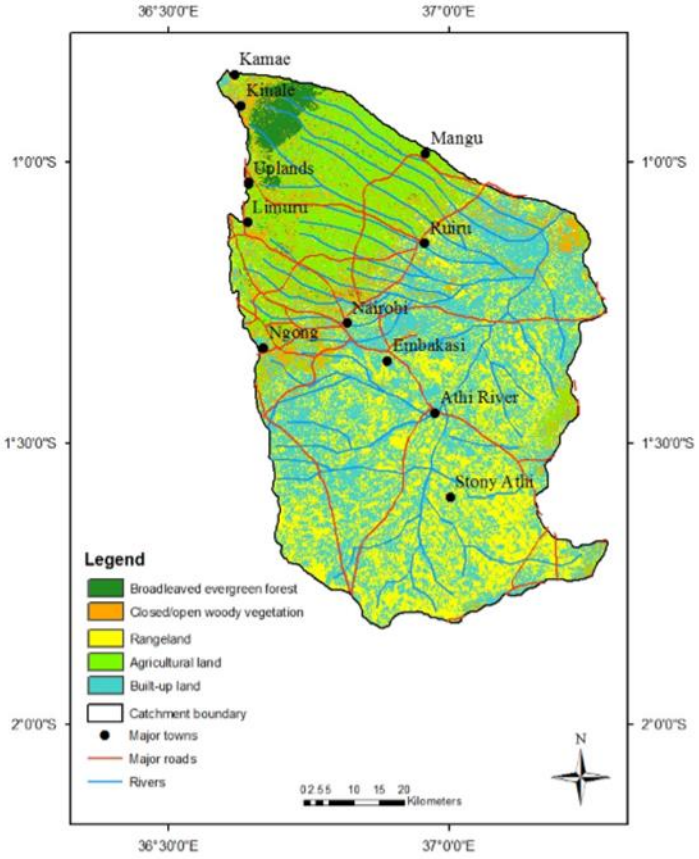
## Figure 7: Spatial and Temporal Land Cover Changes




Land cover types as derived from Landsat TM image of 1984 (Adopted from Katana S.J.S et al)




Land cover types as derived from Landsat TM image of 2000 (Adopted from Katana S.J.S et al)




Land cover types as derived from Landsat TM image of 2010. (Adopted from Katana S.J.S et al)

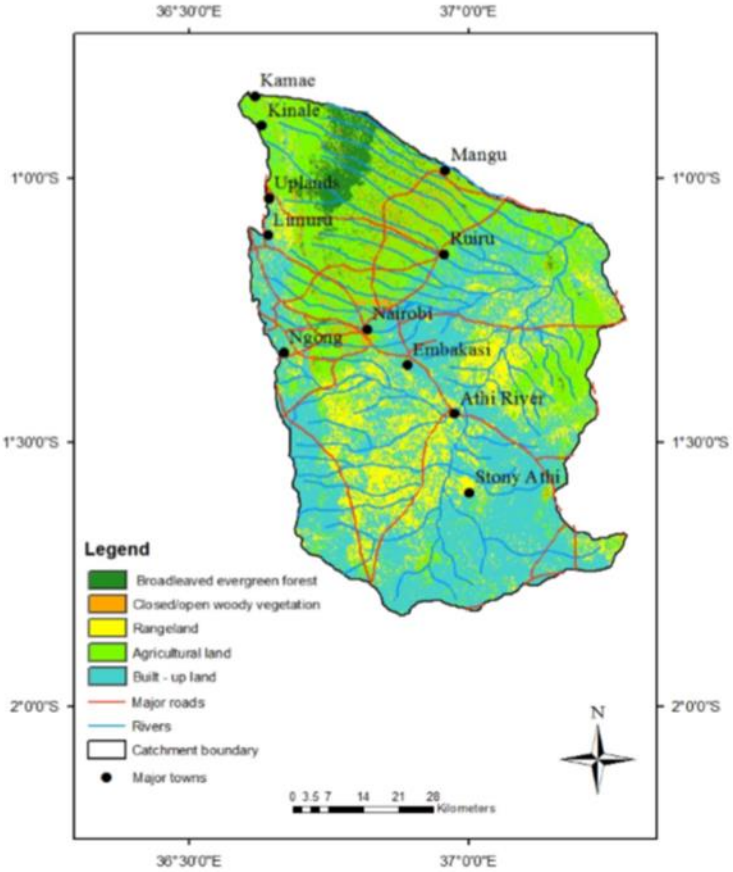



Fig 8: Predicted land cover types of Upper Athi River Catchment in 2030. (Adopted from Katana S.J.S et al)

The researcher observed that the grassland vegetaion cover in the study area comprised of bushland and grass vegetation. Interview at both household and bussines level indicated that individuals and company investors were practicing land banking in the hope of fetching high land rates in the near future after subdivision. Between the years 2000-2010 there was massive development of physical infrastructure e.g Estates such as Green Park Estate and Riverine Park adjavent to Mto-mawe & Athi-river respectively and the SGR on previously undisturbed grasslands area as highlighted by the key informants and corroborated by FGDs. Privately owned grasslands were subdivided for residential and industrial uses while the public grasslands were put into infrastructural uses. As a result, grassland closed/open woody vegetation decreased in the same period with grassland being the the only donor, whereas farmland and built-up/ are absolute recipients.

From figure 8 below obtained by the researcher from Landsat 7 etm+c1 of dates 17-March-2009 and 21-March-2019 using the classification method of Maximum Likelihood it shows that all land cover classes except built up area transitioned from being beneficiaries to benefactor thus their overall area coverage area decreased (Field, 2019) compared to reviewed landsats of 1984-2010.

Therefore its clear that land cover changes were observed from Landsats between 1984 and 2019 with changes on space over a period of time causing rapid expansion of built-up areas and farm-land uses; and a reduction in overall vegetation and grassland covers among other land uses. The major land cover alterations were transformation from vegetation covers to barelands and grasslands to built-up area covers.

| 2009 | | | | |
|---|---|---|---|---|
| Land Cover (LC) | Value | Pixel Count | LC Area (Ha) | % |
| Built-Up | 1 | 37715 | 3394.35 | 4.142862007 |
| Grassland | 16 | 491187 | 44206.83 | 53.95518921 |
| Bareground | 28 | 163728 | 14735.52 | 17.98495322 |
| Quarry | 32 | 11434 | 1029.06 | 1.255985263 |
| Riverine | 33 | 21096 | 1898.64 | 2.317322469 |
| Vegetation | 37 | 83870 | 7548.3 | 9.212828757 |
| Farmland | 41 | 79821 | 7183.89 | 8.768060143 |
| Tarmac | 46 | 21510 | 1935.9 | 2.362798934 |
| TOTAL | | 910361 | 81932.49 | 100 |

*Figure 9:: 2009 Land Uses per Area Coverage ( Author, 2019)*

| 2019 | | | | |
|---|---|---|---|---|
| Land Cover (LC) | Value | Pixel Count | LC Area | % |
| Built-Up | 1 | 56573 | 5091.57 | 6.177231389 |
| Grassland | 16 | 231174 | 20805.66 | 25.24199334 |
| Bareground | 28 | 435298 | 39176.82 | 47.53038497 |
| Quarry | 32 | 34049 | 3064.41 | 3.717825669 |
| Riverine | 33 | 29371 | 2643.39 | 3.207032739 |
| Vegetation | 37 | 31444 | 2829.96 | 3.433384544 |
| Farmland | 41 | 73838 | 6645.42 | 8.062404527 |
| Tarmac | 46 | 24084 | 2167.56 | 2.629742824 |
| TOTAL | | 915831 | 82424.79 | 100 |

*Figure 10: 2019 Land Use per Area Coverage (Author, 2019)*

From the figures 9 & 10 its clear that vegetation cover has reduced from 9.2 % to 3.4 % while bare land has increased to at an alarming rate from 17.9 % to 47.5 %. This implies that the ecosystem functioning of this urban area has been affected. In the same period, the of the ability of the area to regulate flooding, air sequestration and drought regulation are declining as has been observed with flooding instances and erratic rainfall patterns in the last 10 years which was confirmed by 60 % of residents.

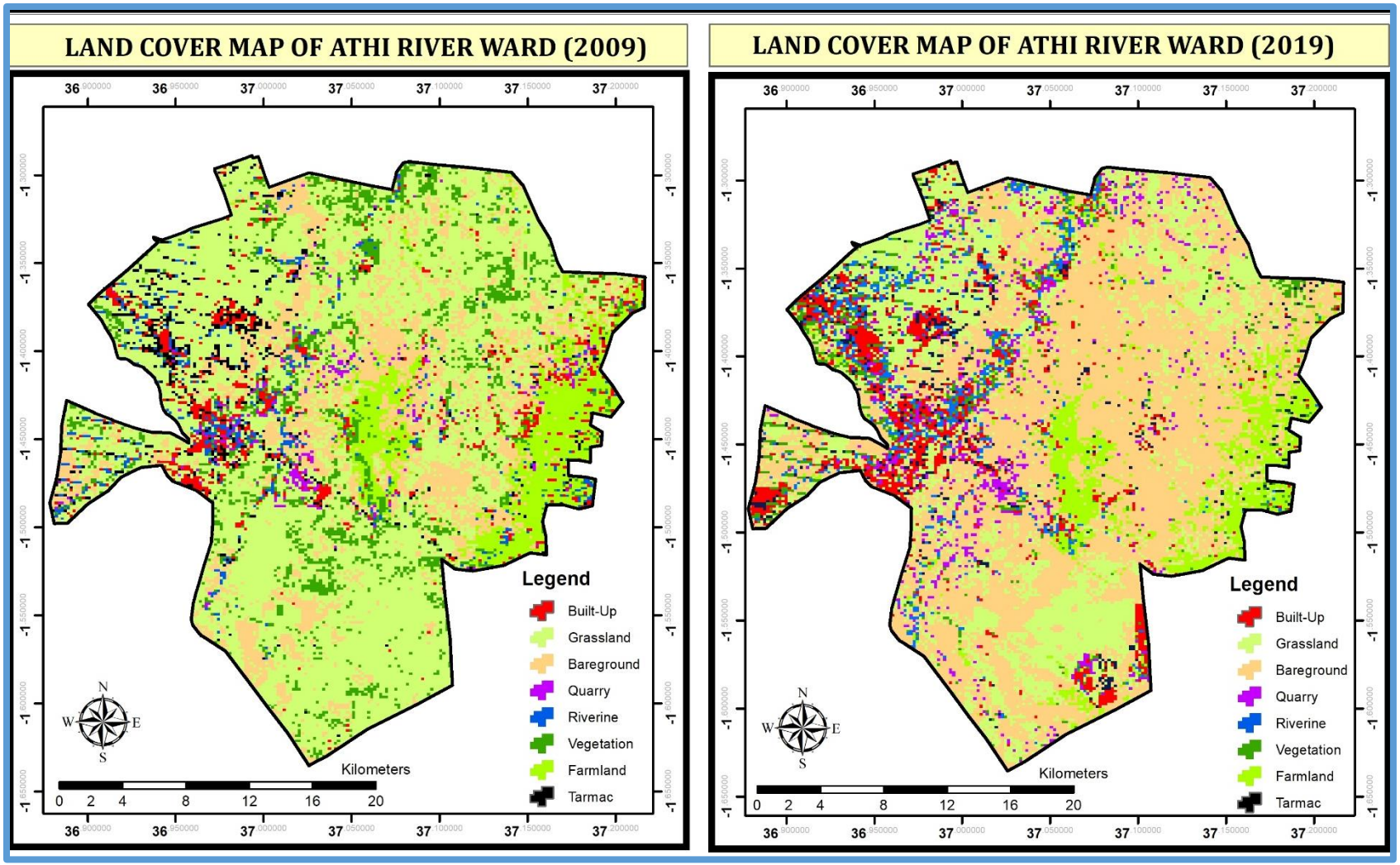



*Figure 11: Land COVER CHANGES OF THE YEARS 2009-2019 (Author, 2019)*

## 5.3 Nature Of Land-use and Urban Ecosystem within Athiriver ; the relationship between land-use change in Athi river and the urban ecosystem.

