# STORM WATER MANAGEMENT CHALLENGES AND THEIR ENVIRONMENTAL IMPACTS – A CASE STUDY OF ONGATA RONGAI TOWN

**BY**

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## DECLARATION

This research project is my original work and has not been presented for a degree in any other institution.

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## DEDICATION

This project is dedicated to my dear family who, through their constant support and encouragement, have enabled the project to be successful and who are the most important aspect of my life.

## ACKNOWLEDGEMENT

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God bless you all!

## LIST OF ACRONYMS

CoK - Constitution of Kenya, 2010

COWSM - Council of Water Sector Ministers

CWSF - County Water & Sanitation Forum

EIA - Environmental Impact Assessment

EMCA - Environmental Management Coordination Act

IWRM - Integrated Water Resource Management

KWFT – Kenya Women Finance Trust

MDGs - Millennium Development Goals

MoE – Ministry of Environment

NEMA- National Environmental Management Authority

NGO - Non-Governmental Organization

NWP - National Water Policy

NWMP – National Water Management Programme

NYSDEC – New York State Department of Environment and Conservation

OMoE – Ontario Ministry of Environment

RWH - Rainwater Water Harvesting

SEP – Science for Environment Policy

SPSS - Statistical Package for Social Science

SSWM- Sustainable Storm Water Management

SW –Storm Water

SWM – Storm Water Management

WAB - Water Appeals Board

WRM - Water Resources Management

WRMA - Water Resources Management Authority

WRUA - Water Resource User Association

WSB - Water Services Board

WSIs - Water Sector Institutions

WSRB - Water Services Regulatory Board

WSS - Water Supply and Sanitation

WSSP - Water Sector Strategic Plan

WSSS - Water Sector Stakeholders Secretariat

WSTF - Water Services Trust Fund

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## ABSTRACT

The issue of storm water management is a big problem in developing countries. In Africa, particularly in Kenya, urban planning in many developments is locally done without consulting experts. It is for this reason that later on issues of poor drainage affect the socio – economic activities of the dwellers. In Ongata Rongai, Kenya, the effects of heavy rainfall floods the settlements situated in the lower parts of the town. The effects of such rainfall are manifold; sanitation, material, economic and environmental impacts.

This project investigated and assessed mainly the environmental challenges and effects associated with storm water management in Ongata Rongai urban centre. Specific objectives were to analyze the bacteriological composition of storm water due to poor sewage disposal; to assess the socio - economic effects of storm water in Ongata Rongai and its management and to evaluate the effectiveness of the National Water policy (2012) in enhancing storm water management and pollution control in Ongata Rongai.

The research study adopted an experimental and survey research design where the experimental design involved analysis of storm water samples collected from three locations in the three clusters of the study area. The survey design adopted a structured questionnaire that targeted a population of 2000 households in Laiser Hill sub-location in Ongata Rongai. Spatial clustering of these households was done depending on their residential and commercial characteristics to arrive at the three clusters and the sample size of 90 in the study area. Quantitative primary data gathered directly from the households was further subjected to analysis using descriptive statistics and inferential statistics (Pearson's chi – square) to test the hypotheses with the aid of statistical software called Statistical Package for Social Sciences (SPSS).

The study found out that environmental pollution challenges in Ongata Rongai is an issue of concern because of lack of established sewerage system to dispose septic tank contents and inadequate storm water drainages. *E coli* detected in sampled storm water during the bacteriological analysis is a clear indication of human fecal waste disposal and contamination. Storm water related diseases such as malaria and diarrhoea have high case recordings at the area's government health centre while there are also numerous court cases pertaining to environmental pollution through sewage disposal as given in appendixes 8 and 9.

The study also established a significant relationship (5.399 at 0.05 $\alpha$ against the critical value of 3.841 at 0.05 $\alpha$) between storm water management challenges and the social economic development of the area. Poor planning, inadequate storm water drainages and a lack of established sewerage systems were the main management challenges of storm water in the study area.

Implementation of the National water policy (2012) was found to be affected by the limited storm water management instruments in the study area: poor planning by the county government, the residents are hardly involved in planning and water management. Majority of the respondents lacked awareness and are not informed about storm water management and flooding issues in the area.

The study concluded that storm water management challenges affect the social life (e.g displacement of populations and diseases), and economic life (e.g damage to infrastructure, goods and services) of the residents living in Ongata Rongai. This is common whenever there is adequate precipitation especially the two rainfall seasons as given in figure1.5. It recommended the construction of new drainages, unblocking of the existing drainages, launching public campaigns to educate the public about storm water management and pollution control, and implementation of the polluter pays principle to policy makers as one way of curbing these challenges.

# CHAPTER ONE: INTRODUCTION

This chapter sets out the overall study on the subject area of urban storm water management as introduced and placed in an environmental and historical context. This research is interdisciplinary and the different knowledge areas within which the research has been positioned are briefly introduced. This is followed by a list of the research objectives to be achieved by this study, how these translate into focused research hypothesis and how these were addressed through a deliberate research design.

## 1.1 Background of the Study

Urban storm water management is a topic that is becoming increasingly important for towns especially in developing countries, and the extent of the issue becomes particularly apparent when there is heavy rainfall that floods the settlements situated in the lowest parts of towns and the large number of urban development issues. Storm water is all the water that runs off the land after a rainfall or snowmelt incident. This is a natural process but in urban areas, due to anthropogenic impacts of a changing landscape, this is not the case (Ferguson, 1998).

Ongata Rongai is a fast growing town with an annual growth rate of 28%. It has a 2015 population projection of 52,513 people (GOK: Kajiado County Development Profile, Ministry of Devolution and Planning May, 2013, pg11), though according to the 2009 population census, Rongai has a population of 41000 people. The township hosts the population that works in Nairobi as they retire in the evening after the day's work due its location advantage.

Ongata Rongai is an area of high economic activities as all the major banks: Kenya Commercial Bank (KCB), Barclays, Equity, Co-operative, Family, Investment &Mortgage (I&M), National, and micro finance institutions including Faulu Kenya and Kenya Women Finance Trust (KWFT). The town is considered to be one of the four metropolitan towns in the process of expanding Nairobi City towards achieving vision 2030 (Nairobi Metro 2030: A world Class African Metropolis, 2008).

The location of Ongata Rongai town along Magadi road in Kajiado County has accelerated some of these storm water management challenges. They include poor planning, poor waste water disposal and management, inadequate drainage facilities, and lack of a sewage and waste water systems. In addition to all these, high amounts of rainfall experienced in the area contribute to

the storm water management challenges which are a threat to achieving sustainable economic and environmental development.

This study aimed at determining the challenges of storm water management and their resulting environmental impacts. The study achieved these by looking at three objectives: to analyze the bacteriological composition of storm water due to poor sewage disposal, to assess the social economic effects of storm water in Ongata Rongai and its management and to evaluate the effectiveness of the National Water Policy (2012) in enhancing storm water management and pollution control in Ongata Rongai.

### 1.2 Statement of the Research Problem

With the growth of towns, storm water management has become more and more complicated, especially in developing countries. This is characterized by urban population explosion over a short period of time, unplanned urban development patterns, severe poverty amongst some of the urban population resulting in environmental problems (Novatech, 2007). These towns are faced with the absence or inadequate sewer systems both in coverage and in performance especially because of inadequate waste management strategies. Most of the urban areas are dominated by unplanned urban development patterns. This constitutes a major obstacle for effective urban drainage. Flood plain and flood-prone areas are occupied either legally or illegally for the purposes of human settlement and business activities. The county authorities quite often lack the skilled manpower and budget to cope with the magnitude of the problem. It also lacks commitment, awareness and good organization which does need considerable amounts of money (Novatech, 2007).

Ongata Rongai area experiences high amount of rainfall, annual rainfall of 844mm although with a lot of variability over the year (Kenya Meteorological Services, 2014).This generates a lot of runoff within the town and its environment and this is even complicated by the black cotton soils in the area which hardly drains water easily (Mulwa et al, 2005). Its storm water drainage system is inadequate and in a poor state. The town came up as a local satellite urban centre along the Magadi road (one main tarmac road classified as a highway in the area), as a centre convenient to the Magadi miners because of its proximity to the Nairobi city(Sojourner, 2014). It then grew without any urban planning and this has facilitated storm water management. In addition, population explosion is causing a severe strain on the meagre resources.

