

**EFFECTS OF FRESH WATER DEGRADATION ON HUMAN ACTIVITIES: A CASE  
OF RIVER ATHI IN MACHAKOS COUNTY, KENYA**

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**A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR  
THE AWARD OF THE DEGREE OF MASTER OF ARTS IN GEOGRAPHY IN  
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## DECLARATION AND APPROVAL

### Declaration

This thesis/project is my original work and has never been presented for any academic award in any institution.

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## **DEDICATION**

I dedicate this research to the government of Machakos County under the leadership of Wavinya Ndeti for the people of Machakos to acquire adequate, safe and clean water to carry out their human activities with ease.



## ACKNOWLEDGEMENT

I acknowledge God's grace throughout the development of this proposal and project. I am thankful to my supervisors Dr. Jane Kagendo Francis and Dr. Thomas N. Kibutu for their overwhelming support and guidance in making this proposal a success. Finally, my gratitude goes to Mount Kenya University for ensuring a conducive environment and adequate study resources through the institution library.



## ABSTRACT

Freshwater degradation arising from human and industrial-related activities is a global challenge that poses problems to individuals and communities who rely on freshwater resources. The United Nation's Agenda 21 asks governments, organizations, and communities to ensure equitable and sustainable use of water resource for socioeconomic development. The study's broad objective was to evaluate the effects of fresh water degradation on human activities along River Athi in Machakos County. The specific objectives were: to assess the effects of fresh water degradation on domestic use, to analyze the effects of fresh water degradation on agricultural activities, and to establish the effect of fresh water degradation on fishing activities in Machakos County, Kenya. To achieve these objectives, the research adopted a descriptive research design through which data was acquired from respondents using quantitative and qualitative procedures. The location of the study was the Athi Catchment Area which is found within latitude  $1^{\circ}$  to  $4.5^{\circ}$  South and longitude  $37^{\circ}$  to  $40^{\circ}$  East. The target population for the study was 2000 persons living within the riparian of the River Athi in Yatta, Athi River and Mwala Sub Counties. Purposive sampling was used to map out the river stretch for the study within Athi River Sub-County from Kithimani to Kayata to Kamuthwa areas while Yamane formula was used to select a sample of 160 respondents. Both qualitative and quantitative data was collected from 160 respondents who included area residents and key informants. Structured questionnaires and interview guide were used to collect primary data. The collected data was analyzed using SPSS version 21. Descriptive statistics was used to review characteristics of the study findings. The findings of descriptive statistics were presented in tables, percentages, frequencies, and graphs. Pearson's correlation test was used to establish existing relationships between the predictor and the outcome variables. The Pearson Correlation results revealed significant relationships between variables at 95% confidence level as follows;  $r=0.195$ ,  $p=0.028$  for domestic activities;  $r=0.215$ ,  $p=0.015$  for fishing activities and  $r=0.28$  for agricultural activities. The study findings revealed that degradation of River Athi had negative significant relationship with domestic, agricultural, and fishing activities in the community that relied on the river as the source of water. This study recommends that the County Government of Machakos should implement mitigation measures to aid in rehabilitating River Athi and to prevent further degradation to preserve the residents' domestic, fishing, and agricultural activities.

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## LIST OF ABBREVIATIONS AND ACRONYMS

UNESCO	–	United Nations of Education Science and Cultural organization
FAO	-	Food and Agricultural Organization
BOD	-	Biological Oxygen Demand
TDS	-	Total Dissolved Solids
CTMM	-	City of Tshwane Metropolitan Municipality
PAHS	-	Polycyclic Aromatic Hydrocarbons
PCBS	-	Polychlorinated Biphenyls
ERB	-	Theory of Environmentally responsible behavior
TCA	–	Tana Catchment Area
RVCA	-	Rift Valley Catchment Area
ACA	-	Athi Catchment Area
NACOSTI	-	National Commission for Science, Technology and Innovation

## **CHAPTER ONE: INTRODUCTION**

### **1.0 Introduction**

This chapter presents the introduction of the research including background information, statement of the problem, objectives, and research questions of the study. Other segments include justification, limitations, delimitations, and assumptions of the study and operational definitions of terms.

### **1.1 Background to the Study**

Fresh water degradation has become a crucial environmental challenge of the 21st century globally. About 70% of global fresh water sources are used for agriculture, 20% and 10% respectively have been used for industrial use and domestic purposes with this demand increasing up to 64 billion cubic meters a year ((United Nations Educational, Scientific, and Cultural Organization (UNESCO), 2009). Water degradation around the world has affected human activities within the areas served by water reservoirs. Most of the fresh water resources including rivers, lakes and ground water have been contaminated. The demand for freshwater is high because many people in the world about 48% live in towns and cities, and these figures are likely to rise to about 60% at 2030 (UNESCO, 2009). Population growth leading to continuous industrialization and, thus, pollution of the available fresh water has increased fresh water demand (Ramakrishnaiah et al., 2009).

Fresh water is a precious resource and degradation poses a significant threat. Even though water covers more than 70% of the world's surface, only approximately 2.7% of the water is fresh with the rest being salty (Ramakrishnaiah et al., 2009). Thus, man has limited fresh water resources to carry out important activities. Rivers present one of the main sources of fresh water to meet demand created by urbanization, population growth, and industrialization (Ramakrishnaiah et al., 2009; Abraham, 2011). Despite this realization, water degradation continues to be a serious challenge facing governments, societies, and individuals. A report from UNESCO (2009) estimated that more than 2 million cubic meters of waste is released everyday making it difficult to protect precious freshwater sources. It is important for governments to design and implement effective interventions to promote the proper management of fresh water resources.

Many environmental scholars believe that pollution is a leading challenge facing the water sector globally (UNESCO, 2009). Water pollution is attributed to different natural and anthropogenic

factors. Human causes of pollution occur when individuals or communities release pollutants to water sources. In contrast, anthropogenic causes of water pollution arise due to outcomes such as weathering of rocks which release heavy metals in water sources (UNESCO, 2009). These natural causes are worsened by poor management of waste resulting in release of additional waste in water sources. Water pollution means that water can no longer support human activities like agriculture and domestic use.

In countries that have developed and other upcoming economies, agricultural degradation has been the leading cause of pollution other than contamination from settlement and industries, which leads to the destruction of inland waters, coastal waters, and other world ground water aquifers (WHO/UNICEF, 2015). Approximately 38% of water bodies in the European Union are mainly polluted by agriculture activities (WHO/UNICEF, 2015). Farming activities are the main reasons of pollution at most water resources, streams, wetlands and lakes pollution in the United States of America (US EPA, 2016). In China most of ground water pollution by nitrates is majorly from agriculture (FAO, 2013).

Environmental scientists use different indicators to determine the quality of water. Water temperature is an important indicator because it affects chemical processes. For example, high temperatures increase the rate of dissolution of minerals or particles in water (Mbui et al., 2016). Electrical conductivity is a second indicator which measures water's ability to carry electrical current. An increase in electrolytes increases water's electrical conductivity. Total dissolved solids (TDS) is another indicator used to indicate the level of dissolved organic and inorganic compounds found in water (Mbui et al., 2016). A second set of indicators include chemical characteristics of water. Alkalinity is an indicator measuring action of hydrogen ions in water as indicated by water's pH. Biochemical Oxygen Demand (BOD) is another indicator which illustrates the amount of oxygen necessary for water to break down waste (Mbui et al., 2016). One research measured BOD in one tributary of River Athi at 540 mg/L, which exceeded the maximum limit for effluent discharged into water sources (Mbui et al., 2016). The presence of heavy metals in water is an important indicator of water quality. Since such metals are non-biodegradable, they harm human health, interfere with children's neurological development, cause autoimmune conditions, and destroy aquatic life (Mbui et al., 2016).

A study that was carried out in River Amazon in South America found that increased degradation of the fresh water affected the flora and fauna that depend on the river for survival (IPCC, 2014). Habitat modification, overexploitation and pollution of the river ecosystem have affected fish species which has a negative influence on the people's lives who depend on the resources from the river for their survival (Dugan et al., 2010).

Degradation of the waters of River Amazon has affected fishing which is the source of livelihood for most people within the region (Merona et al. 2010). In turn, fishing being an economic activity within the region has drastically declined hence affecting the living standards of people (Batista, 2012). The study also shows that most rivers that form the Amazon basin like River Negro and Upper Xingu River suffer a serious problem of deforestation, increased use of fertilizers and pesticides hence contaminating the freshwater sources (Finer & Jenkins, 2012).

In China, River Yellow is polluted with sediments of various heavy metals in large quantities (Yue et al., 2014). The heavy metal pollution has been high because of population growth and high industrialization. These two factors have had destructive impacts on both ecological environmental and human beings (Lin et al., 2016). This pollution in the river has affected human activities such domestic use of water, agricultural activities, and fishing activities resulting in a decline in people's livelihood and health (Li et al. 2013; Chen, 2010).

Hapazari et al. (2015) found that Lesotho's attempt to increase industrialization, agriculture and urbanization to provide employment to the growing population has been the major cause of pollution of Mohokare River which passes through the Maseru city. The degradation of water due to industrial and unsuitable farming practices has negatively affected water usage (Walakari & Okot-Okumu, 2011). The use of water locally especially drinking, cooking and fishing was affected hence harming the people who depend on the water for their survival (Singh et al., 2013).

Fianko et al. (2010) found that anthropogenic activities have posed great risks to human health, domestic water use, and fishing activities in rivers in Africa. Although major anthropogenic pathogens do not affect the river's upstream part of the river, the downstream is highly contaminated and polluted by large amounts of discharges and effluents which affects its quality (Mustapha et al., 2013). Occurrence of water borne diseases which have pathogens that are

found in municipal raw waste that is disposed into the river hence affecting people's health that depend on the water for their daily activities (Adetunde & Glover, 2010).

Studies indicate that water pollution continues to plague Kenyan rivers owing to numerous sources of pollution. Mbui et al. (2016) explains that many rivers in the country are polluted in both point and non-point sources. Environmental scholars in Kenya argue that leading contributors of river pollution in Kenya include urbanization, industrialization, and agriculture (Odha, 2024; Gikundi, 2014). Mbui et al. (2016) write that a quest to realize industrialization in a short time in Kenya has increased water pollution because the nation has failed to invest in sufficient waste disposal infrastructure, policies, and practices. Consequently, Kenyan scholars have discovered that major rivers including River Nairobi and River Athi have experienced high levels of pollution. Other studies have found that the establishment of industries along rivers like Kerio, Nzoia, and Nyando has contributed to significant pollution in the rivers (Mbui et al., 2016).

A study conducted in Lake Naivasha in Kenya indicates the lake has been contaminated with toxic substances due to increased chemical use in industries, agricultural advancement, mining, and urbanization (Spears et al., 2016). Dissolved toxic metals in water have affected the flora and fauna that depend on the water for survival (Ndungu et al., 2014, Armah et al., 2010). A high metal concentration in water has led to a great health risks to the people who use the water from the lake directly and indirectly (Banzi FP et al., 2015). Pollution due to increased industrial growth has mostly affected human activities like domestic use of water, agricultural activities and fishing activities hence having their livelihoods been negatively affected for residents near Lake Naivasha (Barbosa et al., 2010).

Many researches indicate that River Athi water is polluted highly with toxic soluble metals and other dangerous pollutants coming from industries, mining, burning fossil fuels and agricultural activities within the river basin (Otieno et al., 2015). High concentration of polluting materials into the river course has led to high levels of metals and poisonous elements, which have affected human health negatively (Mutia et al., 2015). This has made the water of River Athi unsuitable to carry out any human activities hence affecting the livelihoods of the people within the study area. Another study concluded that an increase of water degradation from industrialization, poor human waste disposal, poor agricultural activities and increase of

population in most urban centres where the Athi River passes through Nairobi, Thika and Mavoko has affected human activities carried out in the area (Kiambi, 2016). These human activities affected include agricultural activities, fishing and domestic use of water which has led to a great risk on people's health that depended on the water from the river (Mustapha et al., 2013). This research sought to determine the impact of River Athi water degradation on human activities in Machakos County.

### **1.2 Statement of the Problem**

Water is essential for many human activities that are of economic value to the lives of people living in the environs of River Athi. Water degradation caused by both natural and human-induced pollutants in River Athi poses a significant problem for individuals and communities in the area because the water is relied upon by many people in the area of study for agricultural, domestic, and fishing activities. This has prompted research focusing on how water degradation has affected human activities such as agriculture, fishing, and domestic use of water as according to the objectives of the study. This degradation has negatively affected the livelihoods of residents within the River Athi area, leading to significant health risks. River Athi, being the main source of water within the area of study and heavily relied on by many people living along its riparian zones for their livelihoods, has experienced degradation that poses a serious challenge to both people and their health. In the agricultural sector, most crops grown using this water have reduced in quality. Domestic use of the water including drinking, bathing, or cooking have also been negatively affected, forcing local residents to seek alternatives for safe water. Fishing activities have suffered due to the degraded water, with fish caught from the river showing traces of heavy metals, making them unfit for human consumption. The continuous degradation River Athi and its impact on human activities in Machakos County form the core objectives of this research.

### **1.3 Purpose of the Study**

The purpose of the study was to examine the effects of fresh water degradation on human activities focusing on River Athi in Machakos County.

#### **1.4 Objectives of the Study**

- i. To assess the effects of fresh water degradation on domestic use in Machakos County, Kenya.
- ii. To analyze the effects of fresh water degradation on agricultural activities in Machakos County, Kenya.
- iii. To establish the effect of fresh water degradation on fishing activities in Machakos County, Kenya.

#### **1.5 Hypothesis of the Study**

- i. Null Hypothesis ( $H_0$ ): Freshwater degradation in River Athi has no significant effect on human activities in Machakos County, Kenya.
- ii. Alternative Hypothesis ( $H_1$ ): Freshwater degradation in River Athi has a significant effect on human activities in Machakos County, Kenya.

#### **1.6 Research Questions**

- i. What are the effects of fresh water degradation on domestic use in Machakos County Kenya?
- ii. What are the effects fresh water degradation on agricultural activities in Machakos County, Kenya?
- iii. What are the effects of fresh water degradation on fishing activities in Machakos County, Kenya?