The existence of the town can be traced back to the siting of Mavoko Railway Station, which culminated into the establishment of central activities around the railway station. The first Athi River Development Plan shows that before 1970 the town was a very small centre with only two industries, namely, East African Portland and K.M.C. The centre then was dominated by activities related to the two industries: the factories, the staff housing and shopping facilities at Makadara and Mavoko, other estates include Kisumu Dogo and Sophia. Since then due to rapid urbanization land-use change has massively taken place. The various land uses were identified by the respodents according to their dominance as discussed below.

### 5.3.1 Human Settlement

As mentioned earlier, the area under study is at the junction of the Nairobi-Mombasa Road-the country's main highway and Namanga Road which is part of the Great North Road which connects Cape Town to Cairo. This is also the confluence of River Athi and the Mombasa-Kisumu railway line (East African Railway-SGR) making the town a node of transport and communication (Koti, 2004). For purposes of data collection and analysis the researcher subdivided the entire ward into two major sections; the core of the town and the suburbub which has highly influenced activities of the core and supports its subsistence through urban agriculture.

- ***Setttlements at The Core of the Town***

*Plate 1: Solid waste disposal on open land at the core & shsck structures*

Settlements at the core of this town comprises of temporary structures made of corrugated iron sheets with no provision of community, sanitary and other support facilities. The poor people of this urban centre are squatters on land to which they have no legal right either on along the

railway line or behind the major industries or on the edge of the Nairobi National Park. They are evicted at the whim of landlords and developers. Most of the residents in this area work in the industries within Athiriver while a few have businesses within the town. At the core of this town are most shack settlements located near the industries. This is a major reason why many people come to reside in Athiriver due to low house rents and employment opportunities can be found in the industries. These residents cannot afford transport costs therefore they live near their work place preferably in these shack settlements.

*Plate 2: Artificial Drainage of the study Area (Source; Field 2019)*

The settlements are characterized by inhuman conditions of overcrowding and congestion; lack of drainage and sanitary facilities, indiscriminate solid waste disposal which has hazardous health implications. The supply for water, solid waste disposal arrangements and sanitary services provision is wanting. Most residents pay for water and deposit both liquid and solid waste on the open drains. The existence of these slums in the core of this industrial town have

detrimental effects on the river ecosystem and the urban environment at large. The artificial drainage is often shallow and filled with refuse from industries, houses, market stalls and kiosks as shown in plate 1 above. Dirty water collects in the channels, stagnates producing foul smell and create breeding ground for disease vectors and parasites. These channels flood during rainy seasons causing damage including drowning of children. The town is of poorly drained soils which make the drainage of lots of swamps and flooding occasions during rainy seasons. This is worsened by stagnant dirty water which has negative health implications. The slope of the land leads to a rapid flow of surface runoff, liquid waste such as oil among other pollutants onto the rivers within the study area.

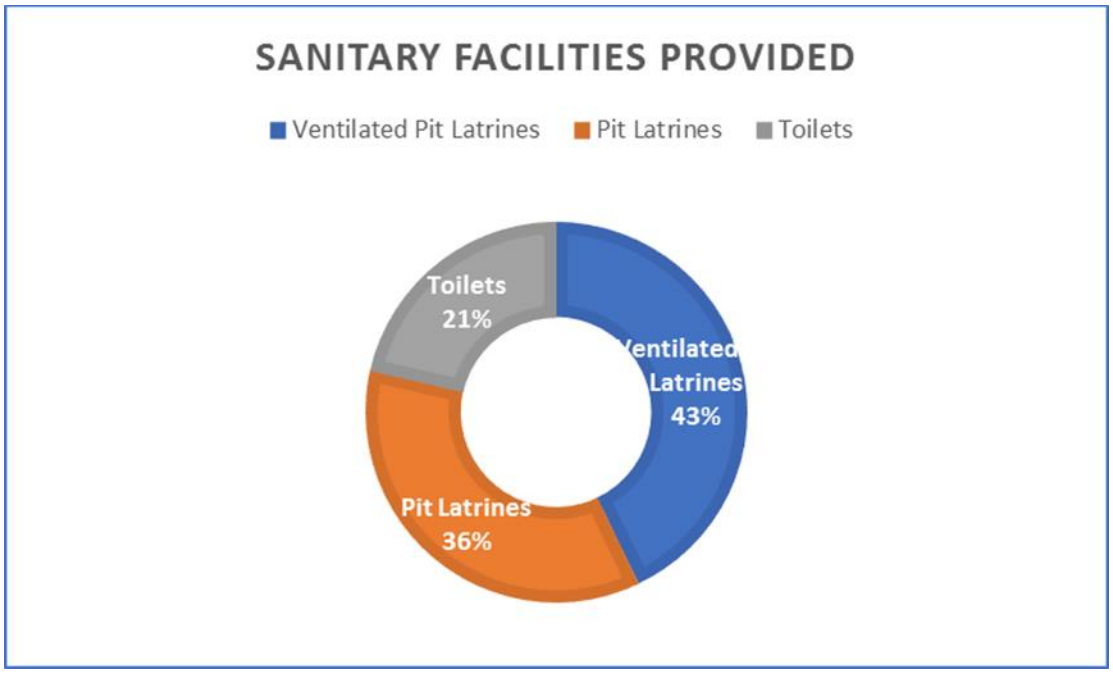



*Figure 12: Provided Sanitary Facilities ( Source; Field 2019)*

The main problems emanate from the fact that these shack settlements are not sustainable in that they lack infrastructure facilities/services including; water supply, solid waste disposal structures and sanitary facilities. Figure 7 above illustrates the sanitary facilities provided in the town.

- ***Settlements at the Sub-urban Athiriver Ward***

Unlike in the core the suburb Athiriver is well planned with better service provision such as better well planned real estate housing developments such as Stone Athi, South Park, Sidai Estate and Green Park Estate among others. Other settlements include individual home developments on freehold land such as Inter-County. 3 bedroomed and two bedroomed houses

dominate this part of the town. Sanitation facilities are provided with septic tanks dominating most settlemets. These settlements are not connected to major sewer line thus cases of flooding are rampant during heavy rainfall seasons. This raw waste ultimately ends up ith the main river in the town Athi-river increasing its pollution to even higher levels. Solid waste disposal in the surburb is more organized with soilid waste disposal bags provided monthly and garbage collected twice a week by private garbage collectors.

*Plate 3: Industries Encroaching onto Riparian Land (Source; Field 2019)*

### 5.3.2 Industries

Over 60% of Athiriver industries are located in the core of this town such as Devki steel Industries, East African Portland cement among others. The study area is surrounded by industries ranging from non- noxious, light industries, heavy and industrial outlets {go-downs} to heavy manufacturing noxious industries. Some of these industries are located in close proximity to Athi-river such that they encroach onto it see plate 3 above.

On the same, the level of air pollution in Athi-river is very eminent. By observation dark foggy smoke could be seen emanating from these industries mostly in the morning and evening hours-

see the plate 4 below. The level of pollutants in the air in Athi-river is quite alarmimg as suggested by previous studies and NEMA reports.

Plate 4: Industrial Air Pollution

### 5.3.3 Infrastuctural Utilities/Services

The Athi-River corridor is an integral service element that accommodates systems of both trunk sewers and water mains. The Athi-River trunk sewer's service is inclusive of all those upstream developments within its drainage basin. In the study area water utility pipes could be observed at several points of the river front often integrated with crossing levels. These connect water to other settlements located across the river. Man holes and main trunk sewers are also constructed on the riparian zone of Athi-River as shown in the plate 5 in the next page{Field Survey, 2019}.

*Plate 5: Infrastructure Facilities on Riparian Zones (source; Field 2019)*

### 5.3.4 Urban Agriculture

Some residents of the study area practice urban agriculture along the riparian zone of Athi-river in the core of the town, Mto-mawe in the suburban and along the old railway line within the town. To them this land is idle and needs to be put into income generating activities such as growing of crops including napier grass, kales, spinach , maize, bananas and sugarcane among others. Other agricultural activities carried out on this zones include livestock keeping by maasai pastoral community where some graze their cow on the riparian zone while others graze on the road/rail way leave or any other land considered as idle land,. See plate below. Most of these farmers carry out subsistence farming and sale surplus to local residents {Field, survey, 2019}.

Plate 6: Cattle Grazing on Riparian Land

### 5.3.5 Existing Land-use Pattern

As stated earlier, the researcher subdivided this Ward into two sections; the urban Athi-river (core) and the sub-urban. In the core of Athi-river ward is the more urban section of the ward which is composed of low income settlements characterized by over-crowding and congestion, poor housing, poor service provision including water, electricity & garbage collection and poor sanitation. Due to insecurity of land tenure most structures are temporary including houses made of corrugated iron sheets, un-articulated shallow storm water channels, electricity and untapped water supply; haphazard solid and liquid waste disposal and lack of proper sanitation facilities. These shack settlements have encroached onto the industrial buffer zones, rail and road wayleaves as evidenced by houses, pit latrines, institutions like churches among others.

On the same, the most predominant land-use in the core of the town comprises of industries ranging from heavy manufacturing like Devki steel industries, chemical industries to light industries. These industries make little or no use of the natural resources within the town but some of the cement factories get their raw-materials from quarries in Lukenya leaving

unrefilled abandoned sites which pose health harzards to the residents around the Quarry sites. However, they indiscriminately discharge untreated/harmful effluents into the riparian zones of Athi River and Mto-mawe and cause massive air pollution with fogs and smoke billowing from these industries in the evening and early morning covering the sky with a cloud of smoke. Pevious studies have linked this smoke with polluting the atmosphere with heavy air pollutants likely to cause regional climate change effects or a sort of a micro-climate within the urban area. Residents pointed out change in climatic conditions of the urban area with majority citing erratic rainfall patterns and extreme temperatues of bitting cold weather and quite hot weather patterns which residents have observed over their 15year plus period of stay in the town.