Sewage and wastewater systems do not exist and therefore residents use septic tanks to dispose their sewerage and waste water. These contents are in most cases released into open storm water drainage systems during the rainy season. This poses serious environmental problems to the residents and the animals living around these areas (The Sojourner, 2014 and The District Public Health, 2014 reports). Solid waste disposal points are inadequate thus; garbage is collected from residents and is then dumped on the road side in the existing storm water drains as in appendix 7 blocking them leading to overflow of storm water. This overflow drains into residential areas, people's business premises and to the access roads making them impassable. The soaked garbage is mashed and rots releasing a bad odour becoming a breeding ground for mosquitoes and flies leading to disease outbreaks

The prevalent flooding causes extensive damage to housing and other infrastructure such as roads, water pipe lines and underground electric cables, which generally disrupts commercial activities in the town. It also creates social effects like population displacement and makes the environment unpleasant. The lack of public awareness, improper demarcation and protection of storm water drains/ditches and their proximity to residential / informal settlements has led to several negative impacts on the bio-physical and social environment.

This study sort to investigate environmental pollution through analysis of bacteriological composition of storm water due to poor sewage disposal. It further assessed socio-economic effects of storm water management, which attempts to understand the effectiveness of the National Water Policy in managing storm water in the town.

## 1.3 Main Objective and Specific Objectives of the Study

### 1.3.1 Main Objectives

To investigate environmental challenges and effects associated with storm water management in Ongata Rongai urban centre.

### 1.3.2 Specific Objectives

1. To analyze bacteriological composition of storm water due to poor sewage disposal in Ongata Rongai town.
2. To assess the socio – economic effects of storm water management challenges in Ongata Rongai

3. To evaluate the effectiveness of National Water Policy 2012 in enhancing storm water management and pollution control in Ongata Rongai

### 1.4 Study Hypotheses

$H_0$1: Bacteriological composition of storm water does not significantly indicate poor sewage disposal Ongata Rongai

$H_i$1: Bacteriological composition of storm water significantly indicates poor sewage disposal in Ongata Rongai

$H_0$2: Storm water management challenges do not significantly affect the socio economic development of Ongata Rongai town.

$H_i$2: Storm water management challenges significantly affect the socio economic development of Ongata Rongai town.

$H_0$3: The effectiveness of the National Water Policy 2012 does not significantly affect storm water management and pollution control in the study area.

$H_i$3: The effectiveness of the National Water Policy 2012 significantly affects storm water management and pollution control in the study area.

### 1.5 Justification of the Study

Ongata Rongai is a fast growing urban centre with an annual growth rate of 28% (GoK: Kajiado County Development Profile, Ministry of Devolution and Planning, May, 2013, pg 11) and faces a serious problem of urban planning (Sojourner, 2014). As a result, the town constantly experiences the consequences of poor planning. One such consequence is that of urban flooding resulting from poor management of storm water. Apart from the urban flooding, storm water has additional environmental impacts which need to be investigated for proper understanding and action. Urban runoffs are contaminated with toxic substances which come into contact with underground water. Since the area largely relies on boreholes for domestic water supply, the contaminated storm water can lead to diseases and health complications.

Separate reports from The Sojourner (2014) and the Ministry of Public Health and Sanitation (2014), there are a number of court cases addressing sewage pollution. For example, Case No. 307/2013 Republic Vs. Tiraz Gitau Jomo where the court stated in part "the view of this court is that individual effort or targeting individual landlords would not solve the sewage system in the area as the county government must be involved to provide outlets for the sewers in the entire area." This is just one amongst many where individuals have been sued for releasing sewage/ waste water from buildings downstream to Olekasisi River basin. This water is a major health catastrophe for the residence of Ongata Rongai and those living along river Athi tributary (the Mbagathi River) in Ongata Rongai in which sewage is disposed into. The town is densely populated with business buildings and residential estates on either sides of the Magadi road. Sewer drainage from these buildings and estates are washed into the river thereby creating a serious health hazard to the residents who are exposed to this roaming danger of environmental degradation. The ministry of Public Health and Sanitation has also reported complaints from residents living downstream that their animals are dying of diseases from poisonous liquids upstream. This shows how serious this is to the public and unless something urgent is done, the situation will continue to deteriorate.

Global climate change has affected weather events including rainfall patterns so that there are unpredictable seasons and rainfall intensity which cause flooding and their ultimate effects. This calls for investigation into effective storm water management practices which are resilient and adaptive to changing climate especially in dealing with urban storm water runoffs (MOE, 2010).

The study, which is geared towards investigating environmental challenges and effects associated with storm water management in Ongata Rongai is significant for literature, decision and policy making by the County government and other key stakeholders in the area. In order to meet the study objectives, an estimated study population of 2000 households in Laiser hill sub location was put in three clusters based on their commercial and residential characteristics. The study pattern involved both experimental and survey design. The experimental design entailed bacteriological analysis of seven samples of storm water collected within the clusters in the study area while the survey design adopted a structured questionnaire to collect data from the field. The findings of the study will help them understand the key issues and address possible areas that are within their control in order to minimize the impact of storm water on the town's

environment, economy, and social life. The study will enable the various stakeholders involved to respond effectively to the problem by putting in place appropriate measures (quality management practices) for managing storm water according to the National water Policy 2012 in order to reduce the resulting floods which are feared to be further complicated by the global climate uncertainty.

## 1.6 Scope and Limitations of the Study

### 1.6.1 Scope of the study

The study was conducted in the town of Ongata Rongai and its immediate surroundings. The subject of the study therefore limited itself to focusing on the environmental aspects posed by storm water in the area excluding the engineering aspects. The study variables which were investigated included analysis of bacteriological composition of storm water due to poor sewage disposal, assessing human and economic related effects of storm water challenges and evaluating the efficacy of the National Water Policy 2012 in managing storm water challenges in the study area. The study therefore suggests that this research can be repeated in future but focusing on the engineering and other aspects of storm water in the study area.

### 1.6.2 Limitations

- Cost

Finances posed the main limitation for the researcher as every steps involved in the study had a financial aspects. The data was therefore collected from one sub-location that experienced a lot of floods.

- Data

There was inadequate household data to guide in conducting household surveys which made it difficult to randomly sample the population. Unlike in developed countries where there is an advance development and every household have a postal code that aids in giving an accurate list. The researcher had to use the data that was available at the chief's office which was updated last in the 2009 population census.

In addition, obtaining secondary data from the involved government agencies and public hospital was a challenge because they were either expensive or inadequate. The hospital data set was not

properly recorded and updated while some of the entries had faded and could not be properly read. The researcher had to manually come up with monthly health records from the available daily outpatient records for the particular seasonal diseases. It was tedious and time consuming.

- Time

Like most researches, this study was time bound. The study relied on the rain to obtain a storm water sample for the bacteriological analysis. It took long before the study area experienced rainfall as is usually the case. There was a slight delay in the expected rainy seasons. Finally, there were rains towards the end of August and early September that enabled the researcher to obtained storm water samples.

## 1.7 Study Area

The study was conducted in Ongata Rongai, Kajiado County, Kenya.

### 1.7.1 Location and Size

#### 1.7.1.1 Location of Ongata Rongai in Kenya

Ongata Rongai town is located in Kajiado County, which is one of the 47 counties in Kenya. It is a cosmopolitan town in Kajiado County that came as a local satellite urban centre along the Magadi road which is the only tarmac road classified as a highway in the area (Sojourner, 2013, Ministry of Local Government, 2013).