#### **1.7 Justification of the Study**

Freshwater plays a critical role in sustaining biodiversity and supporting human livelihoods. In the Kenyan context, water from River Athi is vital for communities in Machakos County, serving agricultural, domestic, and fishing needs. However, both natural processes and human activities have contributed to the degradation of this river, negatively impacting water quality and reducing its usability. This pollution has led to a rise in waterborne diseases and a decline in fish populations, threatening food security and income sources for local residents. The justification for this study aligns with Sustainable Development Goal 6 which aims to realize clean water and sanitation for all and access to safe water and sustainable management of water resources. The study supports the Machakos County Integrated Development Plan (CIDP), which emphasizes environmental conservation, improved public health, and promotion of sustainable livelihoods.

By highlighting the impacts of water degradation, the study provides evidence that can guide local authorities such as the Machakos County Government and NEMA in developing targeted interventions to protect and restore River Athi, thus promoting sustainable development in the region.

### **1.8 Significance of the Study**

The research findings have provided important information to the Ministry of Water, Sanitation, and Environmental Resource Management. Policymakers might use the data in policy formulation to implement interventions to reduce or stop degradation of River Athi in Machakos County and other areas that may be experiencing similar challenges. The study may also assist the people who depend on water of River Athi for their economic activities devise alternative measures to acquire fresh water to continue with their activities.

### **1.9 Scope of the Study**

The study was conducted in Machakos County, specifically in areas where River Athi passes through and supports the livelihoods of surrounding communities. The research focused on assessing the effects of freshwater degradation in River Athi on selected human activities namely agriculture, domestic water use, and fishing. These activities were chosen due to their direct reliance on the river and their economic and social importance to the local population.

### **1.10 Limitation of the Study**

The study faced several limitations. First, it did not include other sources of water within the area, which may also contribute to the same economic activities, potentially limiting the breadth of comparison. Secondly, the research was constrained by financial and time limitations, which affected the scale and depth of data collection. Efforts were made to mitigate these challenges by using cost-effective means of transport and focusing on accessible communities along the river.

### **1.11 Delimitation of the Study**

The study was delimited to Machakos County and concentrated specifically on communities living within the riparian zones of River Athi. It only examined the impacts of freshwater degradation on three selected human activities: agriculture, domestic use, and fishing. Other potential impacts of water degradation (such as on industry or biodiversity) were intentionally excluded to maintain a focused research scope.

### 1.12 Assumptions of the Study

The research assumes that:

- i. River Athi is the only source of fresh water within area of study.
- ii. River Athi water degradation has affected the economic activities within the area of study.
- iii. Data analysis will be done objectively



### 1.13 Operational Definition of Terms

**Aquifer** - It is underground water resulting from water infiltration and penetration into the soil after rains.

**Degradation** - It is the change of the normal biodiversity through the interaction with foreign materials that change the normal function of the influenced ecosystem.

**Ecosystem** - It is the environment where animals, plants and other smaller living organisms are found.

**Effluents** - These are waste material that disposed in the areas where they are not required and it leads to environmental pollution.

**Heavy Metals** – These are soluble metals found in polluted waste materials and once consumed in food or a drink they lead to health risks.

**Intervention** - It is measures taken in order to control occurrence of a losses or problems which may affect the ecosystem negatively.

**Pathogens** - These are foreign materials and disease causing organisms that causes health problems to human beings

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Introduction

The chapter discusses some of studies done before by other scholars related to the studies. The literature review is organized according to study objectives. The chapter also includes the study's theoretical and conceptual framework.

#### 2.2 Effects of Fresh Water Degradation on Domestic Activities

Access to clean water for domestic activities is a backbone of human health. Individuals who use degraded water are vulnerable to numerous diseases arising from water borne pathogens (Lin et al., 2022). Some of the common illnesses arising from water-borne diseases include diarrhea, typhoid, and dysentery. Contact diseases occur when one's skin comes into contact with pathogen-infested water. In contrast, water-based vector illnesses refer to diseases spread by agents living in water and they include malaria which is transmitted through mosquitoes (Lin et al., 2022).

Worldwide water degradation occurs when foreign materials are found in the water sources leading to water degradation and it becomes dangerous to human beings and environment (Alrumman et al., 2016). Water is vital for domestic use and carrying out human developments (Bibis et al., 2016). Human health all over the globe mainly depend on clean water, however, many countries do not meet the World Health Organization (WHO) polluted and unhygienic conditions contribute to more than 75% of diseases (Khan, et al., 2013).

Many studies have attempted to estimate the deaths caused by polluted water. One study argues that unclean water is the number one cause of mortality for human beings in the world (Nischal, 2019). The researchers attribute the outcome to the extensive nature of pollution which affects water sources including lakes, rivers, and oceans. Other studies have found that major sources of water contain fluoride exceeding the WHO recommended range of 0.6 – 1.7 milligrams for every liter (Nischal, 2019). The extensive range of water pollution means that many households around the world cannot access clean drinking water. Such outcome means that people turn to other polluted sources of water that further endanger human health and domestic activities like cooking (Nischal, 2019).

Because drinking water is key to human survival, poor water quality affects human health through both pathogens and chemicals. Severe contamination can make water undrinkable, posing immediate health risks and requiring costly short-term alternatives like bottled water (Kundu et al., 2024). More commonly, contamination presents long-term risks, managed through regular water treatment to eliminate pollutants such as pathogens, nitrates, and pesticides, which can cause both immediate illnesses and long-term diseases (Kundu et al., 2024). However, this treatment is expensive, adding financial burdens on water companies and consumers. The more contaminated the water, the higher the treatment costs, including significant capital expenses, as well as increased energy and chemical usage. Additionally, disposing of extracted contaminants can lead to secondary pollution issues (Kundu et al., 2024).

The European Public Health Alliance (2009) notes that a sizeable number of the world's population cannot access clean water. Specifically, the organization estimates that only less than one billion people have clean water (Krishan et al., 2023). The same study found that more than 50 countries around the world are affected by either partially treated polluted or polluted water. The WHO advises that polluted water is unsuitable to domestic use because pollutants change water composition resulting in contamination which often harms human health (Krishan et al., 2023). Despite this advisory, many individuals around the world continue to use polluted water for lack of alternatives predisposing them to health risks from water-borne diseases and secondary issues arising from products made from polluted water (Krishan et al., 2023).

Most negative effects of water pollution upon ecosystem have led to death of species, reduction of biodiversity and ecosystem loss (Madhav et al., 2020). Common water pollutants come from mining activity, nitrates components from farming, organic molecules, which are chlorinated coming from poorly disposed waste or from water treatment plants (Madhav et al., 2020). A high number of people in the world according to WHO consume polluted water that is not safe for consumption and basic sanitation is inaccessible to 2.4 billion people (EHA, 2009). Waste materials from industries, sewages and pollute drain water lead to pollution of the most water that used in the world (Madhav et al., 2020).

Heavy metals and industrial wastes that are disposed of into rivers and lakes have toxins components that lead to reduction of immunity, reproductive failure, increased poisoning and other transmissible diseases like cholera and typhoid (Juneja & Chaudhary, 2013). Polluted water

is responsible for other transmissible diseases like gastroenteritis, vomiting, diarrhea, skin, and kidney problems (Khan & Ghouri 2011). The insecticides are harmful to humans (Owa, 2014) while wastes from industries pollute the water which harms plants, human beings, and animals (Kamble, 2014).

In China, freshwater resources are under increasing pressure as reported by China's Ministry of Water Resources which stated that water use has passed what freshwater resources can bear (He et al., 2020). Northern region of China has scarce freshwater resources than the Southern region rich with the water resource thoroughly degraded ((He et al., 2020)). Most of China's towns and cities have less water than the nationwide demand for freshwater estimated at 67 % of agricultural output and 84% of the country's total industrial output ((He et al., 2020)). Fresh water points are reducing gradually due to water pollution in Southern China. In China, most of freshwaters are unhealthy for people to use the water (Khan & Wen, 2021). A study reveals 90% of ground water 19 % of numerous river basins, 35% of its twenty-six lakes and other fresh water sources in China are highly polluted through human activities like agriculture and industrialization (Khan & Wen, 2021). Due to high demand of water, polluted water is still used and this leads to soil and crop destruction affecting human and animals that consequently leads to health problems (Khan & Wen, 2021).

Fresh water resources in South Africa are highly degraded by pollutants and contaminants from human activities rendering it unfit for human and animal consumption (Heath et al., 2009). In Vhembe district in Limpopo province water sources have been contaminated by mining and agricultural activities (Musingafi, 2013). Cemeteries, commercial and industrial waste, and sewerage have polluted water sources within Gauteng province, the city of Tshwane posing dangers to health (Musingafi, 2013). This continuous pollution has led to various water borne diseases within the said city (Gambhir et al., 2012).

In Ethiopia a study had been carried out at River Akaki which penetrates through the commercial, residential and industrial parts of Addis Ababa hence having a lot of effluents like heavy metals and human wastes being disposed into the river thus affecting domestic use of water like drinking, bathing, cooking and laundry (Yard et al., 2015). Rivers Leyole and Worka indicate that they receive lots of effluent from manufacturing industries and the waters used for irrigation and domestic purposes thus exposing dangers to human health (Zainabu, 2019).

Similarly, Lake Victoria in Kenya is facing the challenge of increasing pollutions. Studies attribute pollution in Lake Victoria to industrial waste, untreated domestic wastewater, untreated water, and anthropogenic activities (Anyona et al., 2014). Other forms of water pollution are through surface runoffs and spillage like pesticides residues, hydrocarbons wastes (PAHS) and chlorinated wastes (PCBS) leading to pollution in Winam Gulf of Lake Victoria. The result is that drinking water and aquatic life have been affected (Onyango et al., 2012). Also, human activities like farming and fishing within the Lake Victoria basin have been harmed due to the continuous water degradation hence affecting the people lives negatively (Onyango et al., 2012).

The area of study along the River Athi in Machakos County has been highly polluted by industrial and human waste which has in turn affected negatively domestic use of the water of the residents living near the riparian of the river. This has adversely affected the livelihood of the residents (Kithiia, 2007; Chebii et al., 2024). This has prompted the research on the effects water degradation on domestic activities in the location of the study.

### **2.3 Effects of Fresh Water Degradation on Agricultural Activities**

The degradation of freshwater has a lot of negative influence on the production of crops and it affects the food which is unhealthy to human life (Khan & Ghouri, 2011). Research shows a significant association between water degradation and health problem because disease-causing organisms spread diseases directly to human beings and are they are found in well-known areas (Kamble, 2014). The water quality deterioration caused by different forms of pollution have been found in most water supplies used at homes as well as in farm produce, (Twinge et al., 2011).

Water degradation also destroys the quality of irrigation water. Ideal irrigation water is characterized by specific traits of acidity, salinity, solubility, and alkalinity. Salinity refers to amount of salt is dissolved in water while salinity hazard is a measure of the likelihood of salinity affecting crop growth (Zörb et al., 2019). In many instances, polluted water records high salinity levels meaning that crops cannot do well in such regions. Sodium level is another critical determinant of water quality in irrigation. Soil experts have reported that water with high sodium levels is correlated to poor crop yields (Zörb et al., 2019). Specifically, this happens because a high concentration of sodium reduces crops' water infiltration.

Water degradation destroys the production of crops and affects food which becomes dangerous for human life (Khan & Ghouri, 2011). A population of about 10% relies on food grown using

degraded water (Corcoran et al., 2010). Some of the diseases associated with polluted water include diarrhea and neurological disorders (Ullah et al., 2014). In some instances, components of nitrogenous chemicals found on the crops grown lead to cancer and rise of blue baby syndrome (Khan & Ghouri, 2011). Many cancer deaths are reported in rural areas because they use untreated water for drinking while the former have the knowledge of treating water hence have lower risks to diseases due to proper sanitation and hygiene (Jabeen et al., 2011).

In India, waste chemicals from manufacturing industries reaches most surface water and underground water system and cause pollution (Sharma et al., 2022). Common waste chemicals causing pollution include toxic metals like iron and mercury, petroleum products, chlorinated hydrocarbons, salts and other organic compounds with ions increasing the acidity and alkalinity in soil which affects humans, plants and animals (Sharma et al., 2022).

Pollutants have varying impacts on the natural environment. For example, chlorine destroys leaf tips leading to poor plant growth. In contrast, the accumulation of heavy metals like iron in the soil for long destroys crops under irrigation (Sekharan et al., 2022). Research studies illustrate a positive association between industrially polluted water and reduced rice yields in areas under irrigation (Sekharan et al., 2022). These studies indicate that freshwater polluted with industrial pollutants destroys rice, and grains. Other studies indicate that wheat grown on polluted water record low protein content and due to reduced plant height, leaf area and dry matter (Sekharan et al., 2022). A study done in India showed a decline in cultivated land found in villages on the downstream industrial centers like Andhra Town (Kumar et al., 2024).

Similar outcomes on the association between crop yield and pollution have found similar outcomes around the world. In China, research showed association between lower corn quality and quantity in Hebei Province in farmlands irrigated using waste water (Wang et al., 2024). In Tho, Vietnam most of the land that was irrigated with degraded water had yields and profits have gone down. History suggests that industrial water pollution causes crop loss among farmers in Patancheru, Andhra Pradesh who participated grass root protests against industrial pollution in 1980s (Murty & Kumar, 2011).

In Nigeria with the discovery of oil has led to directly and indirectly increased environmental pollution on the available water and other ecological systems bringing risks to agricultural activities, fisheries and domestic water that depended by the people for their livelihoods

(Ugwuanyi et al., 2012). One study shows that 30% of its habitable environment land in Nigeria have been destroyed by oil spills. These pollution activities have resulted in the degradation of rivers and underground water lowering crop yields and land productivity (Ouncer & Hooverian, 2015).

Nigeria being one of the wetlands in the world most of its agricultural productivity have been reduced due to the effects of oil production leading to water pollution (Bayode et al., 2011). Crop production and soil productivity have reduced drastically because of oil spills in rivers and other water sources. This has also reduced the quality of farm produce, killing of fish and contaminating water (Amnesty International, 2009).

The population at Lake Victoria Basin is approximately 42 million people (Bremner et al., 2013) where many of them depend on resource of fresh water ecosystem. In the recent years, increased pollution has led to water degradation (Bird Life International, 2011; Hecky et al., 2010). Most rivers that drain into the lake have water due to the industrial waste; Human waste and increased use of agricultural chemicals make the water unsuitable for farming or carrying out irrigation activities (Masese & McClain, 2012).