*Plate 7: Structure marked for removal by WRA in Green Park Estate*

On the contrary; the suburb is well planned with residential developments mostly comprised of gated communities. These gated communities are privately developed type with all weather access roads. On the freehold land the access roads are all weather while on the leasehold housing developments such as Green Park and Blue Triangle Village the access roads are either cabro paved or tarmacked roads. Unlike in the shack settlements these gated communities have well planned sewerage drainage and solid waste disposal system with private garbage

collectors service providers. On the contrary, some of these gated communities release untreated waste into the riparian zones of the rivers . Some of its residential developmemts have encroached onto the riparian land of these rivers and resource use conflict exist on this part of land with occasional flooding of the houses on this flood plain and a court case in Machakos court over the same see plate 7 above .The presence of the two rivers in this Ward; Athi-river at the core of the town and Mto-mawe at the suburb have facilitated practice of urban agriculture on these riparian lands. Crops like maize, bananas, sugarcane, paw paws; vegetables are grown on these riparian zones and on land adjacent to the rivers. Lastly, mining of construction blocks is also done on the quarry site located along the Mto-Mawe while illegal sand harvesting is done on the banks of Athi-river.

*Plate 8: Urban Agricultutre Field 2019*

## 5.4 Land-use & Environmental Planning Opportunities/ Constraints in Athi-river.

This section of the research findings captures the major land use planning opportunities/ constraints in the town. This was determined using parameters such as the residents perception on the environment and by nature and type of natural resources available and their utilization.

### 5.4.1 Understanding and Perception on Use of Environmental Resource.

The residents of Athiriver had different understanding on what natural resources are. Majority of the residents could identify various natural resources within Athi-river ward but understood these resource as government land/resources as shown in the figure 8 below.

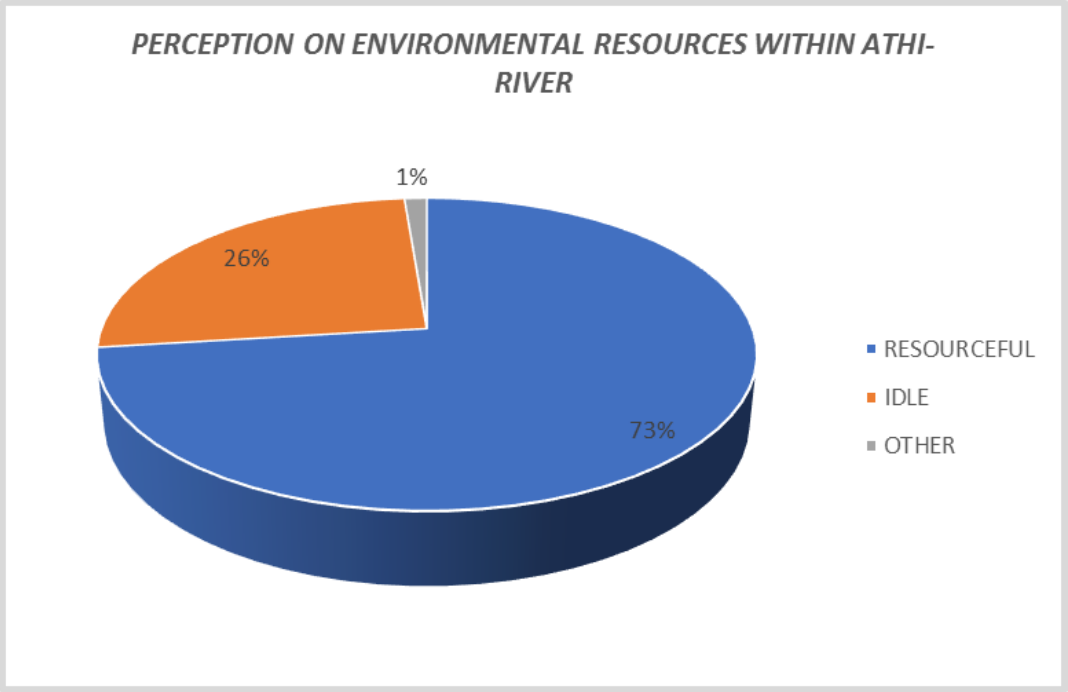



*Figure 13: Different perceptions on natural/environmental resources.*

### 5.4.2 Nature and Types Of Environmental Resources in Athi-River Ward and Their Utilization

Various land-use activities were being undertaken in Athi-river town and its urbanizing suburb at the time of study. The sustainability of these land uses had to be determined in relation to each other and the entire urban ecosystem. The dominant types of developments undertaken in this town were as follows;

a) Housing and Institutional Developments

With the increasing demand for housing far much beyond the supply of the same in the town, most low-income groups who cannot afford better houses end up in the slum settlements increasing pressure on the available land. As a result, the open lands like the rail way leave, riparian zones, roads and industrial buffer zones are targeted leading to encroachment of unplanned structures. Some of the people living in these areas revealed that they had bought the land from veteran residents. On the other hand, institutions such as schools and churches revealed that they erected structures on this land because it was open space that belonged to no one.

b) Infrastructure Utilities

Infrastructure and service networks related to drainage and mobility often affect the urban ecosystems. This is because trunk sewers and water mains among others are normally accommodated within the riparian zone. It's the same case along the riparian zones of Athi-river and Mto-mawe with the belts accommodating open man holes, underground water pipes and sewer lines as shown in plate 9 below.

Plate 9: Open Manhole along Mtomawe Riparian

C) Solid Waste Disposal

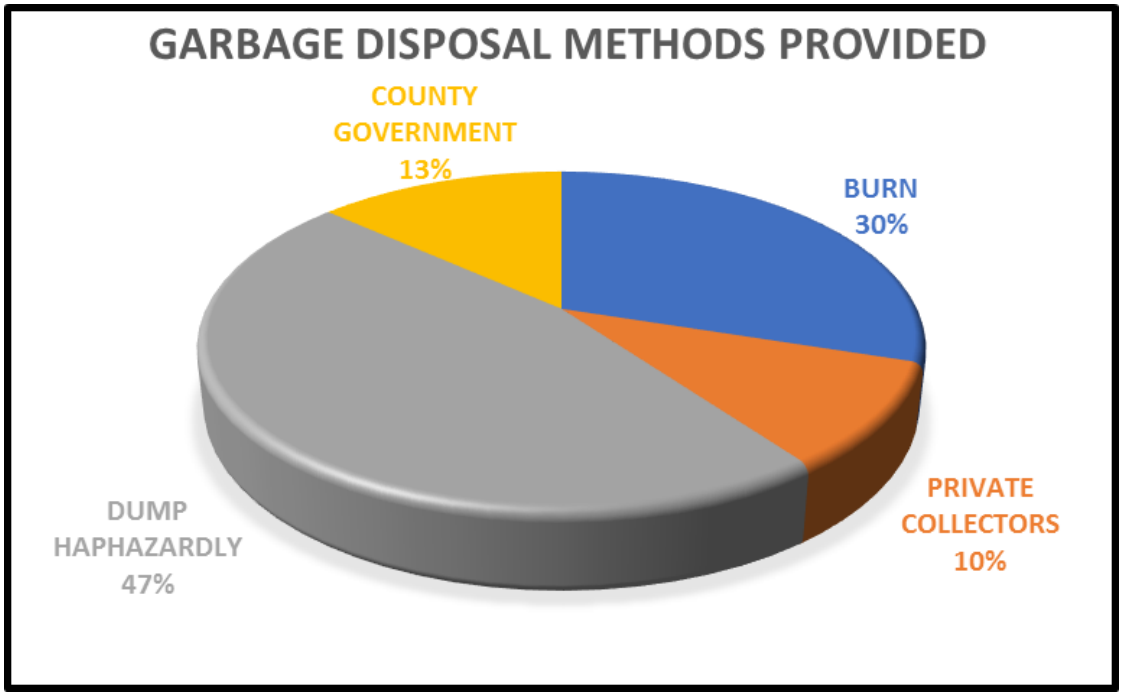



*Figure 14: Solid Waste Disposal Method ( Source: Field Survey 2019)*

Solid waste disposal is a major challenge facing the study area. There is poor provision/lack of garbage disposal collection and disposal services within the slums at the core of the urban centre. This is very evident with proliferation of dumpsites along the roads and railway line. These have led to the reduction of aesthetic value of this town with plastic bags dispersed allover. During rainfall these waste ends up in the river as seen in the river system and on the trees during field work. The study revealed that most residents collect the waste individually and dispose it off along the roads or any other open space within their proximity. Most of this waste is carried away by surface water runoff into the river endangering the lives of animals that rely on this river as source of water. Some of the residents burn their waste in the open spaces within their households while a few said that

*Plate 10: County Government Solid Waste Bin (Source, Field 2019)*

they have access to the County Government of Machakos garbage collection services see plate 10 above.

D} Human Waste Disposal

The disposal of liquid waste in both business and household level is a big problem in this urban centre. The inadequacy in provision of sanitation facilities in the slum is among the reasons given for haphazard human waste disposal. Most of the residents use ventilated pit latrines shared amongst several households while afew have toilets see figure 10 below. The pit latrines in these settlements have taken advantage of the river system, sewer lines and the manholes along these rivers. These latrines are exhausted by private exhausters who end up disposing these human wastes on either Athi-river or Mto-mawe at the odd hours of the night. On the same, the planned residential areas it's either manholes are built on the riparian zone or directly connected to the main sewer or constructed with pipes directly emptying the waste into the river as the case in Green park Estate at the periphery of the ward.

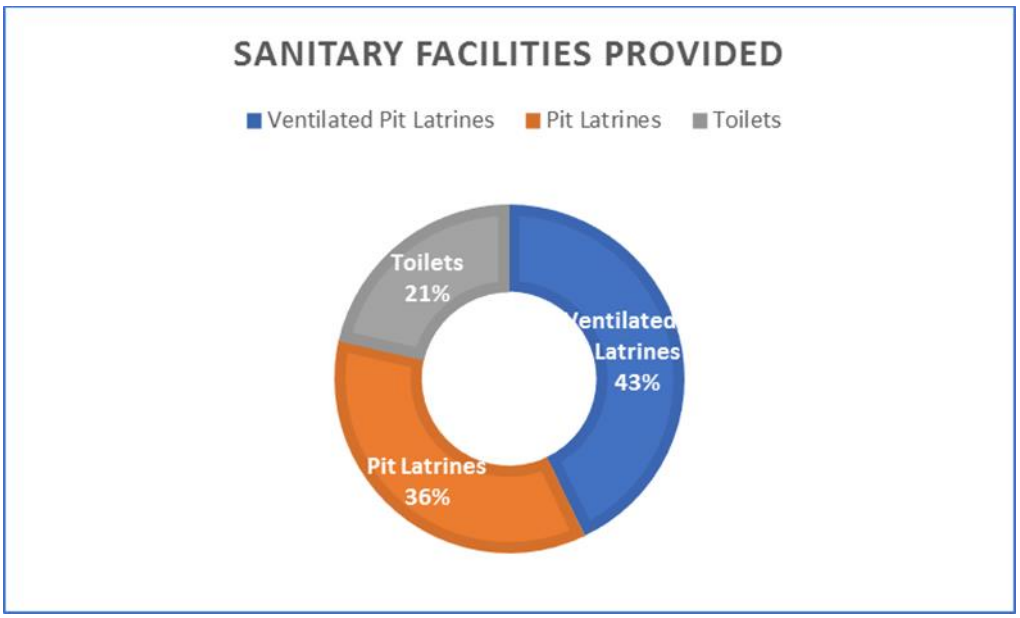



Figure 15: Human waste Disposal Methods ( source; Field Survey 2019)