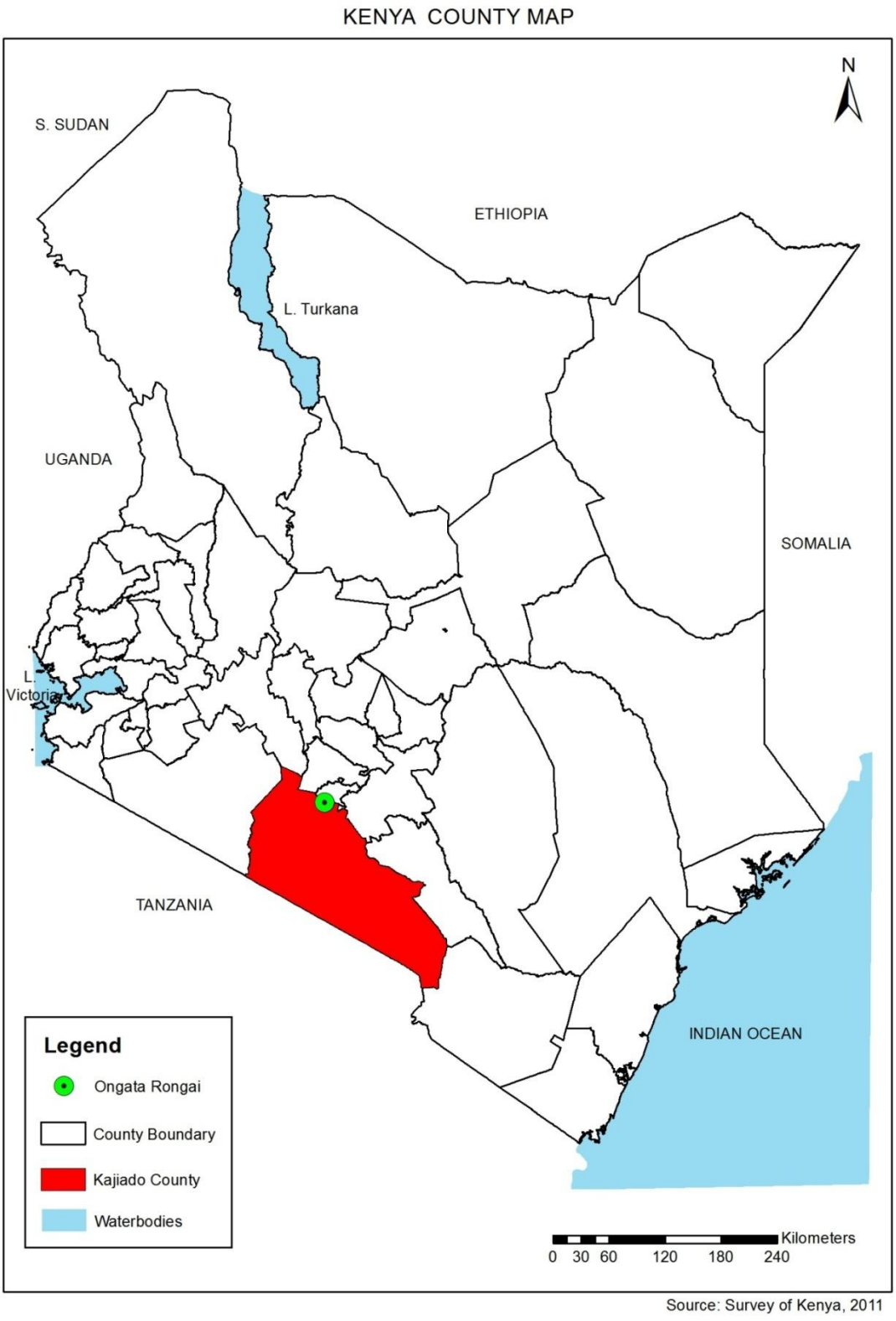



**Figure 1.1: Map of Kajiado County in Kenya**

### 1.7.1.2: Location of Ongata Rongai in Kajiado County

Kajiado County has an area of 21,292.7 km$^2$ with a population of 687,312 people (KNBS, 2009). It lies in the southern metro of the greater Nairobi region. It has several divisions with Ngong division where Ongata Rongai is located being one of them as given in figure 1.1. The county has 7 major towns including Ongata Rongai which is to the north of Kajiado and borders Nairobi to the south.

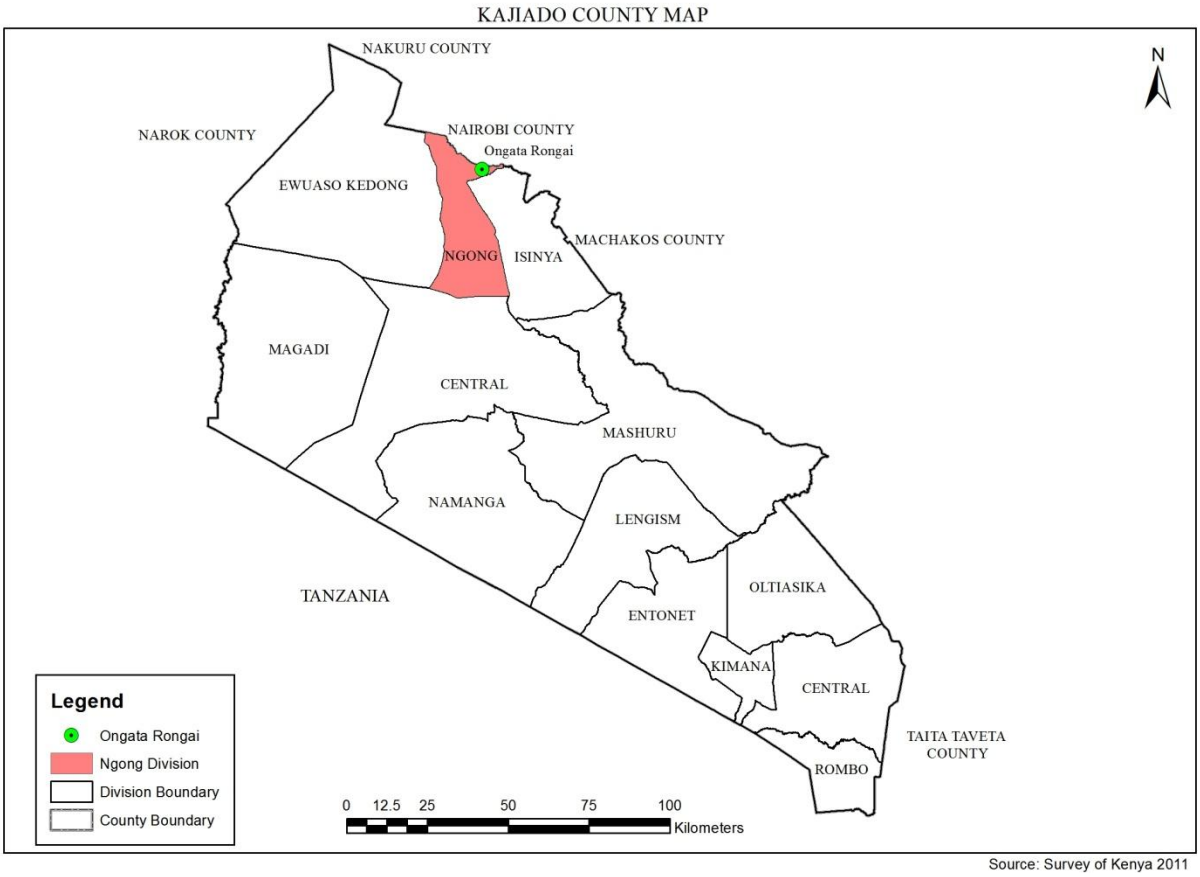



**Figure 1.2: Location of Ongata Rongai in Kajiado County**

### 1.7.1.3 Location of Ongata Rongai in Ngong Division, Kajiado

Ongata Rongai spans an area of 16.5 km$^2$ with a current population of between 41,000 people and a 2015 projection of 52,513 people (KNBS, 2009, GOK: Kajiado County Development Profile, Ministry of Devolution and Planning May, 2013, pg11)). It is a fast developing residential urban aggregation within Kajiado County; situated at Kajiado's border of Nairobi as shown in figure 1.2 at latitude (0° -53' 60 S), and longitude (36° 25' 60 E. It is located 50 Km

from Kajiado District Headquarters and 20 Km from Nairobi City Centre on the Langata-Magadi Road as indicated in figure 1.3.