Population within the basin is likely to rise to 2050 leading to increase of agricultural activities, urbanization and water degradation which in turn affects agricultural activities that are carried out using the same water (Juma et al., 2014). The continuous farming and increased use of pest control measures have led to pollution hence leading to a negative impacts of food web within the Lake Victoria basin (Masese & McClain, 2012).

Increased level of salinity of water due to poor disposal of wastes has affected the fresh water in most rivers that drain into the Lake Victoria basin hence affecting agricultural activities negatively (Kitheka, 2017). Studies of water on many African rivers have been carried out on water degradation, erosion, sediments and nutrients flukes that affect agricultural production by earlier researchers (Sigleo & Erick, 2015).

Changes in climactic conditions has worsened the impact of water degradation on agricultural activities. For example, variations in rising temperatures, precipitation patterns, and evaporation causes changes in water balance resulting in fluctuations in water quality (Russ et al., 2022).

Consequently, farmers are forced to adapt to new agricultural practices to maintain agricultural

productivity. For example, rising temperatures increase the probability of flooding which in turn increases the probability of runoff pollution. Water movement also changes the distribution of pests and diseases, resulting in lowered crop production and quality (Russ et al., 2022). Since agriculture is a major economic activity, water degradation results in economic losses. One study estimates that water degradation in rivers lowered gross domestic product by between 1.4% and 2.5% in more than 10 nations surveyed (Russ et al., 2022).

In the area of where research will be done, in the dry season studies indicate that water at River Athi is highly contaminated with industrial wastes, salinity and other productivity total dissolved solids that affect the plant growth and river course (Kathuli et al., 2013). The highly polluted water from Nairobi city and its environments are directed into Nairobi River Which in turn drains into Athi River which affects irrigation activities within the river (Aywa, 2017; Kiithia & Mutua, 2006). This prompted research on the effects of fresh water degradation on agricultural activities since no research had been done before.

#### **2.4 Effects of Fresh Water Degradation on Fishing Activities**

Numerous studies have assessed the impact of water degradation on fishing activities around the world (Malik et al., 2020; Kay et al., 2022). Environmental scholars have reported that water degradation affects different aspects of fishing ranging from the yield to the income. Studies conducted among fishing communities reveal that fish species avoid polluted regions reducing fishers' catch (Kay et al., 2022). In other instances, fishers report that pollution limits fishing activities because fishers must move to relatively cleaner grounds to catch fish (Deville et al., 2023). Yet other studies report that water degradation lowers the amount of fish by interfering with reproduction, movement, and cycles of growth and development in water bodies (Malik et al., 2020). Some studies have reported that some fish species have gone extinct due to water degradation (Ahmed et al., 2022).

Many fish species depend on coastal water quality for survival, and it supports vital economic activities such as tourism, coastal recreation, fishing, and property values. Coastal waters are influenced by various contaminants from local and distant sources, including point, nonpoint, and airborne pollutants (Chuenpagdee & Jentoft, 2018). Pollution of coastal waterways arises from both natural events (such as cyclones, floods, and droughts) and human activities (such as aquaculture, sewage dumping, dam construction, and plastic waste) (Chuenpagdee & Jentoft,

2018). Fish is essential for food security and nutrition, offering numerous essential micronutrients that protect against hunger and malnutrition-related diseases. Small-scale fisheries (SSFs) employ over 90 percent of the 35 million registered fishers globally. Water contamination complicates effective water management and fair living standards for SSF communities (Chuenpagdee & Jentoft, 2018). The livelihoods of these populations are threatened by issues such as nutrient enrichment, harmful algal blooms, low oxygen levels, hypoxia, pollution, and sedimentation. Many people living along the coastline depend on SSFs for their livelihoods

In Kenai River in USA fresh water biodiversity is at critical point due to continuous pollution of the water bodies leading to extent of some fresh water species (Vorosmarty et al., 2010; Reid et al., 2018). Changes on fresh water systems and human activities are the largest causes of deterioration of fresh water diversity (Brummel et al., 2013; Vorosmarty et al., 2010). The water found in tropical areas is the freshest water systems by volume most stressed the associated morphological changes due to pollution. The area within river Kenai especially Alaska has 34 species of fish that have been threatened due to continued pollution (Schoen *et al.*, 2017). The loss of fresh water habitats and degraded water quality has contributed to the declining of salmon fish at River Kenai (Johnson, et al., 2018). In 2018 the number of types of Salmon fish at River Kenai were generally low that led to the closure of their fisheries in Alaska. This has led to loss of fish within the live hood especially the Alaska local tribes that depend on the fish.

According to Hubert (2016), increased use of chemical and them being washed into rivers that drain in most lakes in Africa especially L. Malawi. It has posed a great danger on the fish species. The environmental concerns like deforestation, poor land use leading to soil erosion and inorganic degradation from agricultural activities most effected the aquatic species especially the fresh water fish as with the case in Malawi (Samikwa et al., 2019). Mineral extraction and industrialization have emerged to be major cause of endemic fish species in the lake (Jamu, et al., 2011). Fish caught in lake Malawi is sold and eaten locally thus making it a source of food for a large population in Malawi but due to pollution of lake water the fish have reduced in numbers and population hence affecting people's lives negatively (Juma et al., 2014; Gom 2011 b). Presence of Lilongwe and Mzusu and human health once they consume the fish (Msilimba & Wanda, 2012).

In Kenyan case, Lake Victoria has been affected by continuous pollution of the lake from industrial effluents, human wastes and poor agricultural activities affected the fresh water biodiversity hence leading to reduction of fish species in the lake (Johnson, 2018). The reduction of the fish from the lake (Juma et al., 2014). As a result of continuous fishing and consumption of the fish which have eaten the waste materials and have swallowed some of the heavy metals by human beings, this affects their health negatively (Reifet al., 2011; Wells et al., 2010). It has been detected parts of three common fish species that are eaten like Nile perch (late Nilotic us), Tilapia (*Oreochromis niloticus*) and Dagaa (*Rastrineobola argentea*) within Lake Victoria basin of Kenya (Omwoma et al., 2015). This has affected the human health and domestic uses of water (Hernando et al., 2011). This led to a research to be carried out on impact of fresh water degradation on fishing activities along River Athi since there was no research that had been done.

## **2.5 Theoretical Framework**

The Theory of Water Pollution and Theory of Sanitation guided this research.

### **2.5.1 Theory of Water Pollution**

This theory explains the interaction between human activities and water pollution. Specifically, the theory argues that individuals are responsible for water pollution which occurs from human activities that generate domestic sewage and toxic waste (Mensah, 2020). In turn, the waste generated from human activities contaminate water with disease-causing micro-organisms. This pollution has devastating impacts on the surrounding ecosystems such as rivers, lakes, dams and oceans. Human activities including agriculture, fishing, and domestic water suffer due to water degradation especially fresh water (Mensah, 2020). This theory influences the research because the continuous degradation of the fresh waters that provide water for human use has affected human activities negatively hence affecting people's livelihoods in region where River Athi passes through. In conjunction to that, degradation of the fresh waters has led to the increase of diseases resulting from the polluted water. The human activities affected by the degraded water form the objectives of the study.

The theory is relevant to this research as it provides a framework for understanding how human behavior contributes directly to the degradation of the River Athi. The pollution of this river has adversely affected critical human activities such as agriculture, fishing, and domestic water use,

particularly for communities living along the river. As these fresh water sources become increasingly polluted, the livelihoods of those dependent on the river deteriorate. Furthermore, waterborne diseases have become more prevalent due to exposure to contaminated water, underscoring the direct health implications of polluted water sources. Thus, this theory underpins the research by linking human actions with environmental degradation and its social and economic impacts in the River Athi region.

### **2.5.2 Theory of Sanitation**

The Theory of Sanitation focuses on cleanliness, absence of germs and the necessity and provision of the facilities to eliminate germs (Wasike, 2010). According to the sanitation theory it is the microorganism that leads to poor health (Wall et al 2012). In the relation to the study the continuous degradation of River Athi water has affected human activities such as agricultural activities, domestic use water and fishing activities along the river. This has hence affected the livelihood of the people within the riparian of the river.

This theory is applicable to the current study as it highlights the health consequences of polluted water sources, as at in River Athi. The lack of proper sanitation infrastructure and the continued discharge of waste into the river have compromised water quality, making it unfit for human consumption and daily use. Communities along the river who rely on it for drinking, washing, and farming face increased exposure to diseases due to this contamination. In this regard, the theory of Sanitation supports the study's findings on the negative impact of water pollution on both public health and the sustainability of human activities in the River Athi basin.

### **2.6 Conceptual Framework**

A conceptual framework is the arrangement of ideas of research in logical way to assist in providing knowledge on how ideas in the research relate to each other (Grant and Osanloo, 2014). The arranged ideas make it easy for researchers to come up with elaborate concepts within a problem of the study (Luse, Menneckie & Townsend, 2012). It identifies factors or variables to be measured by the research. This research is centered on the effects of fresh water degradation on human activities.

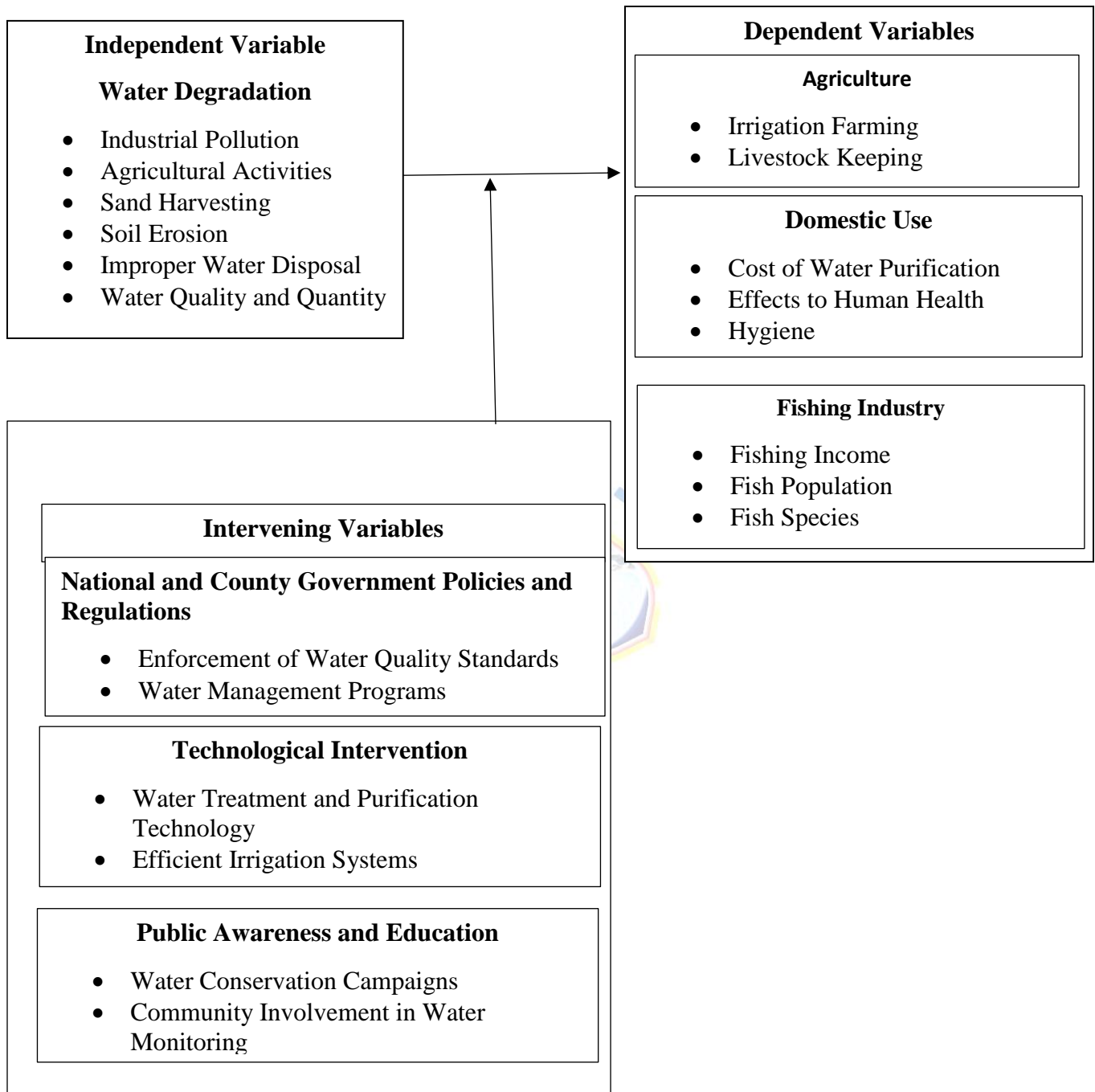
Fresh water degradation has been a centre of interest in research because many fresh water bodies have been polluted and thereafter affecting human activities like agriculture, domestic use of the water and fishing. Agricultural activities have been affected negatively due to the pollution

of fresh waters. This has been evident with the farmers' outcry on the fact that the water from most rivers that they use to irrigate their crops have been polluted by industrial waste, raw human waste and some agricultural chemicals that also pollute the water. As a result, it has made difficult to produce crops which fit for human consumption (Khan & Ghouri, 2011). Most of the crops produced using the contaminated water has mainly led health risks once consumed.

The domestic use of water has also been negatively affected due to the increased pollution of the fresh water supplies. Most inhabitants in rural areas depend on the water from rivers, lakes and swamps for domestic use. But because of continuous pollution of these water sources through poor disposal of industrial waste, human waste and poor agricultural activities have led to introduction of pathogens in the water hence making it unsafe for consumption. Polluted water is responsible for a majority of water borne diseases globally (Gambhir et al., 2012).

Fresh water degradation has influenced fishing activities negatively. Fishing is an economic activity that supports livelihoods in the world. In Kenya most of the fresh water lakes and rivers have polluted intensively leading to death or decline of fish. Due to continuous water degradation fish has declined in most of fresh water sources because some of them die or not fit for human consumption. Once these fish are consumed it can lead diseases related to water or cancer disease due to the effect of the heavy metals (Hernando, 2011; Oulton, 2010; Reif et al., 2011). This has led to the reduced quality of the fish hence affect the livelihoods of the people who depend on fish for survival difficult and unbearable.

The framework explains how the people within of the study area have been affected by the polluted waters of River Athi negatively. This has affected their livelihood negatively and many people have looked either for alternative sources of water to cater for their domestic purposes. It also shows how other human activities like agriculture have been affected due to the continuous pollution of the water. The framework also clearly indicates the main causes of the water degradation on the said area of study pollution. Pollution as result of industrial activities, soil erosion, domestic wastes and agriculture activities are major cause of the water pollution within the area of study. These ways of pollution introduce heavy metals and pathogens that affect human health in a negative way.