E) Storm Water Drainage and Industrial Effluent discharge

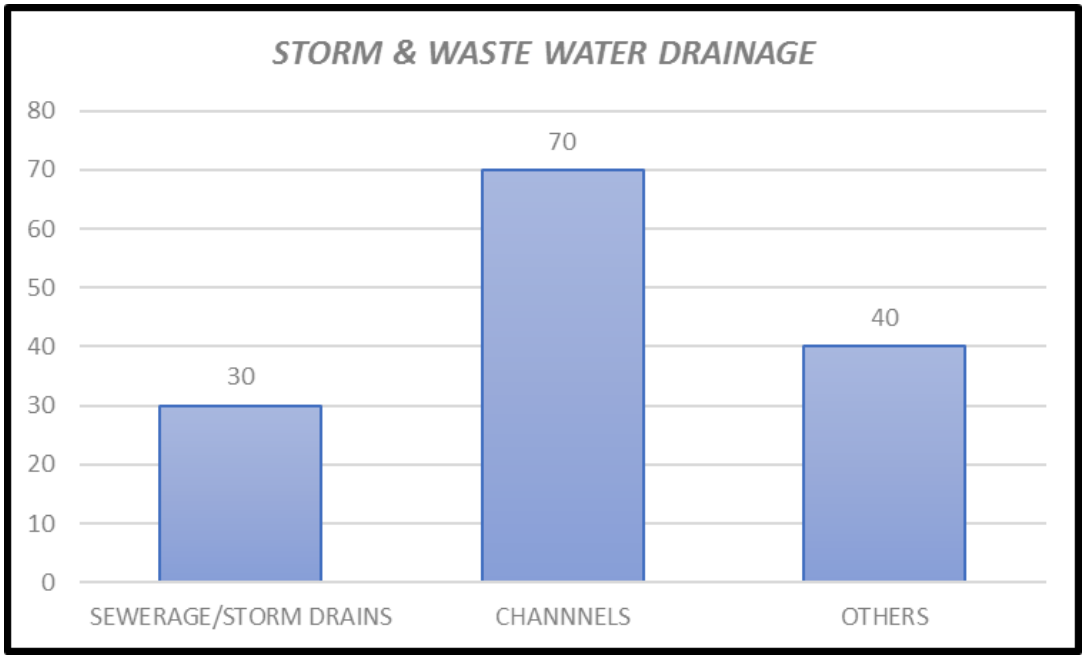



*Figure 16: Storm and Waste water Disposal ( Source; Field Work 2019)*

Interviews and observation at both household and industrial level revealed that there is inadequate provision of storm drains in general see figure 11 above. Storm water drains by gravity with no articulated channels for the drainage. Storm and waste water from industries, business premises and households drain through open channels which are very shallow often causing flooding in the area. Untreated industrial waste and other oil substances from the industries and petrol stations in the town and along Mombassa road flow in these open channels into the river system endangering both the lives of the residents and the community. Of importance to note is the water from carwash services offered at the banks of both rivers. These water heavily polluted with oil drains back into the river compromising the quality of the heavily polluted waters futher.

f) Quarrying / Mining Activities

*Plate 11: Abandoned unfilled Quarry Site In Lukenya (Source; Field 2019)*

The most predominant land-use in the core of the town comprises of industries ranging from heavy manufacturing like Devki steel industries, chemical industries to light industries. These industries make little or no use of the natural resources within the town but some of the factories get their raw-materials from quarries in Lukenya leaving unrefilled abandoned sites as shown in plate 11 above which pose health harzards to the residents around the quarry sites. These quarry sites are a health hazard to the residents because they are deep pits which have been abandoned for a long period of time.

G) Urban Agriculture and Livestock Keeping

This study revealed that residents of this urban centre carry out urban agriculture as shown in plate 12 below. The agricultural activities are carried out on small scale and range from the cultivation of vegetables such as kales, spinach; cultivation of maize, fruits like paw paws and

bananas; sugarcane to cultivation of forage crops such as Napier grass. These farmers carry out farming throughout the year with irrigation sustaining their production. The study also revealed that these farmers do not use fertilizers for their crops but instead use manure from animal dung. But some of the farmers use pesticides on their vegetables. Livestock keeping is also a common activity in Athi-river with most of the farmers allowing their cattle to freely graze on the riparian zone, railway line and any open grass land while a few have zero grazing units for their livestock.

Plate 12: Urban Agriculture (Source, Field 2019)

H) Commercial Activities

The study revealed that there is presence of commercial activities ranging from banking halls, 3 star hotels, supermarkets, whole sale supply deposits to micro-banking, shops/kiosks, community toilets, water and food vendors, shoe repairing, mini hotels to open market space at the core of the town as shown in plate 13 next page. Most business owners revealed that they had legal rights to ownership of their businesses as well as permits/licenses to operate the same. They were allocated land and spaces to establish the business with approval by the county government and other institutions.

Plate 13: Business Activities at Devki. Source: Field Survey, {2019}

In conlusion, land use ctivities in this town are immensely controlled by the physiographic features of the study area and their impacts on each other and on the enviromment are as have been discussed in the table 3 below and shown in figure on page 79.

| **Nature of Development/Type Land-use** | **Effects of the Various land-uses on the Urban Ecosystem** |
|---|---|
| Human Settlements/Housing and Institutions | ✓ The human settlements in the core of this town house thousands of the towns urban poor. To the structure owners who rent them out to tenants these settlements are a source of their income.<br>✓ These settlements encroach on to the rail/road wayleaves and industrial buffer zones reducing the zones compromising the ability of this zones to perform their functions.<br>✓ In general, as much as these settlements offer housing and are a source of income to people, they are unsustainable in that their location along these zones is a health hazard to the community and a threat to the urban ecosystem. |
| Infrastructure utilities & Services | *Infrastructure Utilities/Services* |

- ✓ Infrastructure utilities are supposed to be accommodated along these riparian reserves but the manholes and main sewers along these rivers can be classified as unsustainable land-uses because:
  - Some of the man holes on the riparian zones are open and become a health hazard to the residents.
  - Open manholes block during the rainy seasons because of disposal of solid waste causing overspill of human waste and other oil products into the environment.
- There are frequent sewer bursts that cause seepage and overspill of sewage on the environment.
- ✓ Solid Waste Disposal; Inadequate provision of solid waste disposal methods at the household level has caused to proliferation of solid waste on the environment.
- ✓ Solid waste destroys the quality of urban environments and renders them unattractive for human use.
- ✓ Solid waste along the riparian reserve chock riparian vegetation.

*Human Waste Disposal;*

- ✓ The construction of pit latrines whose waste is dumped on the riparian reserves by exhausters increases the level of organic waste in the rivers thus increasing the BOD demand of the river system.
- ✓ The proliferation of human waste on the riparian reserves, railway/road wayleaves renders the zones smelly and impassable and unsuitable for community recreation activities.

*Industrial Effluent & Storm Water Disposal*

- ✓ Unarticulated storm water channels are highly eroded increasing pollution of Athi-river & Mto-mawe River by sediments.
- ✓ Industrial effluents compromises the quality and quantity of water in these Rivers.
- ✓ The discharge of untreated industrial wastes into these rivers leads to accumulation of toxic effluent on the reserves.
- ✓ This could have long residue effects on human health if crops irrigated using these polluted waters are consumed.
- ✓ Accumulation of these toxic wastes has lead to growth of alien vegetation species due to genetic mutation.

| | |
|---|---|
| | ✓ Growth of these invasive vegetation species suppresses the healthy growth of native vegetation on the reserve. |
| Commercial Activities | ✓ Most businesses in the core of the town have no proper mechanisms for solid waste disposal therefore they dispose off their waste on any open land resulting into accumulation of such waste on the urban environment.<br>✓ To the other business which have access to county government garbage container the waste isn't collected promptly causing spillover and bird , animasl and human scavangers in the town. |
| Urban Agriculture/ Livestock Keeping | ✓ Urban agriculture practices along the rivers in Athiriver are a source of livelihood and job to the poor in urban areas.<br>✓ Urban Agriculture increases the supply of food in the town.<br>✓ But the use of agro-chemical threatens the aquatic/marine life.<br>✓ In addition over cultivation leads to degradation of the riparian zones while overgrazing leads to loss of vegetation cover and increased soil erosion levels.<br>✓ The free grazing of cattle leads to spread of parasites in the town.<br>✓ The water used for crop irrigation are highly polluted and consumption of such crops could lead to human health complications such as growth of cancerous cells among others.<br>✓ The bushy un-landscaped sugarcane plantations are potential sites for criminal activities. |

Table 3: Effects of Land-Uses in Relation to each other and the urban Ecosystem Source: Author, {2019}

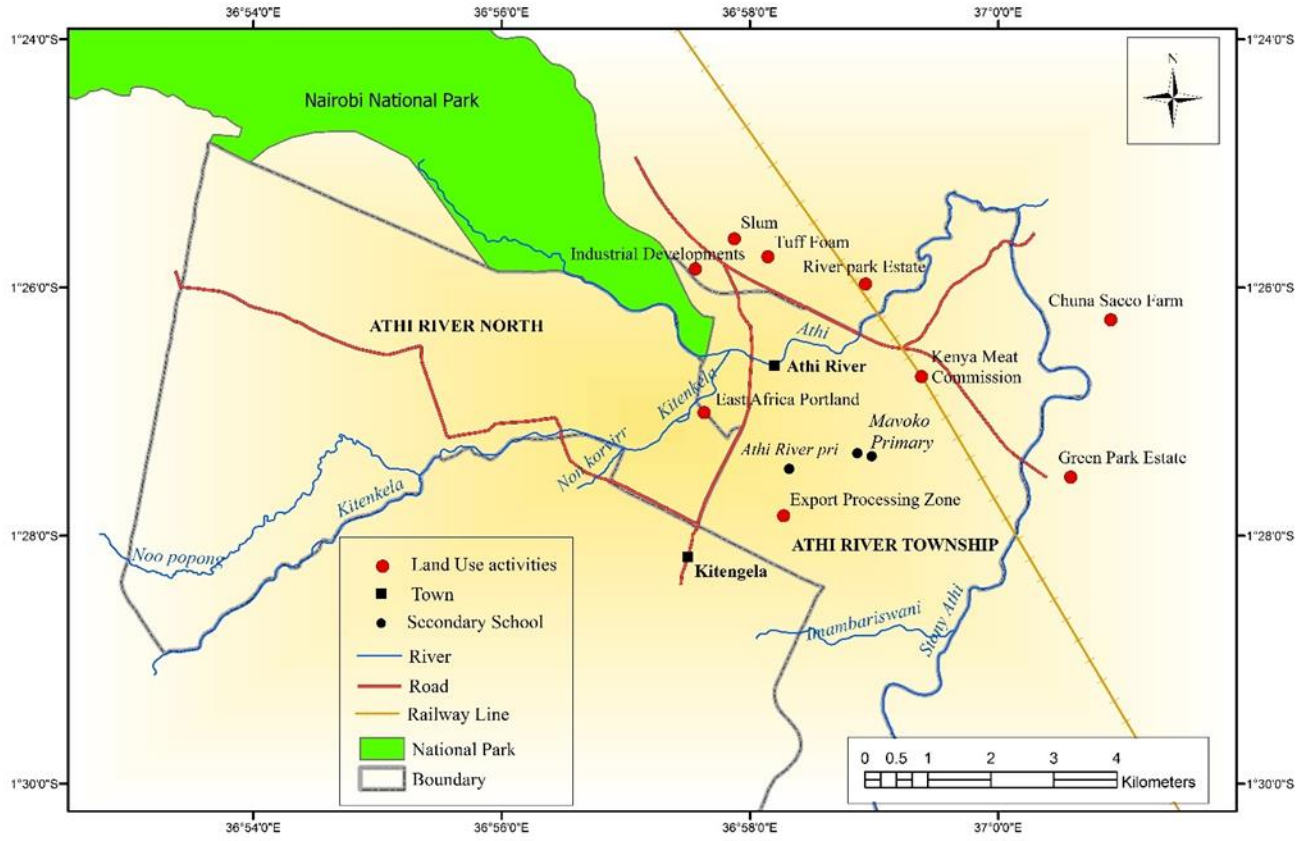



Figure 17 : Major L and-use Activities in Athi-River Ward{Source: Author, 2019}

## 5.5 Land-use Planning for Sustaianble Urban Ecosystem

This section of the research findings looks at sub-objective no.4; the role of land use planning in minimizing the negative effects of land-use change on the environment within Athi-River and it demonstrates why land use planning is important.