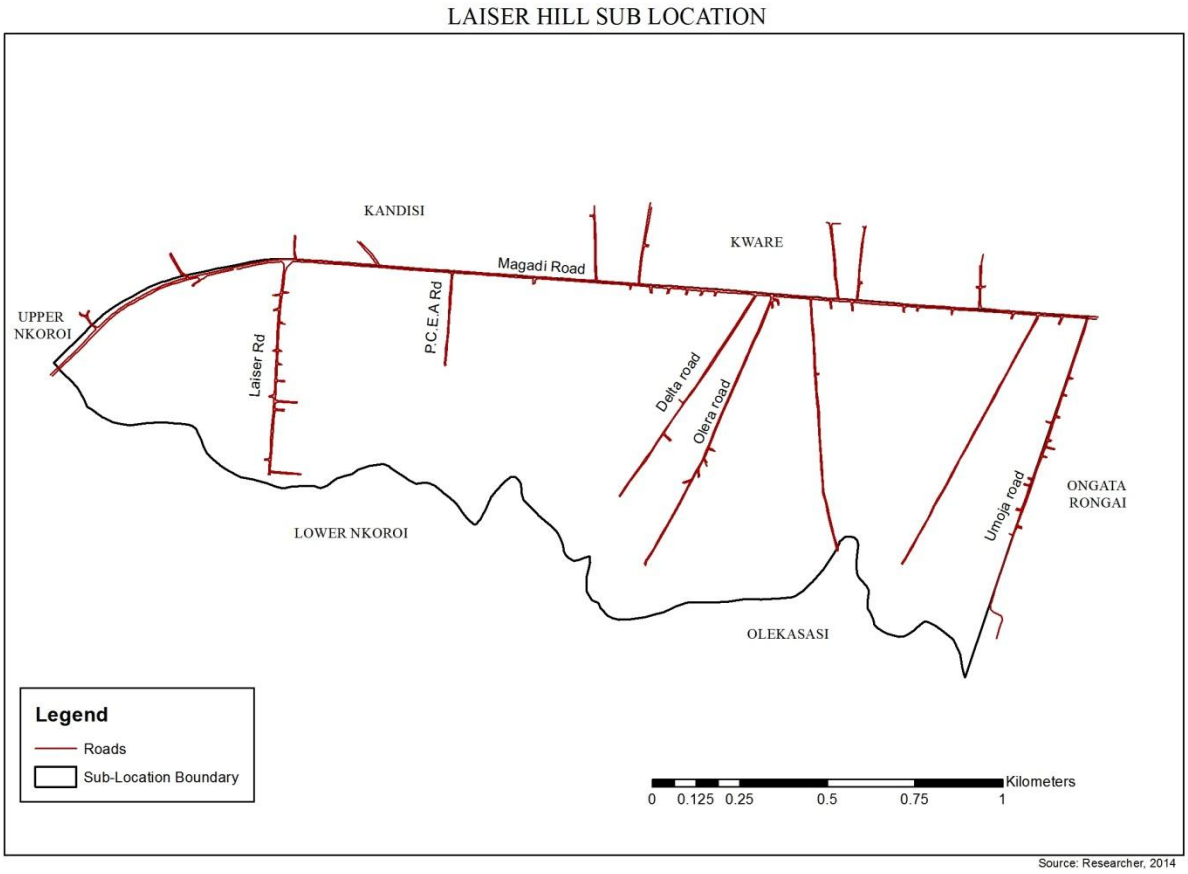



**Figure 1.3: Location of Study Area in Ongata Rongai**

### 1.7.2 Geology and Soils

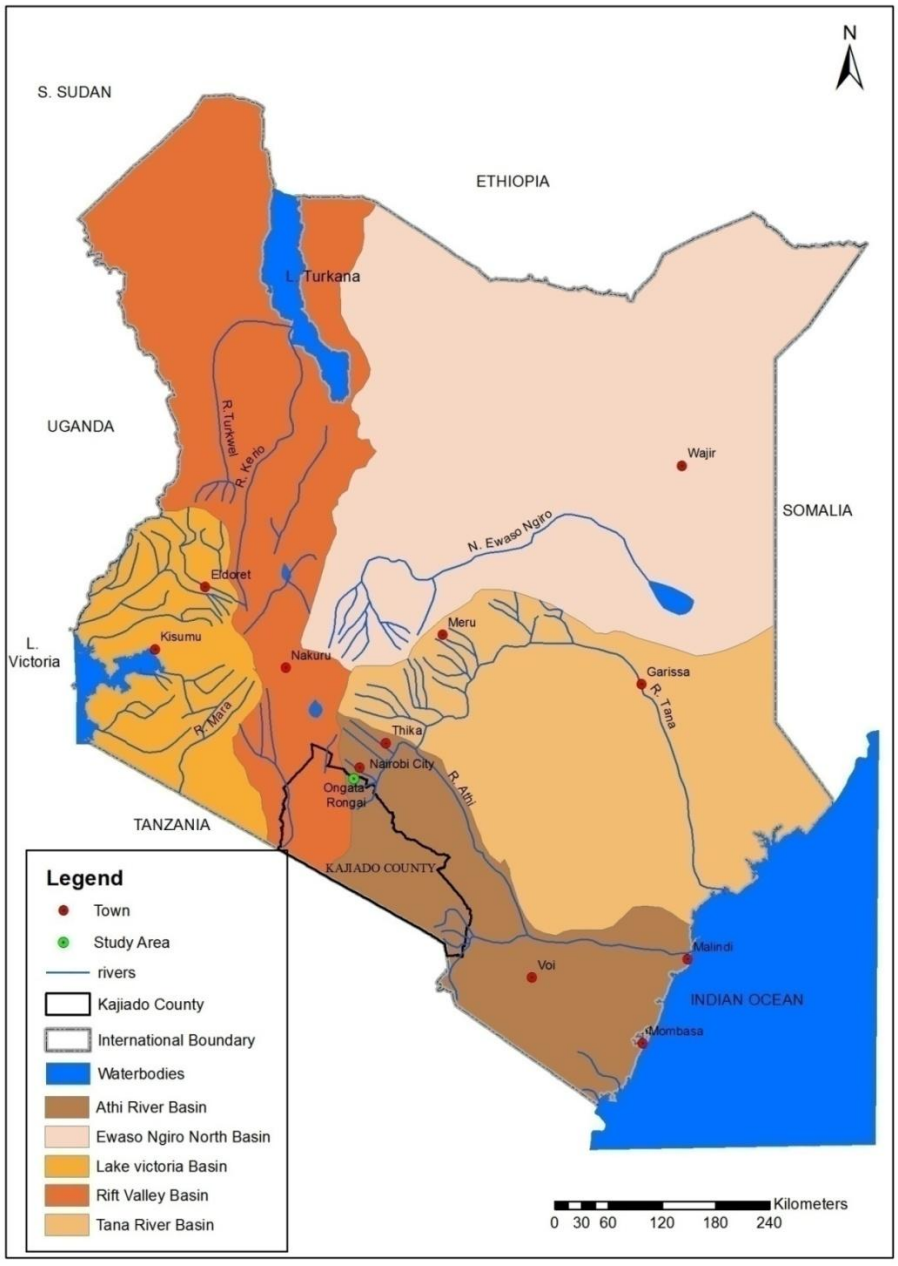
The geology of the area is comprised of volcanic layers of basalts, trachytes, phonolites and tuffs all overlain by thick layers of clay soil. The soil structure of the area is considered poor because it is mainly rocky and black cotton soil which hardly drains water easily. The soil retains water for an extended period of time after the rains (Mulwa et al, 2005). This explains why there is flooding of the open earth drains and surroundings even a week after a heavy rainfall.

### 1.7.3 Topography and Drainage

Rongai comprises of two distinct areas, the Ngong Hills and the upper Kajiado plains which Ongata Rongai town is located. The flat terrain, a contributing factor to the flooding that has caused storm water management challenges. There are five drainage basins in Kenya with

Ongata Rongai being part of the Athi catchment (drainage area 3AA) as indicated on the map in figure 1.4. Mbagathi River in Ongata Rongai is a tributary of the river Athi. The Athi drainage basin covers a catchment area of 66387 $km^2$ with an annual rainfall of 739mm as shown in figure 1.4.