**Figure 1: Conceptual Framework on the effects of water degradation on human activities (Researcher, 2018)**

## **2.7. Summary of Literature Review**

The reviewed literature in this study shows how water degradation both marine and fresh waters has affected human activities negatively. It has also shown that water forms an integral part for human survival. Therefore, when the fresh water bodies are polluted it affects a lot of human activities that form the livelihood of the people using that water resource. The literature has also reviewed that at global and regional levels, pollution has been witnessed and it has affected most of human activities that depend on fresh water. Some of these human activities highlighted are agriculture activities which are the source of food in such countries. Other human activities that have been affected are fishing and domestic use of water.

The literature review has established that agriculture, which is the source food for many countries of the world, has led to human health problems when food has been produced using the degraded water. The continuous fishing and domestic use of the polluted water has brought risks to human health and increased water borne diseases which have claimed many lives of human beings and both domestic and aquatic animals. Many people who depend on the fresh water to cater for their daily needs according to literature review show that their livelihood has been affected negatively leading to increased poverty and high rate of unemployment. It has also increased the mortality rates among the people because of the increased consumption of impure foods and contaminated water. Therefore, it is important to do this research within the selected area since the same research had not been documented. This is to establish the effects of the water degradation of River Athi among the people living within its course in Machakos County, Kenya.

## **CHAPTER THREE**

### **RESEARCH METHODOLOGY**

#### **3.1. Introduction**

This segment details the study's methods of collecting and analyzing data to meet research objectives. It presents research designs, study site, study population of the area and target population. In addition, the chapter explains sampling procedures and techniques, research instruments to be used, piloting testing, validity of research instruments, and procedures for collecting, analyzing, and presenting data, and ethical concerns.

#### **3.2 Research Design**

Research design is a systematic, empirical, and controlled approach to the investigation of hypothetical proposition about relationship between variables under study (Turhan, 2019). This research adopted a descriptive research design through which data was acquired from respondents using quantitative and qualitative procedures. Descriptive research design examined what, where and how an aspect under investigation needs and its current practices (Kothari & Garg, 2014).

Interview guides helped gather data where the interviewers were identified in order to ensure good response from them. The interview guides involved both group and individual interview where open headed questions were used. Both open-ended questions and closed questionnaires applied to get the required information from the respondents. Observation was another method where the researcher observed the water of the river under study and also the effects it has caused to residents living within the river course of the areas identified to be studied.

The researcher also observed the way of life of the respondents and how the water degradation has affected their lives. Before the study was carried out, any relevant information related to the topic of study was obtained from any relevant previous data like journals, magazines, libraries and any record kept on human activities within Athi River.

#### **3.3. Location of the Study**

The study was conducted along River Athi, located in Machakos County, Kenya, within the broader Athi Catchment Area. The catchment lies approximately between latitude 1°00' to 4°30' South and longitude 37°00' to 40°00' East. To the north, it borders the Tana Catchment Area; to

the east and south, it borders the Indian Ocean and Tanzania, respectively; while to the west, it borders the Rift Valley Catchment Area (RVCA).

The Athi River Basin covers approximately 58,639 km<sup>2</sup>, traversing several counties including Nairobi, Machakos, Makueni, Kiambu, Kajiado, Kitui, Nyandarua, Kilifi, and Mombasa. The river passes through major urban centers such as Nairobi, Kiambu, Machakos, and Kajiado.

The topography of the River Athi Catchment is highly varied. It features highlands in the Aberdare Ranges at its source and descends to coastal lowlands at sea level near the Indian Ocean. The river originates from Ngong Hills, forming the upper section of the basin. The middle section borders the Tana Catchment Area and is characterized by gently undulating plains, while the lower course approaches the coastal zone. The catchment is also fed by several important springs, including Mzima, Kiku, Njorokubwa, Nolturesh, and Marere.

The climate within the River Athi Basin is predominantly semi-arid, especially in the lower and middle catchment areas. However, the upper catchment—especially near the Aberdare Ranges and Ngong Hills—is classified as humid to sub-humid. The region receives an average annual rainfall of approximately 810 mm, with a bimodal distribution typically occurring between March–May and October–December.

Soils within the River Athi Basin vary across regions. In the highland areas, soils are predominantly well-drained red volcanic soils, which are fertile and support agriculture. In the lowland and semi-arid regions, soils are often black cotton soils (Vertisols) and sandy loams, which are more prone to erosion and salinity, especially near irrigation schemes. Riverine zones contain alluvial soils, which are deposited during seasonal floods and support riparian vegetation.

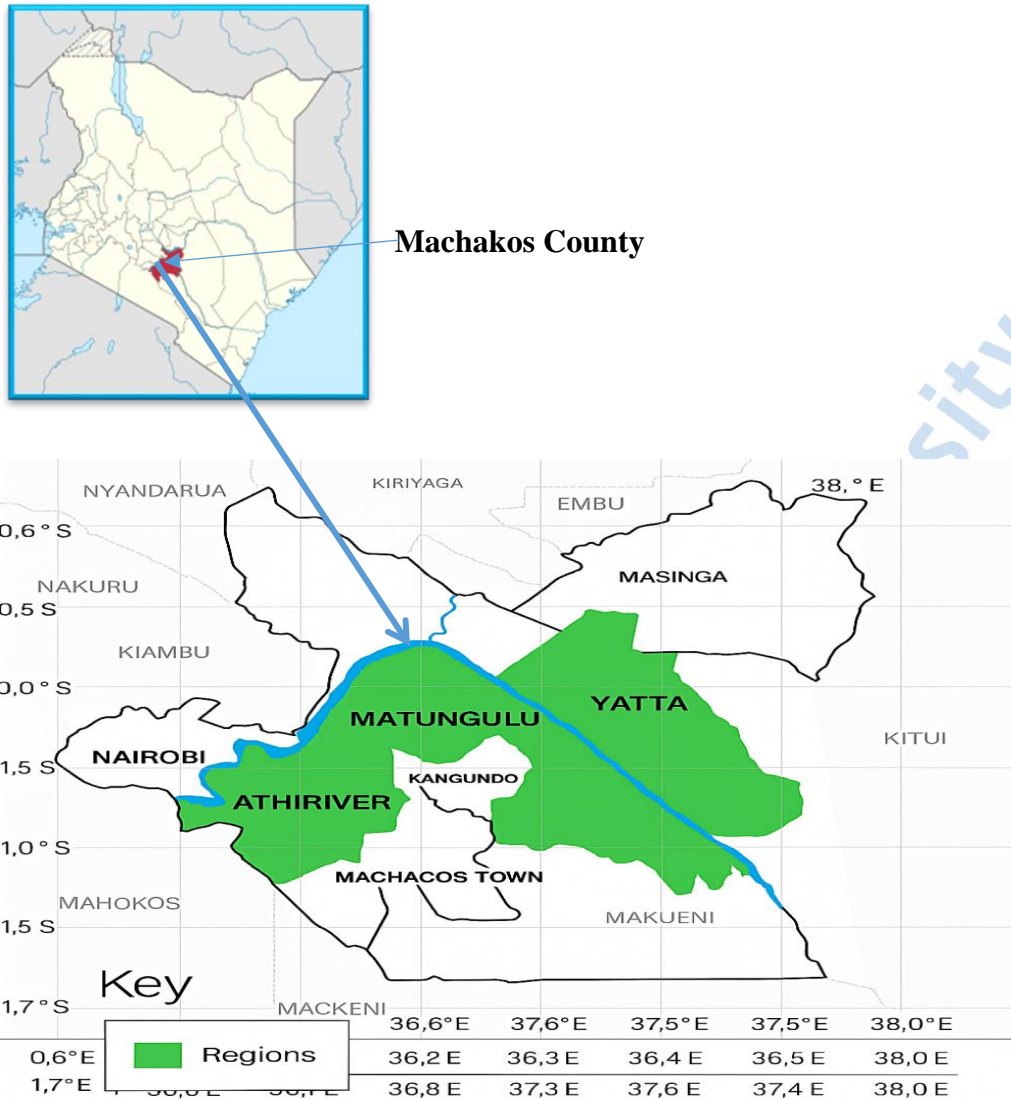
Natural vegetation within the River Athi Catchment includes acacia woodlands, grasslands, shrub lands, and pockets of riverine forest along the riverbanks. The highland zones support montane forest vegetation, while the lower parts are characterized by sparse savanna vegetation, due to limited rainfall. Human activities have led to significant clearance of indigenous vegetation for agriculture and settlement, particularly in Machakos and Kajiado counties.

The River Athi Basin supports a wide range of human activities that are both economically important and environmentally impactful. Crop farming is a major livelihood activity, particularly along the riverbanks where irrigated agriculture is practiced to supplement rainfall.

In the semi-arid regions of Machakos and Kajiado, livestock keeping is a dominant economic activity, benefiting from the availability of grazing land and periodic access to river water. Fishing is practiced in sections of the river where water flow is perennial, providing a source of food and income for local communities. Additionally, urban development and industrial activities are prominent around major towns such as Nairobi and River Athi, contributing to population growth and economic expansion. However, these developments come with environmental concerns. Sand harvesting has emerged as a major income-generating activity along the river, but it also accelerates riverbed degradation and affects the stability of the river's flow. Moreover, waste disposal and the discharge of industrial effluents, especially from urban centers, have significantly contributed to freshwater pollution, posing risks to both aquatic ecosystems and human health.



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**Figure 2: Map of River Athi and Study Area (Best et al., 2024)**

### 3.4 Population of the Study

Babbie (2020) described the population to the study area as the total number of objects, subjects or members with same specification or characteristics. It is also individuals who are selected based on specified characteristics that relate to the variables being studied. It is where the target population is randomly or purposely selected. The population of Machakos County is 1,421,932 according to 2019 population census where men are 710,707 women are 711,191 while intersexes are 34 persons. Those between 0-19 years are 610,743 while above 20 years are 811,189.

The main tribe found in Machakos County is Akamba who have dominated most sub-counties. There are other tribes within the County who form a small percentage of the population. Most of these people from other tribes are in Machakos either as result of employment or have bought a piece of land to settle. Most of the population of the study area is mainly Christians while others are Muslims, Hindus and traditionalists. The people within the study area have their staple food being Githeri since the area mostly comprised of people who their main economic activity is farming. Their cultural aspects were diversified since some of the areas are within urban centers where there are different people with diversified cultures.

The people within the area of study were mainly local farmers who grow crops, keep animals and carry out some fishing along River Athi as their main way of life. Since the area does not receive adequate rainfall, crop growing has become a major problem hence resulting to use the water of River Athi to carry out irrigation and for their domestic use. As a result of continuous degradation of the waters of River Athi which is the main river passing through the area under study, most people have changed some of the economic activities to cater for their needs. That was the reason that prompted for a study to be carried out within the area.

Though some of the people are traders within the major centres within Machakos County, they mainly focus on mixed farming. Adverse changes of water due to pollution within the main source of water many people have thought to look for alternative source water and income where others have had their lives being affected negatively.

### **3.5 Target Population**

These are individuals with the same traits and ensures that research is carried out. A target population was obtained from three sub-counties where river Athi meanders through. Adult residents of Yatta, River Athi and Mwala Sub counties have a population of 417,646. The study targets adults' male and females who are over 18 years of age and above. The target population for the study is 2000 persons living within the riparian of the river of Yatta, Athi Rand Mwala Sub counties. This is because; the said groups of people are the one who carry out economic activities either to cater for their families or themselves. Individuals in the area of study engage in farming, livestock keeping and fishing along the river. The individuals for this study were farmers and the local county administration. The farmers were the people who carried out farming along the river.

### 3.6 The Procedures and Techniques of Sampling

Sampling is expressed as a method used to choose a small group from this used target population to take part in the study. The information obtained from the sub groups is used to develop very useful information affecting the whole population in study area. Stratified random sampling was applied to select the sample of the research.

#### 3.6.1 Sample Size Determination

Different methods were used to obtain samples at different stages. Machakos County was selected purposely because it houses the main area of the study, along river Athi. Machakos County has a population of 1,421,932, for all eight sub-counties. Target population was obtained from three sub-counties where river Athi meanders through. Adult residents of Yatta, River Athi and Mwala Sub Counties were the target population of the study. Therefore, the target population for the study were 2000 persons who are residents within the riparian of the river.

Yamane formula was used to obtain the sample as follows.

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

$$, n = \frac{2000}{1 + 2000(0.05^2)}$$

$$= 160$$

e is 0.05% given that the desired level of confidence when it is 95%.

Resulting in a sample size population of 160.

The sample size was 160 respondents who form the accessible population due to proximity of some areas.

#### 3.6.2 Sample Distribution

Sample distribution is the expresses distribution of statistics got through a wide range of samples that are drawn from specific population. Sample distribution will be determined by getting the sample size required. Randomly sampling applied to obtain respondents randomly from the target population. Each sample set was to have its own sample mean which was the sampling distribution procedure.



**Table 1: Sample size distribution**

Respondents	Sample size	Tool to be used	
		Questionnaires	Interview schedules
Local farmers	130	130	
Officer from the department of water and sanitation	10		10
Officer from the department of environment	10		10
Officers from the department of health	10		10
	Total sample size = 160	Total questionnaires =130	Total interviews = 30

### 3.6.3 Sampling Technique

Sampling involves finding a segment of a population to make inferences about that population. Kombo and Tromp (2006) stated that stratified random sampling design involves population division into groups with same characteristics before random selection of a sample from each cluster. Stratified random sampling agrees with this study since the population consists of heterogeneous features and ensures minimal biasness. The samples were assigned into groups who share the same characteristics and all the information required was obtained from each group. Each group sample was being generally higher hence less generalization of the information because of group differences in the variability of the sample estimates

### 3.7 Research Instruments

Research instruments tools are questionnaires and interviews schedules that are formulated to acquire data from research population. Gathering of data in this study was done through the interactive process involving both researcher and respondents. The researcher administered

questionnaires where some are open-ended while others were closed ended focusing on the following respondents: residents, farmers, local traders and the local administrators within the county. Each respondent was to answer the questionnaires which are relevant to them. One-part questionnaire was to focus on the demographic information while the other part focus on the effects of water degradation on human activities within the area as highlighted in the objectives. Closed ended questionnaires were constructed in such a way that the respondents chose the five options provided, which are agree, strongly agree, disagree, strongly disagree and undecided. Through open-ended questionnaires opinions were to be collected from the respondents. Interviews and observations was also to be carried out as a way of collecting the required information.