### 5.5.1 The Role of Institutions

Various institutions are involved in sustainable utilization of environmental resources within an urban ecosystem. This section highlights the role of some of these institutions responsible for ensuring proper land use planning in this urban centre and its environs to minimize the negative environmental effects of land-use change.

**A. County Government of Machakos**

This research is under the jurisdiction of the County Government of Machakos (CGM) and as the host, the government has to provide guidelines on specific development project standards. The is the local authority charged with planning for developments in Machakos. It's thus responsible for the approval of all development plans in the town. With regards to its county bills the CGM does not allow any developments to take place haphazardly on wayleaves, on industrial and riaparian buffer zones. If any plan does not adhere to recommended distance onto a river front or industrial buffer or road reserve it is not approved.

The CGM is also responsible for the provision of and maintenance of open spaces and greenery in the town. Concerning maintenance of the riparian zones of Athiriver and Mto-Mawe the CGM has failed because they have not been able to maintain this riparians as recreation sites for people of Athiriver who have no access to public open spaces.

The County Government is also responsible for providing essential services including; disposal of solid waste and sanitation facilities. But however, the CGM has failed as a service provider because they consider informal settlements illegal therefore are not considered for service provision by the local government. The CGM in patnership with other governmental and non-governmental organizations have come up with various programmes to ensure rehabilitation and restoration of these urban rivers.

**B. Ministry of Lands**

The Department of planning under the Ministry of Lands plays an important responsibility in land-use planning. The study established that this department has the responsibility to develop land-use policies and advice local authorities on the most appropriate use of land including land management. The department also participates in the process of plan approval, enforcement of planning standards, development control within the city. In addition, the department collaborates with other agencies like WARMA and NEMA to ensure environmental conservation and protection.

**C. National Environmental Management Authority**

NEMA is a regulatory body that deals with environmental issues at a macro level perspective. This study established that the main function of NEMA is to promote integration of environmental considerations into development policies, plans, programmes and projects, with

a view of ensuring the proper management and rational utilization of environmental resources for the improvement of the quality of life in Kenya. The Marine Department in NEMA strives to ensure that all wetlands and their ecosystems are protected from environmental degradation. To prevent degradation all proposed developments are expected to submit E.I.A reports to ensure that the proposed developments do not compromise the quality of the environment. They also came up with a National Wetland Policy and Water Quality Regulation 2006 which governs utilization of wetlands/watersheds, management and conservation. These regulations outline the setback limits for wetlands and recommend the sustainable activities which can be carried within a watershed.

**D. Ministry of Environment and Forestry**

The ministry of environment and forestry is mandated with monitoring, protection, conservation and management of the environment and natural resources by ensuring their sustainable utilization and exploitation for socio-economic development aimed at eradicating poverty, improving living standards and ensuring that a clean environment is sustained now and in the future.

### 5.5.2 Challenges in Land-use Planning for Sustaianble urban ecosystem in Athiriver

a. ***Conflicting Riparian Standards and Enforcements***

The study revealed that different statutes and different institutions have different standards regarding the width of riparian zone. Measurement of each width is measured from the middle of the river to both sides of the banks. Different Acts describe the riparian zone as follows: EMCA, 30M, Physical Planning Act, 10M, Agriculture Act, 10M, CCN By-laws, 30M, Survey Act, 10M and the Water Act, 6-30 M wide zones. These discrepancies in the widths of riparian zone act as a setback in the implementation and enforcement of developments along the riparian zones of Athiriver and Mto-mawe. The Acts also differ on where the measurement of a riparian zone should start with some citing the edge of the river bank, others the centre of the river and others the highest flood/water mark. These conflicting statutes make it difficult for various institutions to carry out enforcements because of the differences in interpretation on the size of a riparian zone a good example is the case on Green-Park Estate Developers and WARMA on Mto-Mawe flood plain whose case on boundary conlict is still pending determination at the Machakos court.

b. ***Inadequate Provision of Facilities***

Inadequacy and the lack of provision of facilities such as solid waste disposal, storm water drains and sanitary facilities within the slums in Athiriver have left the residents with no option other than taking advantage of the open land for solid waste disposal. The study indicated that the residents were not satisfied with the level of service provision and as a coping mechanism they dispose off solid and human waste on the open lands within the town because to them it's idle land. Others who can afford construction of pit latrines empty these wastes directly into the river after exhausting the latrines when they are full.

***c. Lack of Awareness***

The study revealed that a number of the residents of these slums viewed the riparian zone and any other open space as idle land which needed to be put into use. Most of the residents understood the riparian zones as government land while a good number understood this zone as a flood plain which has a 30M wide setback provision for any development. For the people who viewed this zone as idle land they proposed that it should be put into use such as settlement, farming activities among others. Such ignorance has lead to the misuse of these riparian zones rendering them unsustainable riparian systems within the larger urban ecosystem. Most of the institutions interviewed also pointed out lack of awareness on the importance of environmental resources suchs as forests and riparaian zones as the main factor preventing sustainable utilization of these God given natural resources.

d. ***Encroachment of Urban Developments***

The high demand for development land has exerted pressure on available land and further resulted into encroachment of not only road/rail reserves but also on ecologically fragile areas such as the Athi-River and Mto-mawe riparian zones. The problem is further compounded by the emergence of informal settlements which are highly congested and overcrowded. Influx of more population into these slums lead to construction of more housing structures along the road/rail reserves as this is the only open and unbuilt land. These structures and the inadequacy in provision of services and facilities within them compromise the sustainable functioning of the urban eco-system.

On the other hand urban agriculture within the town has encroached on the riparian zones of the two rivers loosening soil increasing erosion and chemical pollution into the rivers from pestcides used on the crops. on the same overgrazing practices within this town increase soil

erosion causing sedimentation of these rivers as loose soil is washed downstream by storm water.The study sought to explore the development opportunities presented by available natural resources to the Athiriver community.

With a great percentage viewing environmental resources as resourceful to them the community proposed various opportunities that the two river systems and private forests present to them. The community and the institutions interviewed highlighted some of the opportunities the riparian reserves can present to the surrounding communities. These included;

i. ***Recreation:*** the riparian zones have no developments and are potential open spaces for recreation activities.
ii. **Eco-tourism**: these zones can be made tourist attraction sites with excellent conservation of riparian biodiversity.
iii. **Urban Agriculture**: residents can embark on sustainable agricultural activities increasing food security as well as providing employment opportunities to the urban poor.
iv. **Business**: the riparian sites can be good sites for open air markets.
v. **Provision of portable water:** enhancement activities and dislugding can increase the provision of portable water in the long-run.
vi. **Tree planting**: the riparian zone can be used as good sites for tree nursery seedlings for sale and afforestation of the river banks.
vii. **Fish rearing**: these riparian zones have potential for aquaculture/fish rearing to provide food to the Athi-river community and the City as well.

### 5.5.3 Constraints Presented by the Riparian Zones of Athi-river and Mto-mawe to the Development of Athi-river Community

Despite the many development opportunities presented by these riparian zones, the community viewed the two rivers as major constraints to development because it's a health hazard to the community, flood their houses in rainy seasons and are crime prone zones. At their current condition the rivers are a health hazard to the community because of their high levels of pollution. During the rainy seasons the rivers burst their banks into people's houses e.g Green Park and Sunrise Estates thus causing temporally displacement and destroying farmers' crops. The unkempt bushes along the rivers act as good sites for criminal activities. Many residents complained of bad odours and poor conditions on the riparian zones rendering them filthy and impassable.

## 5.6 Testing of the Hypothesis

The study endavoured to test the validate the alternative hypothesis that "that there is a significant relationship between land-use change and the state of the urban ecosystem in Athi-river town; as overtime, land cover has changed due to land use conversion/transformation as the town grows causing soil, air and water pollution and environmental degradation. See table 4.

| Physical Attributes | Link between physical Attributes & Effects of Land-use change on the environment (Source: Author {Field Survey, 2019}) |
|---|---|
| ***Geology and Soil*** | ✓ Underlying Black cotton soil is of poor drainage therefore it renders the area poorly drained with a lot of swamps and flooding occasions during rainy seasons.<br>✓ This is worsened by stagnant dirty water which has negative health implications.<br>✓ The slope of the land leads to a rapid flow of surface runoff, liquid waste such as oil from fuel stations among other pollutants onto the rivers within the study area.<br>✓ The soils on the riparian zones and along the road/railway wayleave favour agricultural activities; therefore residents engage in small scale agricultural activities which are a source of income, food and employment to many.<br>✓ Cultivation along the rivers increase sedimentation and chemical pollution in to the river from agro-chemicals. |
| ***Rainfall pattern within Athi-river town*** | ✓ During rainfalls, both riparian zones and major roads floods with dirty water. This leads to displacement of the people from houses located near the riparian zone. Eg Green Park Estate-Athiriver.<br>✓ Rainfall turns the Athi-river riparian zone into a temporary swamp which is hazardous to area inhabitants because some people and children drown.<br>✓ Farmers too lose their crops because they are submerged in the waters or even swept away by the waters.<br>✓ Floods submerge footbridges and the footpaths become impassable and accessibility from one bank of the river to the next is impaired; school going children end-up missing classes, businesses operated along the river are closed and man-hours wasted as people use long routes to link other parts of the town.Eg MTO MAWE. |

| | |
|---|---|
| ***Drainage*** | ✓ The linear drainage of the areas influences the laying out of utilities such as water and storm drain pipes.<br>✓ Most utilities are buried on the road/rail wayleave and riparian zones ranging from water pipes, sewer trunks and manholes. All waste water is directed into the Athiriver River and Mto-mawe or the road open storm drains . Most of this waste water is untreated compromising the quality and quantity of water in these two rivers.<br>✓ Natural storm water drains also follow the drainage pattern often passing through the riparian zones to these rivers. Such a flow acts as river recharge for the river both surface wise and ground water recharge. |
| ***Vegetation*** | ✓ Vegetation found in athiriver such as napier grass makes the zone a suitable grazing land. Overgrazing opens-up the soil cover increasing the rate of erosion hence sedimentation of the rivers.<br>✓ Bushy vegetation such as the sugarcane plantations reduces visibility creating zones for criminal activities.<br>✓ The trees provide shade creating a good environment for recreation and relaxation on the roadsides and along the rivers. |