KENYA'S FIVE DRAINAGE BASINS AND LOCATION OF O. RONGAI




Source: NWMP 2013

**Figure 1.4: Map showing location of Ongata Rongai in relation to the drainage basins in Kenya**

The drainage basin of a place plays a vital role in determining measures to be considered when managing storm water. The type and size of storm water drainage facilities suitable for a particular urban centre is determined from the flow of runoff in a catchment area though the estimation is not an exact science.

### 1.7.4 Climate

The climate of Ongata Rongai areas is warm and temperate with significant rainfall throughout the year, annual rainfall of 844 mm and an average annual temperature of 18.3$^{o}$C (Kenya Meteorological Services 2014, climate data, 2014). The warmest period occurs between January to March. The warmest months are found to have less rainfall as given in table 1.1 and figure 1.5 than the months with heavy rainfall.

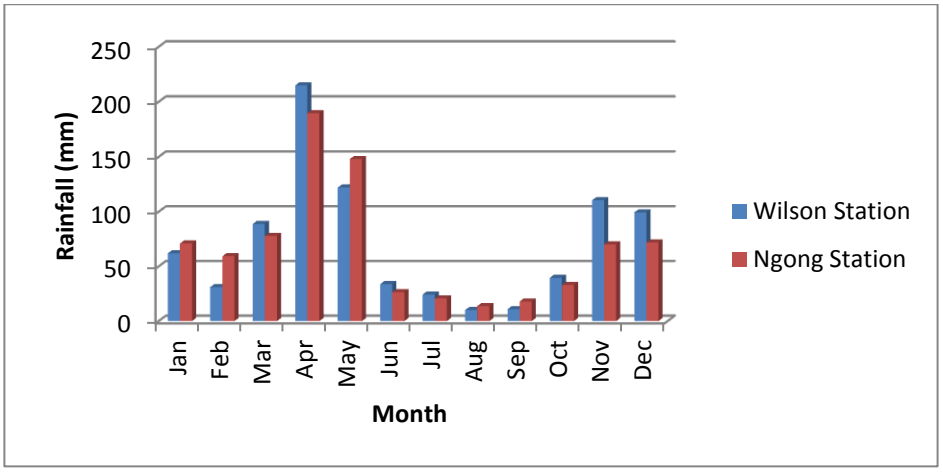
There are a few rainfall gauging stations in the area including the Wilson station and the Ngong D.Os office where the rainfall data (from 1980 – 2013 and 1984 – 1993 respectively) was obtained. From the data, the area has two rainy seasons, the long rains starts at the beginning of March and continues up to May while the short rains season starts at the beginning of October and lasts till December as given in table 1.2 and figure 1.5.

**Table 1.1: A comparison of mean, maximum, and minimum rainfall values between Ngong and Wilson stations from 1984 - 1993**

| Rainfall Variables | | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | Wilson Station | 61.9 | 31.02 | 88.8 | 214.9 | 122.1 | 33.8 | 24.3 | 10.1 | 10.9 | 39.6 | 110.5 | 99.4 |
| | Ngong Station | 70.9 | 59.3 | 77.9 | 189.7 | 148 | 26.5 | 20.7 | 13.7 | 17.9 | 32.9 | 70.1 | 71.8 |
| Max | Wilson Station | 270.4 | 104 | 271 | 414.6 | 300.1 | 103.6 | 88.1 | 22.4 | 30.2 | 144.8 | 157.3 | 201.4 |
| | Ngong Station | 186.8 | 177.5 | 229.9 | 389.6 | 231.8 | 58.1 | 33 | 47 | 56.1 | 86.5 | 114.5 | 146 |
| Min | Wilson Station | 0 | 0 | 5.3 | 9.6 | 1.6 | 2.8 | 0 | 1 | 0 | 1.9 | 66.7 | 25.8 |
| | Ngong Station | 3.6 | 12 | 14.1 | 2.1 | 58.4 | 2.2 | 0 | 0 | 0 | 0 | 42.2 | 20.2 |

**Source: Kenya Meteorological Services, 2014**

The two rainfall stations, Wilsons and the Ngong D.Os office indicate the bimodal rainfall pattern: long and short rainfall seasons between March and May and between October and December respectively. The maximum precipitation, which is the heaviest rainfall ever recorded for those particular months from 1984 - 1993 are the likely cause of flooding events that lead to storm water management challenges in the study area.




**Source: Kenya Meteorological Services (2014)**

**Figure 1.5: Comparison of mean monthly rainfall between the Ngong and Wilson Stations from 1984 – 1993**

The rainfall data recorded in the Wilsons station is slightly higher than the rainfall data recorded in the Ngong D.Os office station. The comparison of monthly rainfall data between the two stations is significant for accuracy and control purposes.

### 1.7.5 Socio-Economic Activities

Ongata Rongai has two administrative wards: Ongata Rongai and Nkaimurunya. Ongata Rongai spatially consists of four areas namely Rongai shopping centre, a commercial area to the north, Nkoroi, an upper class area to the south, Kandisi, a semi-rural area to the east and Kware, a slum to the west. Though predominantly residential, formal and informal commercial developments

have come up in an unplanned fashion, and functionally zoning the area along Magadi road (Kazungu, Gitau, and Gichuru, 2011).

An occupational structure projection of Ongata Rongai in 2030 by the Ministry of Nairobi Metropolitan Development (2011) shows that 68% of the population will be working in the service sector while the remaining 32% will be working in the Agriculture, Transport, and Construction sectors.

The same report further illustrates land use and distribution in Ongata Rongai. This is estimated to be at 55 % for residential use, 15% open space, 12% transport use, 8% industrial use, 5% public use and 5% commercial use.

### 1.8 Definition of Terms

It is useful at the outset to define what is understood in this paper concerning the terms: "storm water", "sustainable", "urban drainage" and "developing countries".

*Greywater***:** It has a lesser health risk, because it does not contain human waste. It is the wastewater from the kitchen and bathroom sinks, baths, showers and laundry (Madungwe and Sakungwa, 2007).

*Storm water***:** Water that originates from precipitation events such as rainfall, snowmelt and hail-fall

*Sustainable development:* Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987).

*Urban drainage:* Urban drainage includes the removal of all unwanted water from urban areas. It includes waste water (sewerage and grey water) - and storm water. Grey water, sometimes called sludge, is domestic wastewater predominately from baths, basins and washing machines. The unwanted water may, or may not, be used for other purposes with, or without, treatment. Indeed, it is part of the philosophy of sustainability that there is, ultimately, no waste; all "waste" from one process should be in input for another (McDonough & Braungart, 2002).

*Developing countries:* There is no generally accepted definition of a "developing Country". In general, Developing countries are still yet to achieve a significant degree of industrialization

relative to their populations, and have, in most cases a medium to low standard of living. There is a strong correlation between low income and high population growth.

*Climate*: is a measure of the average pattern of variation in temperature, humidity, atmospheric pressure, wind, precipitation, atmospheric particle count and other meteorological variables in a given region over long periods of time.

*Heterogeneous:* not uniform in structure or composition

*Climate:* is a measure of the average pattern of variation in temperature, humidity, atmospheric pressure, wind, precipitation, atmospheric particle count and other meteorological variables in a given region over long periods of time.

*Environment:* The natural environment encompasses all living and non-living things occurring naturally on Earth or some region thereof. It is an environment that encompasses the interaction of all living species

*Sewage:* Liquid and solid waste carried off in sewers or drains.

# CHAPTER TWO: LITERATURE REVIEW

## 2.1 Introduction

This chapter reviews literature on storm water management challenges and their environmental impacts both locally and globally. The chapter is divided into different sections each addressing the specific objectives of the research study. It begins by providing a historical background of the Ongata Rongai while reviewing the problem of storm water management in the town. The chapter presents both a theoretical and empirical review of storm water management and examines different methods in which storm water is managed in both developed and developing countries. Finally the chapter explores the knowledge gap which this study intends to fill.