### **3.8 Pilot Testing**

Pilot testing is a small study to test research instruments, strategies to obtain information on the suitability of research instruments before the actual study. It assists in identifying potential problem area and any problems in the research instrument before the implementation during the actual study (Malmqvist et al., 2019). Pilot testing assisted the researcher to become more familiar with the area of study, procedures in the protocol and can help to decide between conflicting study methods such as interviews rather administration of questionnaires (Malmqvist et al., 2019). It assists the researcher to make decision on the right research instruments to be used to carry out the research and get the required information. The pilot test was conducted in a section of the Thwake River in Makueni County, which shares similar ecological and socio-economic characteristics with the River Athi stretch in Yatta, Athi River, and Mwala Sub-Counties. This helped to validate the research instruments without influencing the actual study area.

### **3.9 Validity and Reliability of Research Instruments**

Validity explains the extent to the instrument of research can measure what it was made to measure while reliability of an instrument measures whether an instrument can provide similar results if a research is repeated under similar circumstances.

According to Mugenda and Mugenda (2013), gives an explanation that piloting research instruments is done mainly to correct any mistakes and flaws that may come up during the study process. Piloting of research instruments was carried out among 40 respondents who are not part

for the actual study. Reliability testing of the research instruments was evaluated using coefficient alpha (Cronbach's alpha) that assesses the consistency of an instrument if alpha value is 0.7 or higher the instrument was to be considered reliable.

The interviews schedules and the questionnaires were conducted at Athi River Sub - County which is near River Athi which is under study. The area was selected because it comprises of all respondents that are required to carry out the study. This was to help in revising the research instruments to improve their validity and reliability. Through the pilot study, the appropriate language to be applied in the area was decided upon and the time estimates for carrying out the interviews and filling of the questionnaires. Reliability helped to determine if the research instruments are relevant and valid to answer the three objectives of the study. The areas that are not inconsistent with the study where to be corrected to coincide with the set objectives.

### **3.10 Data Collection Procedures and Recording**

Primary data was obtained using interviews, questionnaires and observation. Most of the secondary data was obtained from journals, magazines and newspaper. Interviews schedules were conducted face to face with the respondents. Questionnaires were designed according to the level of the respondent and were administered to the respondents within the sample size population. Interview schedules at the personal level ensured clarity and probe any unclear information either from the questionnaires.

### **3.11 Data Analysis**

Data analysis involves interpreting raw data to obtain useful insights to yield practical outcomes. The decision made was based on the outcome of analysis. Quantitative data collected through questionnaires was analyzed using SPSS version 21. Descriptive statistics were used in the analysis of quantitative data. The relationship between the variables and study hypotheses were tested through Pearson correlation test while the effects of water degradation on human activities were tested using simple linear regression. One-way ANOVA helped test any significance differences on continuous variables based on categorical variables. Data collected through interview schedules was carefully analyzed and grouped into meaningful themes relevant to the study objectives. Frequency tables, graphs, charts, magazines and journals were used to present data. More preferably this research used graphs, frequency tables and pie charts to present study results.

### **3.12 Ethical Considerations of the Study**

This study adhered to the ethical principles governing research involving human subjects. Participation in the study was entirely voluntary, and informed consent was obtained from all participants after a clear explanation of the study's purpose, procedures, potential risks, and benefits. Respondents were given adequate time to decide whether to participate, and written consent was obtained prior to data collection. To safeguard participant privacy, the principles of anonymity and confidentiality were strictly upheld. Personal identifiers were not collected, and questionnaires were coded using unique numbers instead of names to ensure data anonymity. The study was designed to minimize any risk of physical, psychological, or social harm, and the safety and well-being of participants were prioritized throughout the research process. Ethical clearance for the study was obtained from the University Ethics Review Committee (ERC) of Mount Kenya University. Additionally, a research permit was secured from the National Commission for Science, Technology and Innovation (NACOSTI), and further approvals were sought from relevant county and sub-county administrative offices within the study area. These measures ensured that the research complied with both institutional and national ethical standards.

## CHAPTER FOUR

### RESEARCH FINDINGS AND DISCUSSIONS

#### 4.1 Introduction

This section reports study results and their interpretations. The results include background information, status of water degradation and relationship between the findings and various and other factors of interest to the study.

#### 4.2 Background Information

##### 4.2.1 Location of the Respondents

The respondents provided information about their location along the River Athi. Majority (57.4%) were from Mwala, followed by 35.2% from Yatta and 7.4% from Athi River.

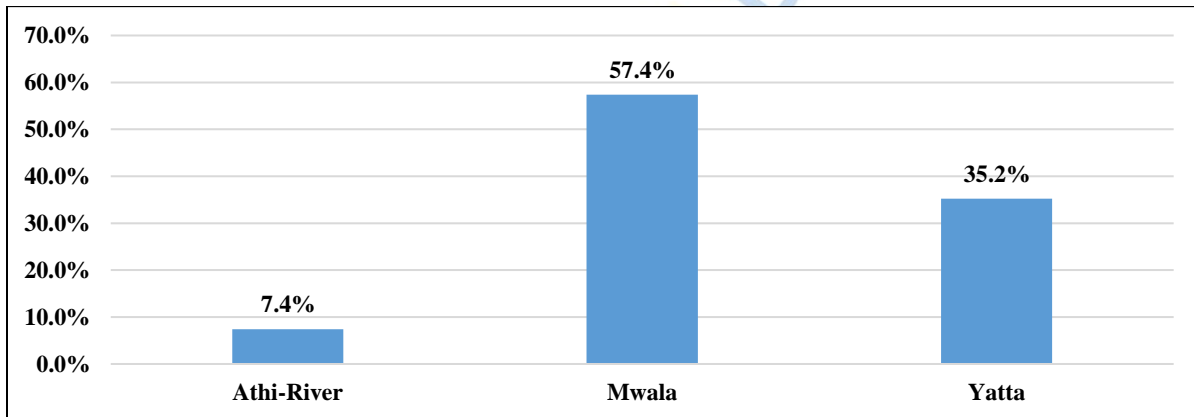
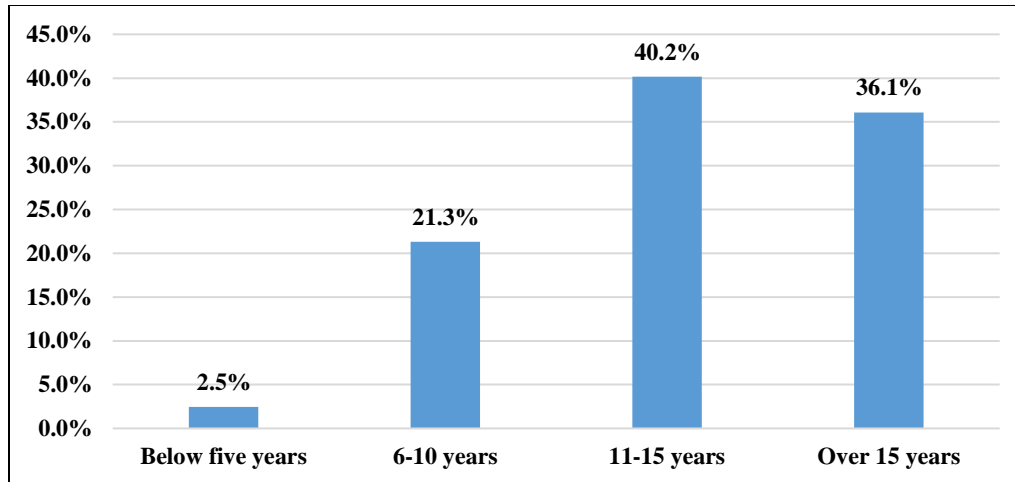


Figure 4: 1 Location of the Respondents

##### 4.2.2 Duration of Stay in the Area of Study

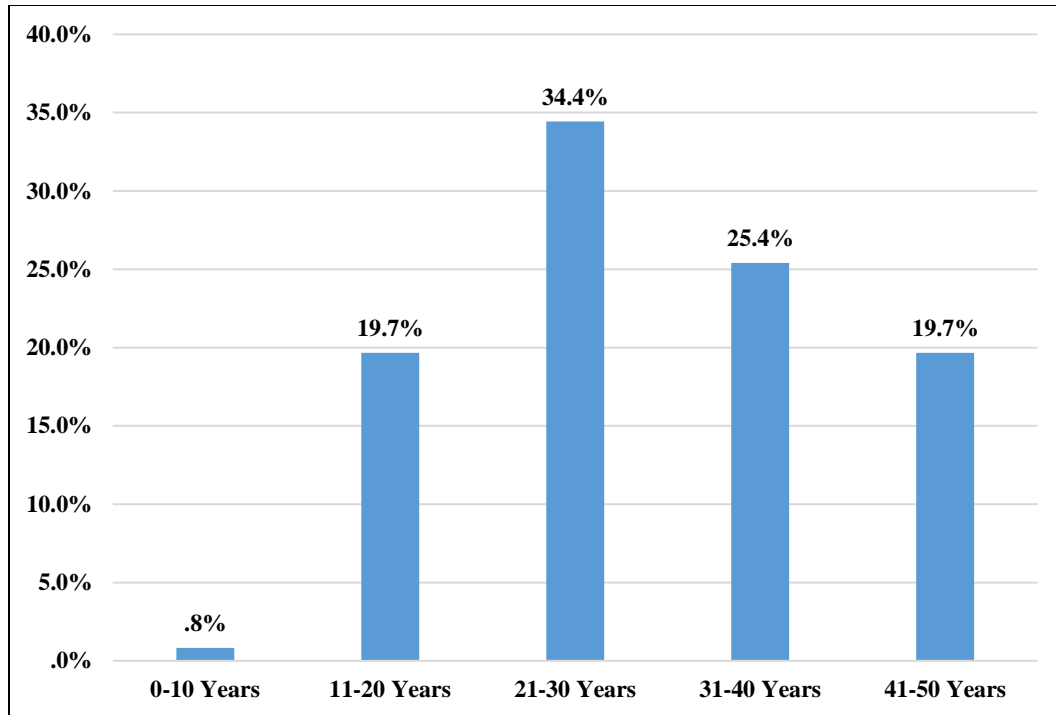
The segment asked the duration they had stayed in their areas of residence. This was crucial as those who had stayed in a particular place for long could tell any observable change within the environment especially pertaining water degradation. From the study, most of the respondents (40.2%) had lived along the river between 11-15 years, 36.1% of the respondents had lived there for more than 15 years, 21.3% between 6-10 years lived along the river for many years and could identify any changes in water degradation and possible effects.



**Figure 4: 2 Duration of Stay in the Area of Study**

### **4.2.3 Age Bracket of the Respondents**

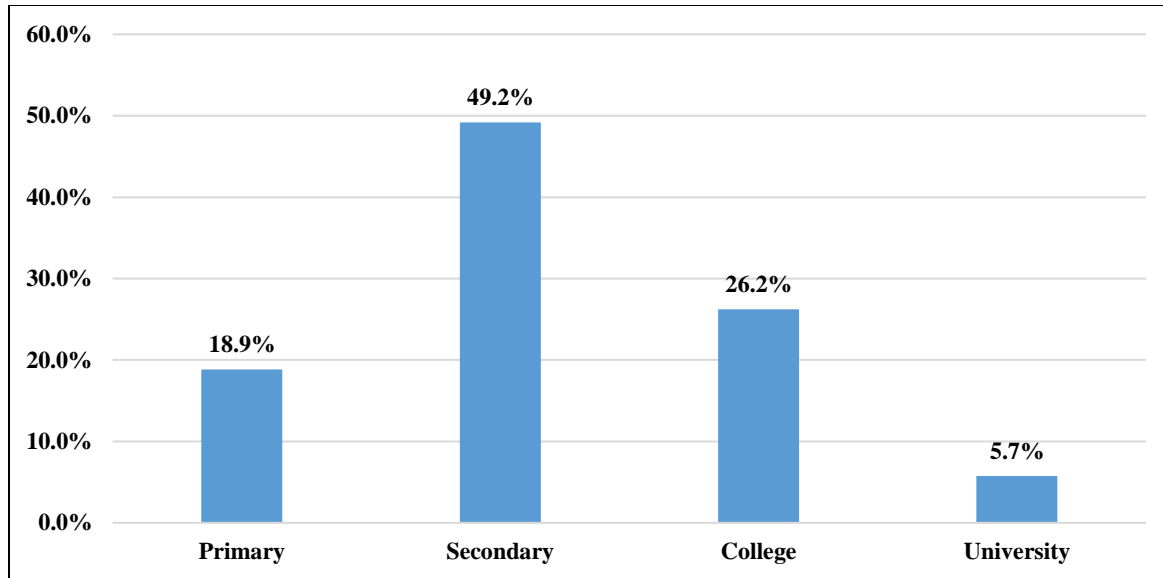
The segment collected information on respondents' age brackets. The age was a good parameter in this study as the aged could identify any change in water quality and possible effects in their midst. From the study, most of the respondents (34.4%) were within 21-30 years, followed by 25.4% aged 31-40 years and thirdly 19.7% who were aged 41-50 years. This shows a good blend of people of different age brackets which was ideal for this study.



**Figure 4: 3 Age Bracket of the Respondents**

#### **4.2.4 Education Level of the Respondents**

This segment considered respondents' education level of the respondents as a major area of interest. This was important education influenced the perceived level of water degradation among the population. From the study, majority of respondents (49.2%) attained secondary school education, 26.2% attained college level education and 18.9% attained primary level education. The percentage of those with university level education was 5.7% indicating that the respondents did not have a lot of educated people. However, it was a reflection of the rural population where level of highly educated people was limited.



**Figure 4: Education Level of the Respondents**

### 4.3 Status of Water Degradation

#### 4.3.1 Status of Water Degradation

Table 4.1 presents the extent of freshwater degradation in the study area. Majority of respondents (50.4%) indicated that River Athi was polluted by industrial effluents to a large extent. Similarly, a 49.6% affirmed that the river had been polluted but the effluents had polluted the river to a very large extent. According to 51.6% (majority) sand harvesting had degraded water in the river to a little extent though 25.4% felt it was to a large extent.