Table 4 : Link between physical Attributes & the Effects of Land-use change on the environment (Source: Author {Field Survey, 2019})

## 5.7 Discussion

In conclusion, it can be generalized that Athiriver town under study is an unsustainable urban eco-system. Several complicated feedbacks exist between the natural environment and urbanization in Athi-river. The urban sustenance and the development that sparks off its economic boom depend on mining or use of environmental assets and ecological services and disposal of waste into the environment. Nevertheless, overexploitation of these resources could lead to their depletion/extinction whereas the build-up of solod/liquid wastes and other toxins can subdue the ecosystems' carrying capacity, exacerbating environmental degeneration and endangering the residents' security & protection and the nations economic development. Overtimne, land cover has changed in Athi-river. Vegetation cover has reduced from 9.2 % to 3.4 % while bare land has increased to at an alarming rate from 17.9 % to 47.5 % (Field, 2019) This implies that the ecosystem functioning of this urban araea has been affected. At the same time, the ability of the area to regulate disasters such as floods and droughts has been declining as flooding instances are on the rise and erratic rainfall patterns in the last 10 years which was reported by several residents. This is proven by the encroachment of land uses onto the riparian

zones, industrial buffer zones and road/rail wayleaves; the unsustainable agricultural activities carried out along these rivers, presence of solid and human waste, presence of pit latrines and ponds filled with industrial effluents, presence of unfilled abandoned mining sites and the presence of bursting sewer lines and open manholes along the riparian zones of Athiriver and Mto-mawe Rivers (Field, 2019)

The settlements at the core of the town are as old as the town itself and several planning attempts in the town tend to treat these settlements like they never existed. The county government doesn't provide essential services in these settlements because they are illegal. Therefore, the slum dwellers with no other option, dispose off solid and liquid waste indiscriminately onto the environment; on open land along the foot paths/roads and the along the railway line and open storm drains. Storm water drains are not well articulated and are vulnerable to erosion increasing sediments into the water courses. The settlement is served by non-sewer sanitation in form of pit latrines. Toilets and pit latrines are constructed with no connection to sewer line and are exhausted when full and the waste dumped into the river illegally at night. Presence of human waste and solid waste is also evident on the railway, foot paths, riparian zone and on the edges of major industrial developments.They are mainly used as a dump site. In conclusion, the interaction between the urban ecosystem and the settlements is unsustainable; with the highly polluted river and the environment being a health hazard to the people while the human activities are degrading the entire urban ecosystem overtime.

As mentioned earlier, this stretch of Athi River remains the highest polluted stream in the country with high chemical pollutants such as heavy metals from the industries (NEMA, 2015. Industries are expected to be responsible institutions which treat all their waste before releasing into water courses. On the contrary, most of these industries release untreated or even insufficiently treated waste water into the river degrading the river ecosystem with a recent case of dead fish floatimg on the riparian zone with industrial pollution been the most speculated cause of their death.The study also established that the community in Athi-river town lacked information on the importance of river protection, conservation and management. This has caused unsustainable utilization of the two rivers compromising the quality and quantity of water in the two rivers. Lack of standard riparian management guidelines and harmonized laws regarding riparian size and utilization has led to its unsustainable use. This is as a result of un-coordinated operations of the same institutions regarding riparian utilization which do no effect the environmental protection and conservation of the riparian belt for sustained utilization.

Despite all this issues; the residents and the various institutions involved in development of these research ideas pointed out the opportunities that these riparian zones can present if sustainably utilized and managed. These ranged from social, economic to environmental opportunities as mentioned earlier. In general these two riparian zones are the major environmental resources within the town. As indicated earlier they are viewed as resourceful by both residents, industrial developments and the neighboring institutions. As resources these riparian zones can be used to improve the living standards of Athi-river residents.

# CHAPTER SIX: SUMMARY OF KEY FINDINGS, CONCLUSION AND RECOMMENDATIONS

## 6.1 Introduction

This section summarizes the entire study by highlighting the emerging issues on land-use change and its environmental implications with reference to socio-economic and environmental dimensions of sustainability of the urban ecosytem. It recommends interventions that may be applied to ensure proper environmental planning for a sustainable community and urban eco-system in the town under study. In the end it proposes areas for further research.

## 6.2 Key Findings

Sustaining this urban ecosystem has proven a very difficult task but not impossible. It requires integration of various activities through stakeholder involvement from the grass root level to the national and international levels. Various issues which compromise sustaining of urban eco-systems have been highlighted ranging from lack of awareness on environment related matters to conflicting laws and policies among others. These issues have been summarized below as emerging issues and their economic, social and environmental planning Implications.

Athi-river's huge and rapidly growing populace is one of the major forces behind the towns un-sustainable use of its eco-system. Present day immigration into urban areas from rural areas, high fertility rates & low mortality rates and lack of proper planning have collectively continued to degrade the town's environmental quality. The prevailing environmental conditions in this dryland are fragile and harsh. Land-use change in Athi-river takes place in an already fragile ASAL area and is aggravated by natural disturbance such as drought and flooding overtime which have lead to land degradation. This scenario is worsened by recurrent famine and the inflow of people from other areas into the town. Subdivision of lands into small inefficient patches has worsened the situation further. As the town grows, its faced with the conundrums of pre-planning for development that will provide sufficient housing and efficient services while protecting the natural environment within and around the town, air and water quality. The sprawling of slum/shack settlements inhibit the delivery of social services negatively affecting the quality of life in this town as most of these settlements encroach onto the road/rail reserves and industrial buffer zone. The riparian zones and road reserves have

been converted into a dumpsite. Due to political and economic instability the County Goverment finds its almost impossible achieve the reccomended growth that would foster comfortable living and sustainbale environments.

The study revealed that a number of the residents of these slums viewed the environmental resources such as the riparian zones, road/rail reserves, the industrial buffer zones and open land as idle land which needed to be put into use such as settlement, farming activities among others. Such ignorance has lead to the misuse of this riparian zone which happens to be the major environment resource in Athi-river rendering it an unsustainable riparian system. The institutions responsible for management and conservation of this riparian zone cannot afford keeping watch on this riparian all the time thus the fate of this river systems lies ultimately with the local communities. With the high ignorance level mentioned above, then sustainability of this river system is rendered almost impossible. In addition, the study revealed that different statutes and different institutions have different standards regarding the width of riparian zone and the point from which this width should be taken. These discrepancies in widths of the riparian zone act as a setback in the implementation and enforcement of developments along the riparian zone. These conflicting statutes make it difficult for various institutions to carry out enforcements because of the differences in interpretation on the size of a riparian zone. If this issue is not dealt with appropriately then sustainability of these urban river systems will never be achieved.

Planning strives to place compatible land uses close to each other while separating incompatible land uses to minimize conflicts between diverse land-uses. In the study area incompatibility of land uses is very evident ranging from location of solid waste dumpsites haphazardly on any open spaces to the proximity of most residents to noxious industries. Such in-compatibility has negative health and environmental implications. The CGM has failed in the provision of infrastructural facilities. Inadequacy and the lack of facilities such as solid waste disposal sites, storm water drains and sanitary facilities within the town have left the residents with no option other than to use the open land resources. About 80% of the residents were not satisfied with the level of CGM service provision and as a coping mechanism they dispose off solid and human waste on the riparian zone and any other open land because to them it's idle land. Others who can afford construction of pit latrines construct empty the waste and dump into the river . Surface water runoff heavily polluted with sediments and oily substances finds its way into the river due to lack of planned storm drains. This has detrimental effects on the river and the urban environment.

The presence of mining activities along these riparian zones compromises the quality and quantity of water in these river systems. The disposal of mining residues in the riparian reserve compromises the quality and quality of water in the river while the unfilled abandoned quarry sites are a health hazard to the community because they become breeding zones for disease vectors such as mosquitoes responsible for malaria outbreak inn the area. In addition, the dis-organized filling processes lead to more solid and chemical waste ending up into the river as human and bird scavengers feed on and or sort out the waste.

Some residents in the study area practice urban agriculture and livestock keeping on these riparian zones and any other open grassland. The use of agro-chemicals threatens the aquatic life. These agricultural activities are characterized by over cultivation which leads to degradation of the riparian zones and overgrazing which further leads to loss of riparian vegetation, increased soil erosion levels and loss of soil fertility.

Issues concerning utilization and management of the environmental resources within Athi-river town have been handled in a 'laissez faire' manner implying that nature is left to take its own course thus there is no control over events taking place on the environment. Institutions responsible for management of the environment are not strict on enforcement and development control. This has led to degradation of Athi-rivers urban eco-system. Such laxity led to negligence by industries as they discharge untreated chemical effluents into Athi and Mtomawe Rivers and air pollutants since there is no strict adherence to the 'Polluter Pays' rule.

## 6.3 Conclusion

As much as urbanization isn't the sole determinant of environmental degeneration, it undeniably inspires choices/resolutions that result in degeneration of both natural and built enviroments. Nowadays, deleterious urbanization is more rampant in impoverished areas of developing countries where the political and socio-economic systems can't sustain the huge immigration into urban areas from the remote rural areas. To restrain these deleterious consequences of urbanization, leaders ought to master how to offset the demands/desires of both the countryside and urbanized population without forfeiting one for the other. Some of the urban issues that need the collaborative deliberation by governments, non-governmental organizations, native residents, civil institutions and development partners include: insufficient housing, rehabilitation and upgrading of informal settlements, joblessness, insurbordination, lawlessness, lack of water, improper drainage and sanitation facilities, lack of satisfactory public transport and ecological degeneration, destitution among others. Enhanced and more

dynamic planning ought to be done to anticipate as well as influence development over the years and financial investment in urban areas should be controlled reasonably with consideration for both the natural and built environment.

## 6.4 Policy Recommendations

**a. Community Sensitization**

Public awareness and education on management and conservation of envrironmental resources among the slum dwellers can provide an entry point to sustaining utilization of this urban eco-system, importance of sustaining urban rivers and how such activity will contribute to their livehood. There is need to educate the residents of Athi-river. This can be achieved by implementing public awareness and environment education campaigns particularly among the slum dwellers on relevant laws and regulations regarding environmental conservation.

**b. Harmonization of Policy, Legal and Institutional Frameworks**

There is urgent need to harmonize policies, regulation and laws on water resources, land allocation and development in general because management of the environment, that is water resources in particular rivers, require integrative and adaptive approaches. Inconsistency in statutory laws and policies undermines their enforcement and development control of riparian zones.

**c. Encouraging Community Participation**

The involvement of communities in proper natural resources' utilization and decision making can bring about sustainable livelihoods and environments. The entire community act need to be collaboratively involved in sustainable use and conservation of the Athi River and Mto-mawe systems. With community participation, high leader-member interpersonal skills and cooperativeness are required. The community would be involved at all stages of environmental planning for efficiency and effectiveness to be achieved. Such participation would help where Participatory Rural/urban Appraisal {PRA} techniques are used because they incorporate approaches the communities themselves can manage and control and employ locally selected and serviceable technologies and policies.