## 2.2 Global Storm Water Management Challenges

Storm water management is a term used to describe the mechanisms for controlling and treating storm water in urban areas (Porse, 2013) which can be both qualitative and quantitative management. These are functions associated with planning, designing, constructing, operating, maintaining and financing storm water management system. It also involves establishing infrastructures for ground drainage and for abating pollution, focusing on mitigating the impact of storm water runoffs in urban areas.

Storm water runoff is generated when precipitation from rain and snowmelt events flows over land or impervious surfaces such as paved streets, parking lots and rooftops and does not seep into the ground. The impact from storm water runoff is a more significant problem in urban and developed areas where there is a greater percentage of impervious surfaces (NYSDEC, 2014).

In urban areas, the increase in the number and size of impervious areas has reduced the amount of rain that infiltrates the ground or is retained by vegetation. Consequently, more storm water run-off enters the drains system and receiving waterways. In rapidly growing towns with limited or no storm water drainage systems to remove storm water runoff from urban areas hence the risk of flooding and stagnation (EPA VIC, 2012)

According to New York State Department of Environment and Conservation (NYSDEC, 2014), Storm Water accumulates and transports chemicals, nutrients, sediment or other pollutants and debris. If the runoff is not captured or it is discharged without first being treated, it can adversely affect water quality in the receiving lakes, rivers and estuaries. Storm water pollutants originate

from many different sources including fuel and oil on our roads, excess fertilizers and soaps from cleaning, litter dropped on our streets and sediment from building sites.

### 2.2.1 Environmental Pollution

Knowledge of the impact resulting from urban wet weather discharges is a basis for determining the severity of the problem and justifying the need for control. Economically, storm water has a serious impact on the economy of a region. It is the main cause of urban flooding. Urban flooding can be defined as the covering of land or property in a built-up environment by storm water overwhelming the capacity of its drainage system. Urban flooding has significant environmental and economic implications (Debo & Reese, 2003). According to industry experts, wet basements caused by urban flooding, has the potential to lower the value of properties by up to 20 percent. Home buyers usually cite wet basement as a deal breaker of purchasing a home or property. Debo and Reese (2003) also contend that whenever there is urban flooding in an area, more than half of businesses never open their doors. This affects the economic output of a region in terms of revenue loss. In England and Wales, urban flooding has been estimated to cost the region more than 270 million pounds a year. A significant number of homes in the region are at risk due to being under a susceptible area to urban flooding.

Environmentally, Ferguson (1998) says that storm water has serious impact that affects human health in diverse ways. According to him, the water travels over the land, picking up all kinds of chemicals and sediments that are not naturally found in waterways. Some of these substances are poisonous, even in small amounts. Others, such as nutrients, are not poisonous but may be produced in such great quantities that natural systems simply can’t cope (Ferguson, 1998). They can eventually cause toxic algal blooms and other pollution problems in waterways (Ferguson, 1998).The oxygen demand loads increases ten folds during storm flow periods. This therefore creates the need to control storm runoff pollution as an alternative means of maintaining the quality of water. Storm water conveys debris and solids to receiving water bodies. The materials can disperse, float, or wash ashore onto embankments and eventually settle creating such nuisance as odours, aesthetic upsets, and corrosive or toxic deposits.

Trimple (2007) categorizes Storm water pollution into three categories: natural, which includes organic materials such as leaves, grass clippings and sediment; chemical, which includes

substances such as detergents, coolant, oil, grease, fertilizer and paint; and lastly, litter, which includes substances as plastic bags and cigarette butts.

Dissolved solids alter the chemical balance of waterways which may kill some aquatic animals and plants. The effects of metals on human and aquatic health can be far reaching (Sommer, Horwitz, Sommer, & Horwitz, 2001). Lead, which is often used as an indicator for other toxic pollutants in storm water, can be harmful or deadly for human. Zinc, although not harmful to humans at concentrations normally found in storm water, can be deadly for aquatic life. Cadmium can bio-accumulate in an ecosystem, soil microorganisms are especially sensitive to it, and it is harmful to human health. Chromium damages fish gills, causes birth defects in animals, and is also dangerous to human health. Mercury is a neurotoxin that bio-accumulates and has led to fish consumption advisories in affected aquatic eco systems (Sommer, Horwitz, Sommer, & Horwitz, 2001).

### 2.2.2 Socio- Economic Effects

Unfortunately, the social impacts of storm water management technologies, although of major importance, have often been ignored. Unless the needs and views of affected local parties are taken into account, national policy objectives to develop sustainable communities and achieve social and environmental justice are unlikely to be met. Public perception of construction is a matter of increasing importance both in the UK and internationally, given that socio-economic parameters have to be taken into consideration in the planning and application of all relevant projects.

### 2.2.3 Policies and Implementation

In the US, The storm water system is protected by a number of different laws including the Environment Protection Act 1993, the Environment Protection (Water Quality) Policy 2003 (the Water Quality Policy), the Local Government Act 1934, the Development Act 1993 and the Public and Environmental Health Act 1987. The new Water Quality Policy offers the most specific protection for the State's waters. It prohibits the pollution of the storm water system and our natural waters. The Policy has general obligations which every person, business and industry must comply with as well as specific obligations for particular activities. Failure to comply with any of these obligations may result in the issuing of a $300 fine, Environment Protection Order, and/or prosecution.

The Policy Review Report on Municipal Storm water Management in the Light of climate change by the Ministry of Environment, Ontario (MOE 2010), states that municipalities are responsible for municipal storm water management (e.g. planning, design, establishment, operation and maintenance). Municipal storm water management which deals with the component of the urban surface run-off that is or would be collected by means of separate municipal storm sewers. Many ministries and agencies provide oversight for storm water management and surface drainage which is complicated by, partly due to the multi-functional purpose of the infrastructure system and the many different agencies involved, and also climate change.

The current approach to storm water management in Ireland promotes sustainable development by restricting the outflow from new developments to the green field values that would have occurred prior to development (Doyle et al, 2003). In practice, this involves determining runoff rates for specified design storms from urban portions of development areas and controlling or attenuating the difference between these and the estimated green field runoff before allowing entry to drainage networks or water courses.

Local authorities and other relevant organizations recognize the importance of public involvement in planning which should, in theory, provide several practical advantages. When the public is properly informed, misconceptions are minimized and unfounded negativity within communities is avoided. When communities become involved in planning, this fosters shared responsibility between authorities and the public. Finally, by engaging with the planning process, the public can demonstrate their contribution to society and can play an active role in decision-making. Listening to and respecting the views of the local community engenders ownership of the solutions and makes a major contribution to the success of a program. Education is also a key component of storm water management. A number of agencies and organizations have launched campaigns to teach the public about storm water pollution, and how they can contribute to solving it. Thousands of local governments in the U.S. have developed education programs as required by their NPDES storm water permits.

Management alternatives of storm water can include attacking the problem at the source by land management, attacking the problem in the collection systems or off-line by storage, and removing pollutants by treatment and employing integrated systems combining both control and

treatment. Land management includes structural, semi structural and non-structural measures for reducing urban and construction site storm water runoff and pollutants before they enter the downstream drainage system. Such measures include land use planning, natural drainage, multipurpose detention, major-minor flooding, controlled storm water entry, surface sanitation, porous pavement, litter control, chemical control, street sweeping, and street cleaning. Street litter includes carelessly discarded materials such as lawn trimmings, sidewalks sweepings, newspapers, cigarettes, and containers from food and drinks are normally found in storm water discharges. Field, O'shea, and Chin (2000) proposes that the need to have antilitter laws that prevent such materials from getting on streets. Natural drainage reduces the cost of drainage and pollution. It enhances flood protection, ground water supplies, and aesthetics.