Most of respondents (46.5%) said that soil erosion was responsible for water degradation in the river to a large extent implying that soil erosion had some substantial impact on the water degradation levels. Majority of participants (75.6%) indicated that the water had been affected by the human wastes to a very large extent which signals that there was high level of human disposal activities affecting the water quality along the river. From the results, there is some evidence that water along the river had been degraded significantly by industrial effluents, soil erosion, human waste disposal and sand harvesting

**Table 4: 1 Status of Water Degradation**

	<b>Very Little Extent</b>	<b>Little Extent</b>	<b>Not At All</b>	<b>Large Extent</b>	<b>Very Large Extent</b>	<b>Total</b>
River Athi has been polluted by industrial effluents	0.0%	0.0%	0.0%	50.4%	49.6%	100%
Sand harvesting has led to water degradation of River Athi	0.0%	51.6%	12.7%	25.4%	10.3%	100%
Soil erosion has led to water degradation in River Athi	3.1%	24.4%	5.5%	46.5%	20.5%	100%
Human waste disposal has led to water degradation in River Athi	0.0%	0.8%	0.0%	23.6%	75.6%	100%

**4.3.2 Location and Water Degradation**

This segment assessed if water degradation in different sections of the river were different. The one-way ANOVA test revealed significant differences in the extent of water degradation along the river given by F statistics were  $F(2, 118) = 2.984, p < 0.05$ .

**Table 4: 2 ANOVA Test on Location and Water Degradation**

<b>ANOVA</b>					
Water degradation					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.482	2	.741	2.984	.05
Within Groups	29.294	118	.248		
Total	30.776	120			

A post hoc test evaluated the exact areas of the river which were more degraded than others. This was done using LSD test where Athi River was significantly more degraded than Mwala

( $p=0.044$ ) and Yatta ( $p=0.016$ ) sections of the river. Mwala was slightly more degraded than Yatta section of the river but the difference was insignificant ( $p>0.05$ ). The reason why River Athi was more degraded than the rest of the sections was likely because it was proximate to the industries in Athi River town and also by the fact that it was in an urban setting hence home to many people contributing to human wastes.

**Table 4: 3 Post Hoc Analysis of ANOVA between Location and Water Degradation**

Multiple Comparisons						
Dependent Variable: water degradation						
LSD						
(I) Location	(J) Location	Mean Difference (I- J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Athi-River	Mwala	.35870*	.17658	.044	.7084	.0090
	Yatta	.44574*	.18264	.016	.8074	.0841
Mwala	Athi-River	.35870*	.17658	.044	.0090	.7084
	Yatta	-.08704	.09681	.370	-.2787	.1047
Yatta	Athi-River	-.44574*	.18264	.016	.0841	.8074
	Mwala	-.08704	.09681	.370	-.1047	.2787

\*. The mean difference is significant at the 0.05 level.

#### 4.3.3 Duration of stay and Water Degradation

The levels of water degradation were perceived differently by respondents who had stayed along the river varying duration of time. Results of one-way ANOVA indicate significant differences within respondents of different groups on the level of water degradation.  $F(3,118) = 2.991$ ,  $p=0.034$ .

**Table 4: 4 ANOVA between Duration of Stay and Water Degradation**

ANOVA					
water degradation					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.175	3	.725	2.991	.034

Within Groups	28.604	118	.242		
Total	30.779	121			

The post hoc test showed that aged group of respondents of over 15 year identified water degradation more than those aged 6-10 years ( $p=0.25$ ) and 11-15 years ( $p=0.28$ ). This is because the elderly had time to see when the waters were clean and unpolluted and could tell the difference with the current situation when the waters were degraded.

**Table 4:5 Post Hoc Test for ANOVA between Duration of Stay and Water Degradation**

Multiple Comparisons						
Dependent Variable: water degradation						
LSD						
(I) Duration of stay in the area of study	(J) Duration of stay in the area of study	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Below five years	6-10 years	.52333	.30083	.085	-.0724	1.1191
	11-15 years	.47109	.29283	.110	-.1088	1.0510
	Over 15 years	.24444	.29358	.407	-.3369	.8258
6-10 years	Below five years	-.52333	.30083	.085	-1.1191	.0724
	11-15 years	-.05224	.12101	.667	-.2919	.1874
	Over 15 years	-.27889*	.12281	.025	-.5221	-.0357
11-15 years	Below five years	-.47109	.29283	.110	-1.0510	.1088
	6-10 years	.05224	.12101	.667	-.1874	.2919
	Over 15 years	-.22664*	.10166	.028	-.4279	-.0253
Over 15 years	Below five years	-.24444	.29358	.407	-.8258	.3369
	6-10 years	.27889*	.12281	.025	.0357	.5221
	11-15 years	.22664*	.10166	.028	.0253	.4279

\*. The mean difference is significant at the 0.05 level.

#### 4.3.4 Age and Water Degradation

The study did a test of the One Way ANOVA to establish differences in perceived water degradation based on the age. The ANOVA test revealed no significant differences on extent of water degradation from respondents of different ages along the river as the F statistics was  $F(3, 117) = 2.028, p < 0.114$ . The value of t was however more than 1.96 implying that there was a group which stated water degradation more than others. A post hoc was subsequently applied to determine the groups with such a relationship.

**Table 4: 6 Age and Water Degradation**

ANOVA					
Water Degradation					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.477	3	.492	2.028	.114
Within Groups	28.398	117	.243		
Total	29.875	120			

A Post Hoc test showed significant difference on how those aged 41-50 years and those aged 21-30 years ( $p = 0.019$ ) rated the level of water degradation in River Athi. This might be explained by the differential gap in experience of the freshness of the water in River Athi.

**Table 4: 7 Post Hoc Test on ANOVA between Age and Water Degradation**

Dependent Variable: Water Degradation						
LSD						
(I) Age	(J) Age	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
11-20	21-30	.13199	.12780	.304	-.1211	.3851
	31-40	.08288	.13468	.539	-.1838	.3496
	41-50	-.16712	.14376	.247	-.4518	.1176
21-30	11-20	-.13199	.12780	.304	-.3851	.1211
	31-40	-.04911	.11560	.672	-.2781	.1798
	41-50	-.29911*	.12606	.019	-.5488	-.0494
31-40	11-20	-.08288	.13468	.539	-.3496	.1838

Dependent Variable: Water Degradation						
LSD						
(I) Age	(J) Age	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
	21-30	.04911	.11560	.672	-.1798	.2781
	41-50	-.25000	.13303	.063	-.5135	.0135
41-50	11-20	.16712	.14376	.247	-.1176	.4518
	21-30	.29911*	.12606	.019	.0494	.5488
	31-40	.25000	.13303	.063	-.0135	.5135

\*. The mean difference is significant at the 0.05 level.

#### 4.3.5 Education and Water Degradation

A test of One Way ANOVA sought to establish differences in water degradation based on the education and found significant differences among respondents of groups with different educational qualifications.

**Table 4: 8 ANOVA Test between Education and Water Degradation**

ANOVA					
Water Degradation					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.789	3	.596	2.428	.069
Within Groups	28.989	118	.246		
Total	30.779	121			

**Post Hoc Tests**

From the test results, the respondents with primary school education identified best how water was degraded compared to those in Secondary school ( $p=0.010$ ). This is probably due to the socio-cultural life where the primary school education had interacted more with the water in the river more than secondary school leavers who might have engaged in other activities far from the river. Also the primary school leavers might be associated to doing manual jobs such as watering of animals or crops and therefore had a better understanding of the waters than secondary school leavers.

**Table 4:9 Post Hoc Test for ANOVA Test between Education and Water Degradation**

Dependent Variable: Water Degradation						
LSD						
(I) Highest level of formal education	(J) Highest level of formal education	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Primary	Secondary	.32038*	.12184	.010	.0791	.5617
	College	.23166	.13549	.090	-.0367	.5000
	University	.34103	.20345	.096	-.0618	.7439
Secondary	Primary	-.32038*	.12184	.010	-.5617	-.0791
	College	-.08872	.10882	.417	-.3042	.1268
	University	.02066	.18674	.912	-.3491	.3905
College	Primary	-.23166	.13549	.090	-.5000	.0367
	Secondary	.08872	.10882	.417	-.1268	.3042
	University	.10938	.19592	.578	-.2786	.4974
University	Primary	-.34103	.20345	.096	-.7439	.0618
	Secondary	-.02066	.18674	.912	-.3905	.3491
	College	-.10938	.19592	.578	-.4974	.2786

\*. The mean difference is significant at the 0.05 level.

#### 4.4 Effects of Fresh Water Degradation on Agricultural activities

##### 4.4.1 Status of Effects of Water Degradation on Agricultural Activities

The respondents were asked whether water degradation affected agricultural activities. The results showed that majority (77.2%) agreed that there were some agricultural activities which were affected by the degraded water. Most of respondents either (52.0%) agreed or 21.3% strongly agreed degraded water affected their crops. Consequently, a majority of respondents agreed that the degradation of the water affected agricultural activities.

Table 4.10 reveals that most (49.6%) of the respondents affirmed their animals/livestock had been affected by degraded water indicating that the degradation of the water along the river affected livestock keeping in the region. However, a sizeable proportion (26.8%) were not sure indicating that they could not connect how their livestock keeping was being affected by water degradation.

Many of participants (46.0%) either agreed or 31.0% strongly concurred there was a cost implication in crop production in the study area due to use of degraded water indicating that degradation of water had made agricultural costly. Furthermore, most of the respondents (46.8%) strongly agreed that land under irrigation using water from River Athi reduced due to water degradation.

**Table 4: 10 Status of Effects of Water Degradation on Agricultural Activities**

	<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Not Sure</b>	<b>Agree</b>	<b>Strongly Agree</b>	<b>Total</b>
There are agricultural activities affected by degraded water	0.0%	11.8%	1.6%	77.2%	9.4%	100%
Crops have been affected by degraded water	0.8%	10.2%	15.7%	52.0%	21.3%	100%
Animals /livestock have been affected by degraded water	0.8%	14.2%	26.8%	49.6%	8.7%	100%
There is cost implication in crop production in the area due to use of degraded water	0.0%	8.7%	14.3%	46.0%	31.0%	100%
Land under irrigation using River Athi waters has reduced due to water degradation	22.2%	11.9%	1.6%	17.5%	46.8%	100%

#### 4.4.2 Location and the Effect of Water Degradation on Agricultural Activities

One Way ANOVA test sought to determine evidence of significant differences on how water degradation affected agricultural activities on different sections of the river. The results of test were F statistics (2,118) =3.118,  $p=0.048$  indicating there were some sections of rivers experienced significantly different agricultural effects than others.

**Table 4: 11 ANOVA Test on Location and the Effect of Water Degradation on Agricultural Activities**

ANOVA					
Agricultural Effects					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.202	2	1.101	3.118	.048
Within Groups	41.673	118	.353		
Total	43.875	120			

#### Post Hoc Tests

A post hoc test aimed to establish sections of River Athi where their agricultural activities were largely affected. Table 12, shows that Yatta's agricultural activities were significantly affected compared to River Athi ( $p=0.034$ ) and also significantly affected compared to Mwala ( $p=0.026$ ). There were significant differences on how the agricultural activities were affected between Mwala and Athi River ( $p=0.575$ ). This is explained by the fact River Athi is the main source of water in Yatta area resulting to more extensive impact on agricultural activities.

**Table 4: 12 Post Hoc Test for ANOVA Test on Location and the Effect of Water Degradation on Agricultural Activities**

Dependent Variable: Agricultural Effects						
LSD						
(I) Location	(J) Location	Mean Difference (I- J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Athi-River	Mwala	-.11836	.21061	.575	-.5354	.2987
	Yatta	-.37933	.21784	.034	-.8107	.0520
Mwala	Athi-River	.11836	.21061	.575	-.2987	.5354
	Yatta	-.26097*	.11546	.026	-.4896	-.0323
Yatta	Athi-River	.37933	.21784	.034	-.0520	.8107
	Mwala	.26097*	.11546	.026	.0323	.4896

\*. The mean difference is significant at the 0.05 level.

#### 4.4.3 Duration of Stay and Effects of Water Degradation on Agricultural activities

The study found no significant statistical differences on respondents with different duration of stay and the effect of water degradation on Agricultural activities through one-way ANOVA test. The F statistic (3,118) =1.200, p=0.313 showed that there were no differences across the respondents with different durations of stay and agricultural activities.

**Table 4: 13 ANOVA Test on Duration of Stay and Effects of Fresh Water Degradation on Agricultural activities**

ANOVA					
Agricultural Effects					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.308	3	.436	1.200	.313
Within Groups	42.875	118	.363		
Total	44.184	121			

#### 4.4.4 Age and Effects of Fresh Water Degradation on Agricultural Activities

A one-way ANOVA test aimed to establish evidence of significant differences on effects of fresh degradation on agricultural activities based on the different age groups of the respondents. The test result as shown by the F Statistic  $F(3,117) = 0.378$ ,  $p = 0.769$  found no significant differences on agricultural activities based on age groups. This indicated that the way young people were affected on issues on agriculture is the way the elderly were affected.

**Table 4: 14 ANOVA Test on Age and Water Degradation on Agricultural Activities**

ANOVA					
Agricultural Effects					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.406	3	.135	.378	.769
Within Groups	41.931	117	.358		
Total	42.337	120			

#### 4.4.5 Hypothesis Testing I

This segment discusses the results of the testing of the first hypothesis. The first hypothesis was stated as follows:

$H_{a-1}$ : There is an effect of fresh water degradation on agricultural activities. A Pearson Correlation was conducted at 95% level of confidence where the alpha value was 0.05. The hypothesis was tested through. From table 4.15, the Pearson Correlation results were given as ( $r = 0.288$ ,  $p = 0.001$ ). These outcomes illustrate a statistically significant relationship between the two variables of water degradation and the extent of disturbances on agricultural activities. From the results, the correlation was positive and significant implying increase in water degradation was corresponding to an increase in the disturbances caused on the agricultural activities along the river. Thus, the study failed to reject the hypothesis of having a significant statistical relationship between water degradation and level of disturbance on agricultural activities.

**Table 4: 15 Correlation between Water Degradation and Agricultural Effects**

Correlations		
	Water Degradation	Agricultural Effects

Water Degradation	Pearson Correlation	1	.288**
	Sig. (2-tailed)		.001
Agricultural Effects	Pearson Correlation	.288**	1
	Sig. (2-tailed)	.001	
**. Correlation is significant at the 0.01 level (2-tailed).			