**d. Stakeholder Involvement**

All the stakeholders who have demonstratable interest on ensuring sustainability of Urban eco-system or who will be impacted either positively or negatively by planning intervention of this

town need to be involved. This would include the relevant government ministries, parastatals, NGOs, private sector agencies and community members. The future condition of environmental resources and services are closely linked to how well all stakeholders cooperate in definition of a coherent management structure and enforcement mechanisms that are acceptable to all.

**e. Rehabilitation/ Restoration of Athi-River and Mto-Mawe**

These two rivers are exposed to many town processes and human activities which pollute the environment and degrade the river systems. Reinstating the health of these river ecosystem is an enormous task for the government and other stakeholders. The County Government should provide efficients solid waste management mechanism to reduce solid waste dumped on these rivers. The whole stretches of the two rivers can be converted into a open spaces for recreation with well planted trees on the banks to prevent erosion. Restoration of this ecosystem-even if only partially will bring forth significant climatic and topographic impacts with high value returns in from improved quality of life, recreation/leisure and economy o the resident population.

**f. Urban and Environmental Planning Design**

There is need to incorporate urban and environmental design in riparian management and conservation. This helps in reducing environmental impacts of the adjacent developments through integrating environmentally sustainable and responsive design solutions. Urban planning environmental designs need to be adopted in river management and conservation activities. These would include measures aimed at improving;

a. Urban Space Quality; elementary issues which would be considered to improve quality of urban space would include: landmarks, balance between private open areas & public open areas in good condition among others.
b. Cultural Heritage; this regards the public interest. The fact that Athi-river borrows its name from its river sytem becomes a good opportunity to design and landscape these rivers for cultural heritage. The value of cultural heritage is influenced by the nature of preservation, the level accessibility among other factors.
c. Human activities at the riverfront; intensification of human activities with these rivers should be considered because it will boost the likelihood of synergism between the river

and the urban residents. Diversification of these land use activities enrich the urban environment by the inteplay between the urban and non-urban improving the aesthetics.

d. Accessibility; its an indirect factor that makes more or less possible for the people to enjoy the aesthetic values of urban waterfront. The way in which people access the river has great importance.

According to World Bank Green Growth is that is efficient in its use of natural resources, clean in that it minimizes pollution and environmental impacts and resilient in that it accounts for natural hazards and the role of environmental management and natural resources in averting natural disasters. Its important for the residents of Athi-river to go green to reduce their reliance on the national grid electricity supply by investing in clean sources of energy such as solar power and wind energy whose potential is quite high in the area. On the same, developers and the residents should be sensitized on the importance of developing energy-efficient buildings and developing physical infrastructure.

**h. Mobilization of Adequate Resources**

All the above possible interventions cannot be possible without adequate financing. Various stakeholders should collaborate with County government of Machakos and mobilize funds to realize implementation.

## 6.5 Research Recommendations

The study recommened several areas for research in future including;

***a) Urban resilience and sustainability of urban ecosystems:*** there is need for further reseatch on nurturing resilience of urban ecosystems in times of environmental, social , economic and political uncertainities and ameliorating the risk of environment related disasters to achieve and sustain resilience in the event of climate change**.**

***b) Riparian urbanscapes***, There is need for further research on Riverine landscapes which considers the environmental effects of things on space, the relations they have with other things and how these relationships and their impacts are controlled by the features of the surrounding urbanscape pattern at different levels over time.

***c) Riparian management through urban design:*** there is need for further research on how well designed urban plans can be used as an effective means to promote wise use of riparian zone enhancing management

# REFERENCES


Andrew S. Goudie, (1987) The Human Impact on the Natural Environment, 2d ed. (Cambridge, MA: MIT Press)

Anderson, J.R., Hardy, E.E., Roach, J.T. and Wittmer, R.E. (1976). A land use and land cover classification system for use of remote sensing data. US Geological Survey Professional Paper 964. Washington.

Borje, J. and the rest of the Marikina Team (2004). Save the Marikina River. Sound Practice No.6, 3cd Sound Practice Series. Metropolitan Manila, Philippines [Accessed: June 2019]

Bryan R. Roberts, (1995). "Urbanization and the Environment in Developing Countries, in Population and Environment, D. Heddy (editor),, Chapter 10, pp. 303 336.

Carole L. J, Barbara Boyle et. al (1989) "Impact of Trends in Resources, Environment and Development on Demographic Prospects,".

Dasmann, Raymond F,.(1973), "Ecological Principals foe Economic Development"Newyork John Willey & sons.

Francis Koti, Same Place Yet Different Worlds ( 2004) "A GIS and Society Perspective on Kenyan Peri-Urbanization : Morgantown, West Virginia"

Government of Kenya, Census Report KNBS 2009.

Government of the Republic of Kenya, (1999). "Environmental Management and Coordination Act", Government Printers, Nairobi, Kenya.

Government of the Republic of Kenya, (2005), "Forest Act", Government Printers, Nairobi, Kenya.

Government of the Republic of Kenya, (1993), "Local Government Act", Government Printers, Nairobi, Kenya.

Government of the Republic of Kenya, (2012)"The Physical Planning Act", Government Printers, Nairobi, Kenya.

Government of the Republic of Kenya, (2010)"The Constitution of Kenya", Government Printers, Nairobi, Kenya.

Government of the Republic of Kenya, (2002)"Water Act", Government Printers, Nairobi, Kenya.

Government of the Republic of Kenya, (2007)"Kenya Vision 2030", Government Printers, Nairobi, Kenya.

Gretchen Kolsrud , Barbara Boyle Torrey,(1992) "The Importance of Population Growth in Future Commercial Energy Consumption," in Global Climate Change: Linking Energy, Environment, Economy and Equity.

Güneralp Burak, Karen C. Seto et. al. (2013) "Evidence of urban land teleconnections and impacts on hinterlands." Current Opinion in Environmental Sustainability.

Güneralp, Burak, and Karen C. Seto. (2013) "Futures of global urban expansion: uncertainties and implications for biodiversity conservation."

Güneralp, Burak, and Karen C. Seto. (2008) "Environmental impacts of urban growth from an integrated dynamic perspective: A case study of Shenzhen, South China."

Holdren J.P and P.R. Ehrlich (1974) "Human Population and the Global Environment," American Scientist, vol. 62.

Katana S.J.S., Ucakuwun E.K. Munyao T.M. (2013)" Detection and Prediction of Land Cover Changes in Upper Athi River Catchment, Kenya.

Karen C. Seto ,Creutzig, Felix, et. (2015) "Global typology of urban energy use and potentials for an urbanization mitigation wedge."

K. Nsiah-Gyabaah, (2003) "Urbanization, Environmental Degradation And Food Security In Africa"

Kolsrud and Torrey, "The Importance of Population Growth in Future Commercial Energy Consumption": 268.

Lambrechts, C., Woodley, et al (2003). "Aerial survey of the destruction of the Abardare range forests". United Nations Environment Programme, Nairobi, Kenya.

Liu, J., H. Mooney et al. (2015)"Systems integration for global sustainability."

Martin Brockerhoff, (1 996) "Fertility and Family Planning in African Cities: The Impact of Female Migration," Journal of Biosocial Science 27, no. 3.

Martin Brockerhoff and Ellen Brennan, (1998) "The Poverty of Cities in Developing Regions," Population and Development Review.

M. Gordon Wolman, (1993"Population, Land Use, and Environment: A Long History," in Population and Land Use in Developing Countries, ed.

Mulwa P. Ndinda (2012), "Investigating The Sustainability Of The Ngong River System" A Case Of The Stretch Cutting Across Mukuru Slums.

National Research Council, Cities Transformed (2003) "Demographic Change and Its Implications in the Developing World"

National Research Council, (2003) "Understanding Climate Change Feedbacks" Washington, DC: National Academy.

Olima, WHO (2001). "The Dynamics and Implications of Sustaining Urban Spatial Segregation in Kenya – Experiences from Nairobi Metropolis".

Organisation of Economic Co-operation and Development (OECD),"1997 "Better Understanding Our Cities, The Role of Urban Indicators.

Pandey, Bhartendu, and Karen C. Seto (2014) "Urbanization and agricultural land loss in India: Comparing satellite estimates with census data." Journal of Environmental Management.

Seto, Karen C., Burak Güneralp, and Lucy R. Hutyra. (2012)"Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools."

Seto, Karen C., Anette Reenberg et. al(2012) "Urban land teleconnections and sustainability.".

Seto, Karen C., and David Satterthwaite. (2010)"Interactions between urbanization and global environmental change." Current Opinion in Environmental Sustainability.

Seto, Karen C., Roberto Sánchez-Rodríguez, and Michail Fragkias. (2010) "The new geography of contemporary urbanization and the environment."

Seto, Karen C., and Marshall J. Shepherd. (2009) "Global urban land-use trends and climate impacts (2009)." Current Opinion in Environmental Sustainability.

Seto, Karen C., Paolo Gamba, and Martin Harold. (2009) "Global Urban Issues: A Primer." In Global Mapping of Human Settlements.

Seto, Karen C., Robert K. Kaufman, and Curtis E. Woodcock. (2000) "Landsat reveals China's farmland reserves, but they're vanishing fast." Nature 406, no. 6792: 121.

Vandana Shiva (1991) "The Violence of Green Revolution: Third World Agriculture, Ecology and Politics 1991.

S.Uttara, Nishi Bhuvandas & Vanita Aggarwal (2012) "Impacts of Urbanization On Environment"

Tama Francis Koti, (2004) "Same Place Yet Different Worlds: A GIS and Society Perspective on Kenyan Peri-Urbanization"

Turner, B. L., Meyer, W. B and Skole, D. L. (1994) "Global land-use/land-cover change: towards an integrated study".

United Nation (2005) "One Planet Many People":Atlas of Our Changing Environment.

United Nations (2004) "World Urbanization Prospects": The 2003 Revision (New York: UN,).

United Nations 2007a, "World Urbanization Prospects": the 2007 Revision. Population Division of the Department of Economic and Social Affairs, pp244.

United Nations 2007b, "State of the World Population 2007": Unleashing the Potential of Urban Growth. United Nations Population Fund, pp108.

United Nations Human Settlements Programme (2006), "State of the World's Cities"

UN-HABITAT, (2006) "State of the World's Cities".

United Nations (1998) "Kyoto Protocol to the United Nations Framework Convention on Climate Change". United Nations.

UN (1997) "Stockholm Convention on Persistent Organic Pollutants". UN.

University of Nairobi (2005) "Assessment Desk Study, Department of Chemistry, Water Quantity and Quality"

United Nations Environment Programme, (1999) "Annual Evaluation Report, Evaluation and Oversight unit"

World Bank, World Development Report (2002) "Building Institutions for Markets" New York: Oxford University Press for the World Bank.

World Commision on Environment & Development (1987). "Our Common Future"

World Health Organization (2005) "Millennium Ecosystem Assessment".

World Resources, (1996) "A guide to the global environment, The urban environment"

# ANNEXES

## FIELD OBSERVATION CHECKLIST

1. Various land covers
2. Land use activities
3. Utilization of natural resources
4. Observable land, soil, and water pollution
5. Conflicting land-uses
6. Social amenities and infrastructure facilities
7. Natural disaster instances-flooding etc

**UNIVERSITY OF NAIROBI**

**DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES**

***OBJECTIVE:*** *A STUDY ON THE EFFECTS OF URBANIZATION ON ENVIRONMENTAL RESOURCES IN ATHI-RIVER TOWN*

***DECLARATION***: *Information generated through this questionnaire is confidential and will be held professionally. It will only be used to identify issues within Athi-river and to assist in the synthesis of Project Recommendations.*

LOCALITY(Ward)……

QUESTIONNAIRE No.……

DATEOFINTERVIEW…….....