Traditional water resources management, particularly in urban environments, employs a reductionist approach whereby water supply, sewage and storm water are controlled and managed separately through linear, engineered systems. Newman (2001) termed these as '19th century solutions' designed to collect, store, treat and then discharge water within a framework of expansion and efficiency. However, as urban population densities increase, demand for and use of water increases (Birrell et al., 2005), and as variable climatic conditions continue (Howe et al., 2005), a fundamental shift in the way urban water issues are perceived and managed will be necessary. Furthermore, improved management practices are required to enhance the quality of storm water and receiving waterway health. Indeed, in a recent report released by the Prime Ministers Science, Engineering and Innovation Council (2007) suggested we need a diverse portfolio of water supply options, thus storm water should be viewed as a potential resource rather than as a waste product. One such innovation with growing appeal among urban water professionals is an Australian concept, water sensitive urban design (WSUD) WSUD aims to reintroduce the aesthetic and intrinsic values of waterways back into the landscape through urban design. To transition from the 'old-world' management approach to one that operates in a 'total water cycle' requires a cooperative management framework.

## 2.3 Storm Water Management Challenges in Africa

### 2.3.1: Environmental Pollution

In developing countries, Storm water management has been a delicate issue. With the growth of cities, this task has become more and more complicated, which are characterised by urban

population explosion over a short period of time, unplanned urban patterns, severe poverty, and accumulation of problems. In the cities of these countries, sewer systems are inadequate in coverage and in performance, especially because of inadequate waste management. Most of the urban area is dominated by unplanned urban patterns, which constitute a major obstacle for urban drainage. Flood plain and flood-prone areas are used for human settlement and business activities, both legally (with building permit) and illegally (squatter settlement).

In South Africa, the impact of poor water quality on the urban aquatic system is increasingly being highlighted in studies and media reports. The reports focus on the failure of sewage systems due to emotive nature of the pollution and the ability to identify who is responsible due to the point source nature of the pollution. Storm water pollution on the other hand is in general diffuse and difficult to attribute responsibility. Studies conducted in the country reveal that polluted storm water is a contributor to the deteriorating water quality in the urban aquatic system, as well as contributing to the failure of sewage treatment works that become overloaded as a result of storm water ingress into the foul sewer networks.

### 2.3.2 Socio- Economic Effects

One of the challenges of third world countries in this new century concerns the management of cities, where there is a trend to uncontrollable urban explosion and the accumulation of problems. In this challenge, the question of water management constitutes one of the burning issues on two grounds: resources and risks. Flooding in Niger caused losses estimated at 15.4 billion CFA francs during the winter of 1998 (Novatech, 2001). The event of 24 August 1998 alone made 2,000 people homeless in Niamey. In Addis Ababa, in each of 3 cyclical events in the last two decades, flooding affected 7,000 inhabitants, with loss of human life (12 fatalities in 1978, 9 in 1995). In the case of Addis Ababa, where the site presents favourable topographic conditions, two factors aggravated the risks: precarious housing and river-bank occupation.

The events of April 1989 in Djibouti left 150,000 homeless (1/3 of the entire national population). The impact was even more severe in Venezuela, where 30,000 deaths and 150,000 people made homeless were recorded in December 1999 1. In the world it is estimated that 60% of deaths and 30% of economic loss due to natural disasters is caused by flooding (Novatech, 2001). In fact most of these phenomena were caused by exceptional events which cannot be managed by a classical approach and sewer system. The most appropriate way to deal with the

whims of water is to have good organisation. The question of organisation in the case of water management concerns two aspects: spatial and institutional. Account should also be taken of economic loss and worsening of health indicators found in low-income communities. Observations for the city of Conakry show that rates of death and of intestinal infection double (to 10.3% and 14% respectively) in the rainy season, aggravated by runoff which becomes a vector for diseases (Novatech, 2001).

The other and most crucial problem of cities is resource scarcity, with a doubling of the world population forecast for the coming 50 years. The question of resources above all concerns land and water, two fundamental elements for human subsistence. The future of cities is determined by integrated management of land and water in order to ensure the necessary water resources for consumption and to avoid (or at least minimise) water-related problems.

### 2.3.4 Policies and Implementation

Improving water quality in Africa's urban aquatic system requires water resource management policies that consider catchment wide strategies that capture the whole urban water cycle. In South Africa, the Urban Water cycle is managed in a fragmented manner. In many of the larger cities, storm water management is frequently the responsibility of the roads department. However, there is poor integration of storm water management which results in a less holistic approach by the municipalities to cover all water services. It is the constitutional obligation of municipalities to provide a safe healthy environment while ensuring economic development and extending the provision of services in a progressive and sustainable way.

Storm water management in South Africa partly falls to the issue of underfunding. Municipal infrastructure requires extensive re-investment in capital and maintenance expenditure. This underfunding of storm water management is not unique to South Africa as other African countries' water policies are rendered less efficient due to underfunding. The local authorities most often lack the skilled manpower and budget to cope with the magnitude of the problem. There is, however, also a lack of commitment, awareness and good organisation, which would not need considerable amounts of money. There are fortunately high degrees of socialisation, solidarity and community spirit and, recently, of active citizen involvement. These sociological and organisational aspects constitute key elements for achieving sustainable development.

The above-mentioned conditions clearly distinguish the nature of storm water management in Africa from the developed countries. Storm water management systems (technical as well as institutional) should be formulated in such a way as to respond to the real problems of these cities. In reality most solutions have been formulated on the basis of models and concepts belonging to developed countries, without going into local specificities. Such blind transfer which has been broadly discussed and condemned by several authors, results more in a waste of time and money than in providing any applicable solutions. On the one hand, studies not based on real socio-economic and cultural conditions cannot be implemented. And, on the other, there is a failure of appropriation, commitment and know-how, since local actors (including inhabitants) are not involved in the planning process. It is high time to begin thinking of pertinent methods and concepts based on local realities, and to share experience with a view to achieving the best management performance. For this, a spatially based approach is of great interest on both analytical and planning grounds.

## 2.4 Storm Water Management Challenges in Kenya

### 2.4.1 Environmental Pollution

Kenya also experiences a serious challenge of storm water management. Common problems witnessed in the country include flooding of urban areas due to poor storm water drainage systems and environmental pollution of water sources. . These drainages in most are open earth with poor soil structures such as black cotton which are known to retain water for an extended period of time (Mulwa et al, 2005). The urban runoff is the main source of pollution because it mixes with sewage and waste water as it flows downstream. Decreasing water quality is therefore a major threat to urban water in Kenya.

According to an assessment report by Kloss (2009), Kenya experiences inefficiency in sewer and drainage systems within urban settings. There are 43 sewerage systems in Kenya and waste water treatment plants in 15 towns that serve a total population of 900,000. The operation capacity of these wastewater treatment plants is estimated at around 16% of design capacity. The main reasons for this inefficiency are: inadequate operation and maintenance and low connection rate to sewers.

Of the wastewater and storm water that enters these sewer networks, only about 60% reaches the treatment plants (Kloss, 2009). The most common solution used for wastewater treatment in Kenya is waste stabilization ponds. One of them is the Dandora Waste Stabilization Pond System which treats the industrial and domestic sewage from the city of Nairobi and is the largest pond system in Africa. Mixing industrial effluent and domestic sewage in mixed sewer system, however, often causes poor performance in Kenyan pond treatment systems.

The Citizen Report Card moreover indicates that septic tanks are often used for the disposal of wastewater from flush toilets in Mombasa. Pit latrine users from Nairobi, Kisumu and Mombasa indicated that some wastewater empties into storm sewers, soak-always and cess pits designed for kitchen waste, thus causing environmental pollution. In 2001 a pollution incident occurred in the town of Embu where raw sewage was discharged from sewage treatment works into a nearby river and caused the death of 28 people who used the water downstream for domestic purposes (MCM, 2002). This calls for investigative research into the causes, effects and the impacts of raw sewage discharge into the environment

In Ongata Rongai, donkeys are commonly used domestic animals to carry loads of goods and to push water carts. The animals are allowed even in the urban centre where they leave their excreta everywhere. The animal wastes are also known to spread water borne and food borne diseases (Trimble, 2007). As the storm water run offs come into contact with the wastes, bacteria and other pathogens are deposited in water bodies and underground water. This poses a serious health risk to the region.