#### 4.5 Effects of Fresh Water Degradation on Fishing activities

##### 4.5.1 Status of Fresh Water Degradation on Fishing Activities

Table 4.16, shows that majority agreed (64.5%) and 31.5% strongly agreed that there had been a reduction in the fish population in River Athi. Further majority 82.0% agreed that degradation of the water had affected the type of fishing activities found along the river. More findings on the same shows that majority of the respondents either strongly agreed (52.0%) or agreed (44.9%) that degradation of water in the river led to reduction in the availability of fish. Further, majority (55.1%) strongly affirmed that water degradation had reduced the fishing income of the people along the river. The types of fish species along the river had also reduced according to most of the respondents (49.6%). The results show degradation of the water had some far reaching effects on fishing along the river.

**Table 4: 16 Status of water degradation on Fishing Activities**

	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree	Total
Over the past few years fish population in River Athi have decreased	0.8%	0.8%	1.6%	65.4%	31.5%	100.0%
Degradation has affected the type of fishing related activities along River Athi	0.0%	0.0%	15.3%	82.0%	2.7%	100.0%
Fish availability has been affected by the degraded water	1.6%	0.8%	0.8%	52.0%	44.9%	100.0%
Water degradation has led to reduction in fishing income	2.4%	0.8%	0.8%	40.9%	55.1%	100.0%
There has been reduction in fish species in River Athi	1.6%	19.7%	5.5%	49.6%	23.6%	100.0%

##### 4.5.2 Location and Effect of Fresh Water Degradation on Fishing Activities

The study found no statistically significant relationship between the effect of water degradation and fishing activities through one-way ANOVA test. The F statistic (2,118) =0.923, p=0.400

showed that there were no differences across the river sections implying that fishing activities along the river sections were affected uniformly.

**Table 4: 17 ANOVA Test on Location and Effect of Water Degradation on Fishing Activities**

ANOVA					
Fishing Effects					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.297	2	.148	.923	.400
Within Groups	18.978	118	.161		
Total	19.275	120			

#### 4.5.3 Duration of stay and Effects of Fresh Water Degradation on Fishing activities

A one-way ANOVA aimed to assess any differences on duration of stay and fishing activities.

The test results  $F(3,118) = 0.469$ ,  $p = 0.705$  shows that there were no differences from the respondents showing that fishing activities were affected based on their duration of stay.

Therefore, the fishing activities of those who stayed along the river for long and those who had stayed there for a short period were similar.

**Table 4: 18 ANOVA Test on Duration of Stay and Water Degradation**

ANOVA					
Fishing Effects					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.227	3	.076	.469	.705
Within Groups	19.056	118	.161		
Total	19.283	121			

#### 4.5.4 Age and Effect of Freshwater Degradation on Fishing Activities

A test was done to establish whether fishing activities of respondents of different ages were affected differently. The results found no significant differences on effects of fishing activities based on the age of the respondents.

**Table 4: 19 ANOVA Test on Age and Water Degradation**

ANOVA					
Fishing Effects					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.707	3	.236	1.485	.222
Within Groups	18.574	117	.159		
Total	19.282	120			

**4.5.5 Hypothesis Testing II**

This section reviews the results after conducting tests to test the second hypothesis.

H<sub>a</sub>-2: There is a relationship on effects of Fresh water degradation on fishing along Athi River.

A Pearson Correlation test was done at a 95% level of confidence and the alpha value at 0.05.

From table 4.20, the Pearson Correlation results were given as (r=0.215, p=0.015). This shows that there was a significant statistical association between water degradation and disturbances on fishing activities. From the results, the correlation was positive and significant implying increase in water degradation was corresponding to an increase in the disturbances caused on the fishing activities. Thus, the study failed to reject the hypothesis proposing a statistically significant relationship between water degradation and extent of disturbance on fishing activities along the river.

**Table 4: 20 Correlation between Water Degradation and Fishing Activities**

Correlations			
		water degradation	Fishing Effects
water degradation	Pearson Correlation	1	.215*
	Sig. (2-tailed)		.015
Fishing Effects	Pearson Correlation	.215*	1
	Sig. (2-tailed)	.015	

\*. Correlation is significant at the 0.05 level (2-tailed).

## 4.6 Effects of Fresh Water Degradation on Domestic Activities

### 4.6.1 Status of Fresh Water Degradation on Domestic Activities

The section aimed to assess how degradation along the river influenced domestic activities. From the results, majority (54.0%) indicated that to a large extent diseases had emerged as a result of water degradation. Further, 47.2% of the respondents indicated that there existed residents who had been affected by consumption of crops grown with the water from River Athi to large extent followed by 30.7% who indicated that they had been affected to a less extent. Further, the costs of treating water for domestic use drawn from River Athi was higher to a very large extent according to 75.6% of the respondents implying that water degradation had affected the domestic use of water and other routine activities.

**Table 4: 21 Status of Water Degradation on Domestic Activities**

	Very little extent	Little extent	Not at all	Large extent	Very large extent	Total
There are diseases that have emerged as a result of water degradation	0.0%	8.7%	7.9%	54.0%	29.4%	100.0%
There are residents who are affected by consumption of crops grown with the water from River Athi	3.1%	30.7%	12.6%	47.2%	6.3%	100.0%
There has been increased cost of treating water for domestic use drawn from River Athi	0.0%	0.8%	0.0%	23.6%	75.6%	100.0%

### 4.6.2 Location and Effects of Fresh Water Degradation on Domestic Activities

The study run an ANOVA test to determine whether the effect of water degradation on domestic activities was uniform across locations. The study showed no significant differences on the effects of the water pollution in different locations as the F Statistics  $F(2,118) = 0.1927$ ,  $p = 0.150$ . This indicates that regardless of the location the respondents were affected uniformly in their domestic activities.

#### 4:22 ANOVA Test between Location and Effects of Fresh Water Degradation Domestic Activities

ANOVA					
Domestic Effects					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.931	2	.466	1.927	.150
Within Groups	28.513	118	.242		
Total	29.444	120			

#### 4.6.3 Duration of stay and effects of water degradation on Domestic Activities

ANOVA test aimed to assess if there were any significant differences on duration of stay of the respondents and how their domestic activities had been affected by water degradation. The test shows  $F(3,118) = 0.473$ ,  $p = 0.702$  implying no significant differences on the extent of disturbances on domestic activities based on the duration of stay.

**Table 4: 22 ANOVA Test between Duration of Stay and Domestic Activities**

ANOVA					
Domestic Effects					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.350	3	.117	.473	.702
Within Groups	29.094	118	.247		
Total	29.444	121			

#### 4.6.4 Age Bracket and Effect of Water Degradation on Domestic activities

A one-way ANOVA aimed to establish if there existed any differences on how respondents experienced effects of water degradation on domestic activities. The F Statistics  $F(3,117) = 0.304$ ,  $p = 0.823$ . This shows that there existed no significant differences on how respondents experienced effects of water degradation on domestic activities based on their ages.

**Table 4: 23 ANOVA Test between Age Bracket and Domestic Activities**

ANOVA					
Domestic Effects					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.214	3	.071	.304	.823
Within Groups	27.430	117	.234		
Total	27.644	120			

#### 4.6.5 Hypothesis Testing III

This section reviews the results on tests to test the third hypothesis of the study. The hypothesis stated there was a relationship between water degradation and domestic disturbance along River Athi

H<sub>a</sub>-3: There is a relationship between Water Degradation and level of Domestic Disturbance along River Athi.

A Pearson Correlation at 95% level of confidence and the alpha value of 0.05. From table 4.25, the Pearson Correlation results were given as (r=0.195, p=0.028). This shows that there was a significant statistical correlation between water degradation and disturbance of domestic activities. From the results, the correlation was positive and significant implying increase in water degradation was corresponding to an increase in the disturbances caused on the domestic activities of individuals residing along the river. Thus, the study failed to reject the hypothesis proposing a statistical significant relationship between water degradation and disturbance of domestic activities.

**Table 4:24 Correlation between Water Degradation and Effect on Domestic Activities**

Correlations			
		Water degradation	Domestic Effects
Water degradation	Pearson Correlation	1	.195*
	Sig. (2-tailed)		.028
Domestic Effects	Pearson Correlation	.195*	1
	Sig. (2-tailed)	.028	

\*. Correlation is significant at the 0.05 level (2-tailed).

#### 4.7 Effect of Fresh Water Degradation on Human Activities

To determine the effect of water degradation on agriculture, domestic life and fishing activities along River Athi, simple linear regression tests were done for each activity. The results are given the following paragraphs.

##### 4.7.1 Effect of Fresh Water Degradation on Agricultural Activities

The coefficient table 4.25 shows that the effect of water degradation on the agricultural activities was significant ( $p=0.001$ ). A linear regression yields the following regression equation:

$$A=2.345406+0.345X1$$

Where A= Agricultural Activities and X is extent of water degradation. From this equation, the impact of constant water degradation on the level of agricultural activities is 2.382. The coefficient of the regression was 0.345 at ( $P>0.05$ ). This meant that increase in the water degradation by 1 unit increased the disturbances on agriculture by 0.345 units which can be deduced to mean that water degradation affected agricultural activities along the river. This result is similar to the findings of a study done along River Limpopo in Lesotho which found that pollutants and contaminants from human activities make it unsuitable for human and animal consumption (Heath et al., 2009).

**Table 4: 25 Regression Coefficients-Effect of Water Degradation on Agricultural Activities**

Coefficients <sup>a</sup>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.382	.408		5.838	.000
	water degradation	.345	.103	.288	3.363	.001

a. Dependent Variable: Agricultural Effects

##### 4.7.2 Effect of Fresh Water Degradation on Fishing Activities

The second regression test was done to test the effect of water degradation on the fishing activities. The resulting equation was given by:

$$F=3.494+0.167Y$$

Where F= Fishing activities and Y is extent of water degradation. From the equation, constant water degradation leads to a level of fishing activities of 3.494 units. The coefficient of the regression was 0.167 at (P<0.05). The result implies a unit increase in water degradation increases disturbances on fishing activities by 0.167 units. This shows that degradation of River Athi waters affected fishing activities along the river. These results align with findings from past studies investigating the impact of fresh water degradation on fishing activities. Human waste and increased use of agricultural chemicals make the water unsuitable for farming or carrying out irrigation activities (Masese & McClain, 2012).

**Table 4: 26 Regression Coefficients-Effect of Water Degradation on Fishing Activities**

Coefficients <sup>a</sup>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.494	.269		12.989	.000
	water degradation	.167	.068	.215	2.467	.015

a. Dependent Variable: Fishing Effects

#### 4.7.3 Effect of Water Degradation on Domestic Activities

The third regression test was done to determine the effect water degradation had on the domestic activities. The resulting equation was given by

$$D = 3.236 + 0.195Y$$

Where D= Domestic activities and Y is extent of water degradation. The result shows that when water degradation was held constant, the level of domestic activities was 3.236. The coefficient of the regression was 0.195 at (P<0.05) implying that water degradation significantly affected domestic activities. The results indicate that a unit increase in water degradation resulted into 0.195 units increase in disturbances on domestic activities. The results show that degradation of water affected domestic activities negatively. These results align with a study done in Lake Victoria has been affected by continuous pollution of the lake from industrial effluents, human wastes and poor agricultural activities affected the fresh water biodiversity hence leading to reduction of fish species in the lake (Johnson, 2018).

**Table 4: 27 Regression Coefficients-Effect of Water Degradation on Domestic Activities**

<b>Coefficients<sup>a</sup></b>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.236	.348		9.289	.000
	water degradation	.195	.088	.195	2.226	.028

a. Dependent Variable: Domestic Effects



## CHAPTER FIVE

### SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Introduction

This study investigated the relationship between water degradation and human activities among individuals living along the basin of River Athi. The types of human activities studied are domestic activities, agricultural activities and fishing activities. This section discusses the study's findings and conclusions and makes recommendations from the results.

#### 5.2 Summary of the findings

The research was done along River Athi to assess the effects of water degradation on human activities. According to the findings, there was indication that the quality of water in River Athi had been affected. This was manifested by a variety of results such as pollution of water by industrial effluents, sand harvesting, soil erosion and indiscriminate human waste disposal.

The results on water degradation on domestic activities showed that degradation of water along River Athi brought about health challenges as some reported having been affected health wise after consuming crops grown using water from the affected river. Also, water treatment for domestic use because of water degradation.

The effect of water degradation on agriculture was also highlighted. The respondents agreed that agricultural activities were affected by degraded water in a number of ways such as reducing crop production, animal/livestock keeping, increasing the cost of crop production and reducing the acreage of land under irrigation.

On fishing activities, the study found that water degradation had some effects on fishing activities such as reduction in fish population in the river, lower quality of fish found along the river, reduced fishing income and reduced fish species.

### **5.3 Conclusion**

The research revealed water quality in River Athi is compromised. This is because it had been contaminated by industrial effluents and disposal of human wastes as the main agents of water degradation. The quality had also been lowered by soil erosion and sand harvesting which to be rampant along the river.

There is a positive correlation between water degradation and negative effects on agricultural activities. Further the regression test showed a significant effect of water degradation on agricultural activities along the river. This shows that as the water was being degraded it in turn affected the agricultural activities negatively.

The study indicated that pollution of the water in River Athi affected the domestic activities of the people living near the river's basin. A regression test found a significant effect of degrading water on the domestic activities. This was mainly due to increased cost of life and cost of health care arising from health complications after prolonged use of the water.

The regression test showed that degradation of water in River Athi affected fishing activities negatively along the river which supports some livelihood. This included reduced income from sale of fish, reduced fishing related activities, fish species and fish availability.

The study revealed significant differences on the extent of water degradation along the sections of River Athi studied. The study shows that River Athi was more degraded in some sections than in other sections of the river. This was mainly due to the fact that River Athi is more densely populated and prone to industrial effluents and human waste disposal.

### **5.4 Recommendations**

#### **5.4.1 Recommendations for Practice**

The study found some indicative pointers of water degradation along River Athi as evidenced by pollutants and polluting activities in the river such as soil erosion, industrial effluents and human waste disposal among others. The extent of degradation was however not determined. It is recommended that a water quality assessment be undertaken to determine the extent of water pollution along the river to come up with relevant mitigation measures.