## A. RESPONDENT PROFILE

1.Respondent's Name {Optional} ……

2.Respondent's Age……

3. Gender Male ☐ Female ☐

4. Marital status? Single ☐ Married ☐ Widowed ☐

5. How long have you stayed in this area? .....

6.Where is your place of work? ……

7. Do you own this house? Yes ☐ No ☐

8. If yes, which year did you buy it/built it? ……

9.If you built it, how did you obtain the plot? ……

10. What is the land tenure of this land? Rented ☐ Owned ☐

Other{Specify} ……

**B. PHYSIOGRAPHY**

11a. Do you have any natural resources (River, Quarry, forest etc.) relevant to you in the neighborhood? YES ☐ NO ☐

11b. What is the distance to the nearest environmental resources relevant to your home?

| **Resource Type** | **Distance km (approx.)** | **Minutes walking (approx.)** | **Minute Driving (approx.).** |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

11c. How do you benefit from these resources as a resident of Athi-river? (both direct indirect)

.....

.....

12 a. Do you know about any environmental resources' use conflict within your neighborhood?

YES ☐ NO ☐

If yes, please specify ….....

12 b. Do you use wood-fuel as an energy source? YES ☐ NO ☐

If yes, where do you get the wood fuel from? .....

13 a. Do you experience any notable pollution in the direct neighborhood of your house?

YES ☐ NO ☐

If yes, what kind of pollution?

Water ☐ Land/Soil ☐ Air ☐ Others (specify)

13 b).What recommendations/advise would you give for a good management practices for environment and natural resources in the area?

14. Are there any notable effects of climate change, if any, on your immediate neighborhood?

.....

15. Have you observed any notable soil erosion in your neighborhood? YES ☐ NO ☐

If yes, specify where……

16. What sanitary facilities are provided?

Ventilated Pit Latrines ☐ Pit latrines ☐ Toilets ☐

Other {Specify} …….

17. How do you rate the quality of sanitary facilities {e.g. Toilets/pit latrines} provided?

Excellent ☐ Good ☐ Poor ☐ No provision ☐

i. If no provision, specify your alternative sanitary facilities ……

18. What garbage disposal methods are provided?

Burn ☐ Private Collectors ☐ County Government Collectors ☐

19. How do you rate the quality of garbage disposal method provided?

Excellent ☐ Good ☐ Poor ☐ No Provision ☐

i. If no provision, specify alternative method {s} of garbage disposal you use.

……

19. How does storm water and waste water drain within your compound?

Sewerage / Storm drains ☐ Channels ☐ Other {Specify} …….

20. How do you rate the quality of storm and waste water drainage in your area?

Excellent Good Poor No provision

i. If no provision, specify how liquid waste and storm water drains.

……

## C. MIGRATION TRENDS

21a. Have you always lived in Athi River? YES NO

21b. If not, where did you live previously? .....

21c. When did you move to Athi-river) From? …..…….. (Month) …… (Year)

21d. Why did you choose to settle in Athi-River?

Work School Other (Specify) ……..……

21 e. Where was your previous residence?.....

21 f. Why did you decide to change residence? .....

21g. How satisfied are you with the living conditions in Athi-river?

Very satisfied Satisfied Undecided Dis-satisfied Very Dis-satisfied

## D. LAND AND LAND USE

22. Do you own the land that you live on? YES NO 23. What is the size of the land (acre)?

1/8 ¼ ½ 1 and above Any other (specify)

24. What is the nature of the land tenure? Leasehold Freehold Customary

25. Do you own land elsewhere in Athi-river? YES NO

If yes, where……

26. What (main) land use activities do you carry on the land?

Residential ☐ Commercial ☐ Agricultural ☐ Other (Specify)……

27. When did you acquire this piece of land? If bought; what was the Price?

1960s ☐ 1970s ☐ 1980s ☐ 1990s ☐ 2000s ☐ 2010s

28 a. How did you acquire that piece of land?

Inherit ☐ Purchase ☐ Gift ☐ Allotment ☐

28 b. Have you ever subdivided your land? YES ☐ NO ☐

Please give reasons / explain your answer…….

## E. ENERGY SECTOR

**29.** Fill the table below as guided. (**1=High, 2=Moderate, 3=Low**

| **Source** | ***Supplier*** | ***Use*** | | | ***Rank by Use*** | | |
|---|---|---|---|---|---|---|---|
| | | ***Cooking*** | ***Heating*** | ***Lighting*** | ***Cooking*** | ***Heating*** | ***Lighting*** |
| **Electricity** | | | | | | | |
| **Charcoal** | | | | | | | |
| **Wood fuel** | | | | | | | |
| **Petroleum** | | | | | | | |
| **Gas** | | | | | | | |
| **Bio gas** | | | | | | | |
| **Solar** | | | | | | | |
| **Others (specify)** | | | | | | | |

## F. LANDUSE PLANNING

30. Do you know what an environmental/natural resource is?

Yes ☐ No ☐

31.Wha is your understanding of natural resources?

……

32. How do you perceive environmental resource {Idle, resourceful etc.} within Athi-river River? ……

33. What opportunities for development do these natural resources present to your commuity? …….. ……..

34. What constraints to develoment do these nvironmental resources present to your community? …….

33. How would you like these environmental resources to be utilized for the benefit of your community? ……

36. What has hindered the environmental resource within from being utilized as you have proposed?.....

**UNIVERSITY OF NAIROBI**

**DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES**

***OBJECTIVE:*** *A STUDY ON THE EFFECTS OF URBANIZATION ON ENVIRONMENTAL RESOURCES IN ATHI-RIVER TOWN*

***DECLARATION***: *Information generated through this questionnaire will be held professionally and will only be used to identify issues within Athi-river and to assist in the synthesis of Project Recommendations.*

Questionnaire No: .....

Section A

1.Respondent's Name {Optional} ……

2.Respondent's Age……

3. Gender Male ☐ Female ☐

4. Marital status ☐ Single ☐ Married ☐ Widow ☐

5. Type of business?

Grocery ☐ Food vending ☐ Shop/Kiosk ☐ Other {Specify}

……

6. When was this business established? ……

7. Do you own the business? Yes ☐ No ☐ { If no go to Question 8}

8. Who owns the business? .....

9. Do you have a business license to run this business? Yes ☐ No ☐

{If yes go to Question 10 &11}

10. Which institution issued the license? ……

11. How did you obtain this space for your business?.....

12. How do you dispose- off solid waste generated from your business?

Burning ☐ Dump in a site ☐ Collected by garbage collector

Dump haphazardly ☐ Other {Specify} ……

13. How do you dispose off waste water?

Pour in storm drains ☐ Pour in open sewage channels ☐

Pour anywhere ☐ Other {Specify} ……

Section B

14. Do you know what a natural resource is? Yes ☐ No ☐ {go to Question 18}

15. What is your understanding of natural resources? ……

16. How do you perceive natural resource {Idle, resourceful etc} within Athi-river River?

……

17. What opportunities for development do these natural resources present to your community? ……..

18. What constraints to development do these environmental resources present to your community?.....

19. How would you like these environmental resources to be utilized for the benefit of your community? ……

20. What has hindered the environmental resource within from being utilized as you have proposed?.....

**UNIVERSITY OF NAIROBI**

**COLLEGE OF HUMANITIES AND SOCIAL SCIENCES**

**FACULTY OF ARTS**

**DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES**

***OBJECTIVE:*** *A STUDY ON THE EFFECTS OF URBANIZATION ON ENVIRONMENTAL RESOURCES IN ATHI-RIVER TOWN*

***DECLARATION***: *Information generated through this questionnaire will be held professionally and will only be used to identify issues within Athi-river and to assist in the synthesis of Project Recommendations.*

Questionnaire No: .....

1. Name of the industry/factory …….

2a. Type of industry? Manufacturing Processing Motor Assembly Other {Specify} ……

b. if processing, where do you source your raw-materials?

3. When was this industry or factory established? …….

4. How does this factory handle its wastes?

a)Solid Waste ……

b) Liquid Waste ……..

c)E-Waste ……

5. What is your understanding of an environmental resources? ……

6. How do you view the environmental resources within Athi-river? …….

7. What investment opportunities the environmental resources within Athi-river present to this factory? ……

8. What constraints do these environmental resources present to this industry's development?

……

9. What role does these environmental resources play with regard to this industry's/factory's activities?.....

10. How would you like these environmental resources to be utilized for the benefit of the industry and the surrounding community?.....

11. What has hindered these environmental resources from being utilized as you have proposed? ……

**NEMA Interview Schedule**

**UNIVERSITY OF NAIROBI**

**DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES**

***OBJECTIVE:*** *A STUDY ON THE EFFECTS OF URBANIZATION ON ENVIRONMENTAL RESOURCES IN ATHI-RIVER TOWN*

***Declaration****: The information obtained from this interview is confidential and will be used for academic purposes only.*

1.What factors have contributed to rapid of urbanization in Athi-river?

2.What effects does such rapid rates of urbanization have on the urban environment?

3. How has NEMA intervened with regard to depletion/pollution of environmental resources by rapid urbanization?

4. What are the challenges faced in the management and conservation of the environmental resources within Athi-river?

5. How is NEMA addressing the challenges of managing and conserving the environmental resources within urban areas?

6. What opportunities and constraints do these environmental resources have for the urban community?

**Ministry of Environment & Mineral Resources Interview Schedule**

**UNIVERSITY OF NAIROBI**

**DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES**

***OBJECTIVE:*** *A STUDY ON THE EFFECTS OF URBANIZATION ON ENVIRONMENTAL RESOURCES IN ATHI-RIVER TOWN*

Declaration: The information obtained from this interview is confidential and

will be used for academic purposes only.

1. Does the Country have an Environmental Resources' Use policy?

2. What guidelines exist regarding the use of environmental resources?

3. What role has the ministry so far played in conserving the Environment in Athi River?

4. What are the challenges faced by the Ministry in ensuring propel land-use planning?

5. How is the Ministry addressing the challenges of managing and conserving the environmental resources within urban areas?

6. What opportunities and constraints do the environmental resources within Athi-river have for the urban communities' development?

**County Government of Machakos Interview Schedule**

**UNIVERSITY OF NAIROBI**

**DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES**

***OBJECTIVE:*** *A STUDY ON THE EFFECTS OF URBANIZATION ON ENVIRONMENTAL RESOURCES IN ATHI-RIVER TOWN*

**Declaration:** The information obtained from this interview is confidential and will be used for academic purposes only.

1. What are the planning standards in respect to various environmental resources within Machakos County?

2. What types of land-uses are allowed on the riparian zone?

3. Does the County approve all developments taking place within Athi-river?

4. If no, what measures has the county taken to prevent unapproved developments?

5. What are the challenges faced in the planning, management and conservation of the Environmental resources within Athi river?

6. How is the County addressing the challenges of planning, managing and conserving Environmental resources within Athi-river?

7. What opportunities and constraints do these environmental resources have to the urban community's development?