Given that River Athi water quality has been significantly degraded due to industrial effluents and human waste disposal, it is recommended that the National Environment Management

Authority (NEMA) intensify monitoring and enforcement of environmental laws. Industries should be required to treat their waste before discharge, and penalties for non-compliance should be enforced. Additionally, there should be investment in proper sewage systems to prevent direct human waste disposal into the river.

Since water degradation has negatively impacted agriculture, there is a need to introduce water purification systems for irrigation purposes. The Ministry of Agriculture, in collaboration with local authorities, should train farmers on the use of clean irrigation water and promote climate-smart agriculture practices to minimize dependency on polluted river water.

In response to the adverse effects of water degradation on domestic use, including health complications and increased living costs, there should be community-level water treatment initiatives such as Solar Disinfection (SODIS), chlorination, or small-scale filtration systems. The government should prioritize access to clean water by investing in protected boreholes and water piping systems for communities relying on River Athi.

#### **5.4.2 Recommendations for Further Areas of Study**

The research collected data from selected sections of River Athi: Athi River, Mwala and Yatta. The level of degradation was different in the sections of the River which the study focused on. It is thus recommended that further research be done on other sections of the River Athi to investigate the relations of water degradation and human activities in those areas.

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## APPENDICES

### Appendix I: Research Tools

#### Semi-structured questionnaires

Name of the institution: Mount Kenya University

#### Demographic Data

1. What is the location? (Tick your area)

Athi – River ( ) Mwala ( ) Yatta ( )

2. Duration of stay in the area of study

Below five years ( ) 6-10 years ( ) 11- 15 years ( ) Over 15 years ( )

3. What is the age? (Tick your age bracket)

0-10 years ( ) 11-20 years ( ) 21-30 year ( ) 31-40 years ( ) 41-50 years ( )

4. What is the highest level of formal education?

Primary ( ) Secondary ( ) College ( ) University ( )

#### PART A: Water Degradation:

To what extend do you agree with the following statement?

**Kindly note that; 5=very large extend, 4 = large extend, 3=not at all, 2=little extend and 1= very little extend**

	Statement	1	2	3	4	5	Mean	Std dev
1.	River Athi has been polluted by industrial effluents							
2.	Sand harvesting has led to water degradation of River Athi							
3.	Soil erosion has led to water degradation in River River							
4.	Human waste disposal has led to water degradation of River Athi							

## PART B: Effects of fresh water degradation on Agriculture

To what extent do you agree with the following information?

*Kindly note that: 5 – strongly agree, 4– Agree, 3 – Not Sure, 2– Disagree, 1 – Strongly Disagree*

S/N	Statement	5	4	3	2	1	Mean	Std dev
5.	There are agricultural activities that are affected by the degraded water							
6.	Crops have been affected by the degraded water of River Athi							
7.	Animals or livestock have been affected by the degraded water							
8.	There are cost implication in crop production in the area due to use of degraded water							
9.	Land under irrigation using the waters of River Athi has reduced due to water degradation							

## PART C: Effects of fresh water degradation on fishing activities

To what extent do you agree with the following statement?

5 – Strongly agree, 4 – Agree, 3– Not Sure, 2 – Disagree, 1 – Strongly Disagree

SN	Statement	5	4	3	2	1	Mean	Std dev
10.	Over the past few years fish population in River Athi have decreased							
11.	Degradation has affected the type of fishing related activities along River Athi							
12.	Fish availability has been affected by the degraded water							
13.	Water degradation has led to reduction in fishing income							
14.	There has been reduction in fish species in River Athi							

#### **PART D: Effects of Fresh Water Degradation on Domestic Activities**

To what extent do you agree with the following statement?

**Kindly note that; 5=very large extend, 4 = large extend, 3=not at all, 2=little extend and 1=very little extend**

SN	Statement	1	2	3	4	5	Mean	Std dev
15.	There are diseases that have emerged as a result of water degradation							
16.	There are residents who are affected by consumption of crops grown with the water from River Athi							
17.	There has been increased cost of treating water for domestic use drawn from River Athi							

## Interview guides for key informants

1. a) Are you working with the department of water and sanitation, department of environmental conservation and department of health?  
b). If yes for how long have you worked within the department?
2. The water of River Athi is degraded mainly because of? Mention the causes of the water degradation.
3. a) What are the major causes leading to degradation of the waters of the river?  
b) If yes, which are these causes of pollution?  
c) How can the degraded be noticed within the river course?
4. a) Is the water in River Athi good for agricultural activities?  
b) Which crops are mainly grown with the water of River Athi?  
c) The crops grown either cash crops or food crops are they fit for human consumption?  
d) Crops grown for sale are they accepted once exported?
5. a) Has the water of River Athi affected the fishing activities?  
b) Which fish species is mainly found in River Athi?  
c) How has the fish species being affected by degraded water?  
d) Has the fish species found in River Athi reduced in number due to water degradation?
6. a) What are the domestic uses of River Athi water?  
b) The polluted water is used for cooking, washing and drinking. What are the effects of the water to human being and animals?  
c) The polluted water is good for bathing and washing of clothes: If not what are the effects once is bathed or clothes are washed?

## Appendix II: ERC Certificate



### DIRECTORATE OF GRADUATE STUDIES

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MAGE/2018/41346

27<sup>th</sup> April, 2022

*The Director, Research Coordination Division  
National Commission for Science, Technology & Innovation  
Utalii House, 8<sup>th</sup> & 9<sup>th</sup> Floor  
P.O Box 30623- 00100  
NAIROBI*

Dear Sir/Madam,

**RE: MUTUA STEPHEN KYALO - REGISTRATION NUMBER: MAGE/2018/41346**


The purpose of this letter is to introduce the above named student who is pursuing Master of Arts in Geography in the Department of Languages and Humanities in the School of Social Sciences.

The title of his research is *"Relationship between fresh water degradation and human activities: A case of Athi River in Machakos County, Kenya."*

He has been cleared by the University's Ethics Review Committee (Certificate attached) and now has to proceed to the field to collect data for his research between April and July, 2022.

Any assistance accorded to him will be highly appreciated.

Thank you

  
Dr. Samuel M. Karenga, Ph.D  
Director, Graduate Studies  
Enc.

## Appendix III: Introduction letter from Mount Kenya University

# Mount Kenya University



REF: MKU/ERC/2173

Date: 21 April 2022

TO: MUTUA STEPHEN KYALO

REG: MAGE/2018/41346

Dear Sir/Madam,

**RE: RELATIONSHIP BETWEEN FRESH WATER DEGRADATION AND HUMAN ACTIVITIES: A CASE OF ATHI RIVER IN MACHAKOS COUNTY, KENYA**

This is to inform you that **Mount Kenya University** has reviewed and approved your above research proposal. Your application approval number is **1246**. The approval period is **21/04/2022 - 20/04/2023**.

This approval is subject to compliance with the following requirements;

- i. Only approved documents including informed consents, study instruments, MTA will be used
- ii. All changes including amendments, deviations and violations are submitted for review and approval by **Mount Kenya University**
- iii. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to **Mount Kenya University** within 72 hours of notification
- iv. Any changes, anticipated or otherwise that may increase the risks or affect the safety or welfare of study participants and others or affect the integrity of the research must be reported to **Mount Kenya University** within 72 hours
- v. Clearance for export of biological specimens must be obtained from relevant institutions
- vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal
- vii. Submission of an executive summary report within 90 days upon completion of the study to **Mount Kenya University**






Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) <https://research-portal.nacosti.go.ke> and also obtain other clearances needed.

Yours sincerely,

✓ The Chairman  
Mount Kenya University  
Ethics Review Committee  
P. O. Box 342 - 0100, Thika

**Dr. Peter G. Kirira**  
Chairman, Mount Kenya University IERC

**Appendix IV: NACOSTI Research License**

 REPUBLIC OF KENYA	 NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION
Ref No: 533360	Date of Issue: 04/May/2022
<b>RESEARCH LICENSE</b>	
	
<p>This is to Certify that Mr.. STEPHEN Kyaio Mutua KIANGA of Mount Kenya University, has been licensed to conduct research in Machakos on the topic: RELATIONSHIP BETWEEN FRESH WATER DEGRADATION AND HUMAN ACTIVITIES: A CASE OF ATHI RIVER IN MACHAKOS COUNTY, KENYA for the period ending : 04/May/2023.</p>	
License No: NACOSTI/P/22/17157	
533360 Applicant Identification Number	 Director General NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION
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**Appendix V: Field entry/ Research Authorization**

**EFFECTS OF FRESH WATER DEGRADATION AND HUMAN ACTIVITIES: A CASE OF RIVER ATHI IN MACHAKOS COUNTY, KENYA.**

**PEER PARTICIPANT:**

I invite you to participate in the study entitled: **Effects of fresh water degradation and human activities: A case of River Athi in Machakos County, Kenya.** I am currently enrolled in Master's in Geography in Mount Kenya University.

The purpose of this research study is to get real facts on how the River Athi water degradation has negative effects to the human activities in the area of study. This study will establish how the water degradation has affected the human activities that provide for the people with livelihoods. Risks of using contaminated water to facilitate human activities like agricultural activities, fishing and domestic use will be established hence providing a platform to find a solution.

The questionnaires and interview guides are designed assist the researcher to collect information on my thesis. Your participation in the answering of the questionnaires and interview guides is completely voluntarily. As a participant you may decline totally or leave blank any questionnaire that you may not want to answer. The response that you give remains confidential. There will be no straight gain for participating in this research.

The questionnaires are designed to take only ten minutes. Please if you have any questions contact me (0727993974) and the supervisor (0721576267). If you have concern about your rights as a participant, please be in touch with the Chairman of Mount Kenya University Ethical committee Po Box 342-01000, Thika.

Thanks for the assistance.

Consent

I have read and understood the provided information.

Participant:                      Sign:                      Date:

Researcher:                      Sign:                      Date:

Appendix VI: Similarity Index Report

# EFFECTS OF FRESH WATER DEGRADATION ON HUMAN ACTIVITIES: A CASE OF ATHI RIVER IN MACHAKOS COUNTY, KENYA

*by* Mutua Stephen Kyalo

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**Submission date:** 06-Jun-2024 04:26PM (UTC+0300)  
**Submission ID:** 2396884349  
**File name:** Water\_Degredation\_4\_2.docx (356.72K)  
**Word count:** 21391  
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Mount

# EFFECTS OF FRESH WATER DEGRADATION ON HUMAN ACTIVITIES: A CASE OF ATHI RIVER IN MACHAKOS COUNTY, KENYA

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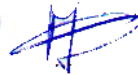
Dr. Jane Kagendo Francis

Sign



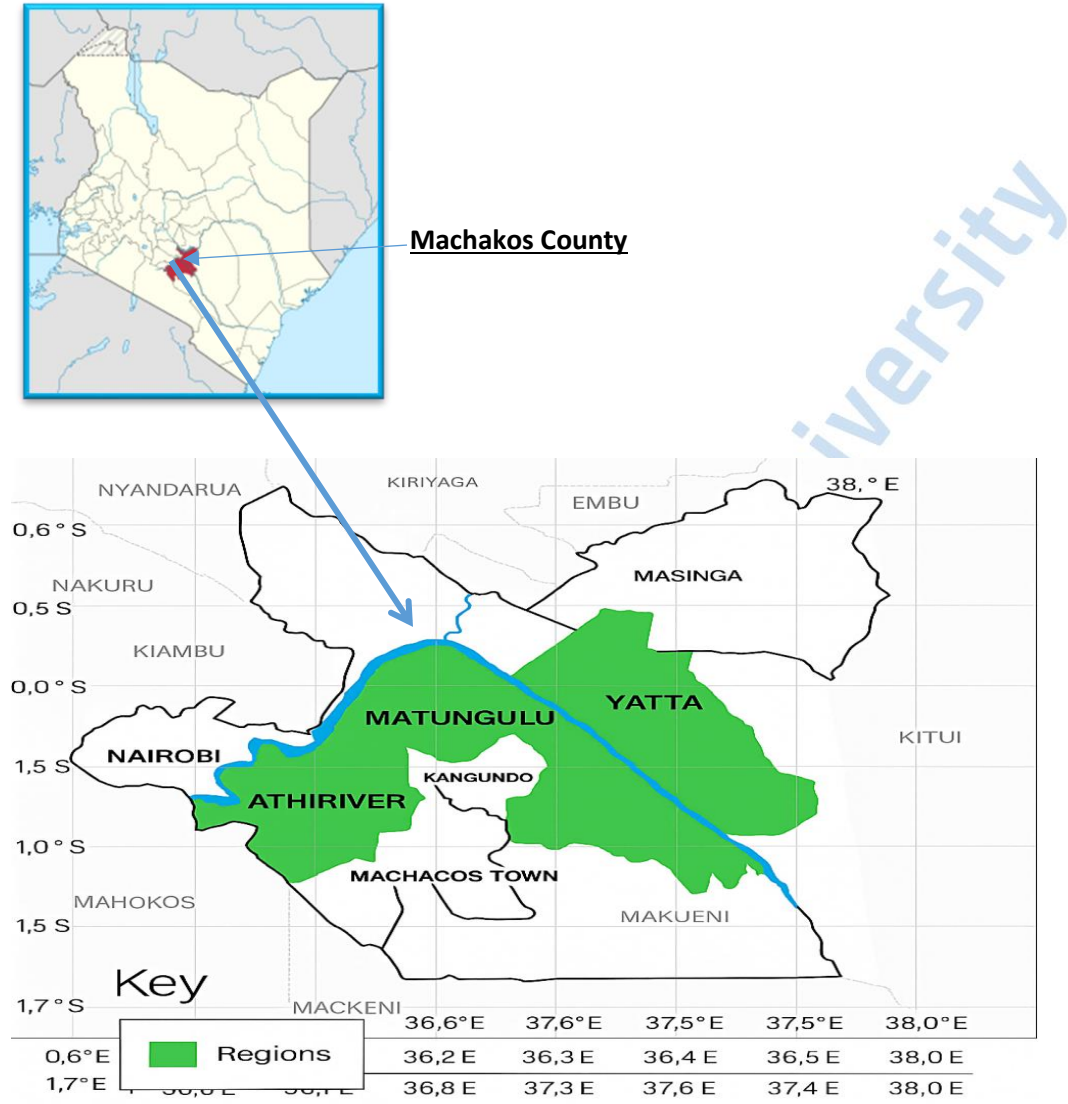
Dr. Kibutu Thomas

Sign



Mount Kenya

**Appendix VII: Research Site Map**



**Figure 3: Map of River Athi and Study Area (Best et al., 2024)**