Ongata Rongai situation on Magadi road has increased its drainage and management challenges of storm water. Magadi road is classified as a primary road under category C of the Ministry of Roads classification system as outlined in the Road Design Manual Part 1- Geometric Design of Rural Roads, 1979. Class C roads are currently designed, constructed and maintained by the Kenya National Highways Authority (KeNHA) under the Ministry of Roads. Ongata Rongai as an urban centre requires local roads and urban collector class of roads which can easily be designed and managed by the local authorities however this facilities are non-existent and the whole pressure is on Magadi road which unlike urban roads is designed for mobility and high speed transit (GOK : Ministry of Local Government, 2013).

Magadi road being a classified national road designed to traverse rural settings was not provided with sufficient storm water drainage facilities that can withstand urban environment. The lack of these facilities therefore has led to severe drainage problems on all urban centres along Magadi road, Ongata Rongai included.

Drainage facilities on a road must be provided to remove storm water from the road and transmit from one side of the road to the other and disposing at appropriate outfalls without any detrimental effects on the adjacent properties and environment. Common drainage facilities used in Kenyan roads include bridges, culverts, channels, Kerbs and various types of surface and subsoil drains. (GOK: Ministry of Local Government, 2013).

As outlined by the draft feasibility Study Report by the Department of Urban Development on Consultancy Services for storm water Drainage Facilities for towns, Machakos included which is in the Athi Catchment together with Ongata Rongai, the design standards and approach takes into consideration factors such as rainfall of the area: mean, maximum and minimum monthly rainfall In this study we will consider precipitation and run off as elements of which contribute to storm water management challenges and their environmental impacts . The size of storm water drainage facilities is determined from the flow of runoff in a catchment area though the estimation is not an exact science.

Ongata Rongai town being situated along a trunk road which was originally a private road for Magadi Soda has limited and substandard drainage facilities for an urban centre, and a totally absent sewer system so that septic tank is used as a method of household waste disposal. As mentioned in a maintenance reported by Kenya National Highways Authority (KeNHA, 2014), sewage and waste water from these septic tanks find their way into the limited side drains on Magadi road and any other part of the town during the rainy season. In both urban and rural catchments, the amount of water that runs off an area is basically dependent on the condition of the surface on which the rain falls and the rainfall intensity. Ongata Rongai is affected by both its location and inadequate storm drains as the area, being an urban centre has a lot of impervious surfaces that generates maximum runoff during the rainy seasons

### 2.4.2 Socio- Economic Effects

Flooding is among the major Storm water management challenges which lead to negative social economic impact such as loss of life and property, loss of livelihoods, decreased purchasing and production power, mass migration, psychological effect, hindrance to economic growth and development, and political implications. Immediate impacts of storm water management challenges in Kenya include damage to property, destruction of crops, loss of livestock, non-functioning of infrastructure facilities and deterioration of health condition owing to waterborne diseases. In monetary terms, the extent of damages caused by floods caused by storm water management challenges is on the one hand dependent on the extent, depth and duration of flooding, and the velocities of flows in the flooded areas. On the other hand it is dependent on the vulnerabilities of economic activities and communities.

Damage to infrastructure also causes long-term impacts, such as disruptions of clean water and electricity supply, transport, communication, education and health care. Loss of livelihoods, reduction in purchasing power and loss of land value in the areas affected lead to increased vulnerabilities of communities living in the area. The additional cost of rehabilitation, relocation of people and removal of property from flood-affected areas can divert the capital required for maintaining production.

### 2.4.3 Policies and Implementation

The water sector in Kenya is facing enormous challenges today. It is affected by poor provision of water supply and sanitation services in Health, Industry and commerce and Agriculture. The National Water Policy (NWP) 2012 was developed in line with mandate, vision and mission of the ministry in charge of water in Kenya, built on the achievement of Water Act 2002, and based on sector principles in NWP 1999 so as to align it with the Constitution of Kenya C.o.K) 2010

It is geared towards meeting its constitutional requirement of ‘the right to water’ and other country, regional and international arrangements regarding water and environment. The policy has seven chapters and this study has focused on chapter 2 objectives: enhancement of Storm water management and the enhancement of pollution control.

According to the National Water Policy 2012, there is an increasing pollution of water resources incidences in the country in disregard of public health risks and the water requirements of

downstream population, inadequate flood and storm water management, insufficient recognition of climate change issues, weak regulation and enforcement, inadequate information sharing and reporting, inadequate financing of Water Resource Management and development and conflicting institutional mandates is among other major issues facing this sector.

Among the Policy Objective and Policy Statements to be addressed by this sector is enhancing storm water management and rainwater harvesting. Seasonal torrential rainwater in certain areas create expansive storm water runoff, often leading to disasters in the form of landslides and floods (all of which cause massive erosion of landscapes and destruction of infrastructure), siltation of rivers and water storage facilities, cholera and typhoid and harmful effluent infiltrations into water bodies and ground water aquifers. The sector will require a water-related disaster preparedness and rainwater harvesting and storage strategy in order to contain this menace and sustainably manage water resources storm water included.

In addition, other policies stated in the Act which are important to be mentioned in this study is enhancement of pollution control of water bodies which can only be achieved if existing and envisaged regulations are enforced through the 'user/polluter pays' principle and other legal and administrative actions for offences defined by the Regulator and stated in EMCA 1999 and other related legislations. The government should also establish sound research and development in the water sector through an established national institution to pursue a scientific and technological research and development agenda on water affairs.

Chapter 3 of the Act highlights the provision of water services including the provision of safe and clean drinking water, sewerage collection, transport and effluent treatment. These are the key responsibilities of the water sector institutions and water service providers which they shall concentrate on and should by no means stop any water sector institution or water services provider to engage in the promotion of actions which help to improve public or private sanitation if they wish to do so. In contrast, service provision faces different realities in the rural than in the urban setting due to technologies, management concepts, ownership of assets, financing possibilities among others which are very different in rural and in urban areas. Therefore, the policy recognizes such detrimental differences with different approaches (NWP 2012).

The large urban towns in Kenya have sewerage systems which often suffer from low connection rate leading to a low cost recovery rate and low coverage contribution. In addition, such sewer systems are malfunctioning especially in terms of effluent treatment which stands presently at 20% treatment efficiency countrywide (Kloss 2009). In smaller and less financially endowed urban centre most buildings are linked to stand alone septic tanks which require exhausting when full. Exhauster services are provided by the private sector which if uncontrolled, dump illegally the human waste untreated into the environment. For public health reasons Water Service Providers need to play a role in the collection and treatment of sludge regardless of its source. The urban low income areas remain the sanitation hot spots in the country and living conditions therein are rapidly deteriorating (Kloss, 2009), due to inadequate water services provision. Regrettably the Water Service Providers operating public sewer systems are among the biggest polluters of the environment in the country.

Chapter 5 of the act illustrates the institutional framework or the organizational set-up of water governance in Kenya. The National Water Policy 1999 and the Water Act 2002 provided for a new institutional set-up for water resources management and water services provision at national and basin level. Concerning urban Water Supply and Sanitation a national regulator was established at the national, water asset developer and manager at regional level with contracted water services providers as operator for the provision of water services. In addition, a pro-poor basket was established to channel funds for pro-poor-related investments, to provide national concepts and to offer capacity building for implementers. For participation of users/consumers and their empowerment, the Water Resource User Associations (WRUAs) and Water Consumer Groups (WCGs) were established. Effective stakeholder participation ensured that water conflicts are resolved in a more amicable manner and awareness increased.

In addition, Water Services Boards (WSBs) were established to promote asset development. With the establishment of such autonomous Water Sector Institutions the sector moved to a higher level of performance and standards, improved information and monitoring systems, service quality and fostered transparency and accountability. This was also supported by embracing best practices of separating regulatory mandates from implementation functions in order to avoid impaired accountability resulting from self-regulation. The introduction of a

constitutionally guaranteed right to water calls for minimum standards for all and consequently for national regulation of services.

### 2.5 Summary of the Study Gaps

The study attempts to fill the following gaps

- Ferguson 1998, studied introduction to storm water where he found out that storm water picks up all kinds of chemicals and sediments that are not naturally found in waterways hence causing environmental pollution. He did not focus on biological composition of storm water which this study has filled by analysing the bacteriological composition of storm water due to poor sewage disposal
- Novatech, 2007 in his research on *Challenges for the Sustainable Urban Storm water Management in Developing Countries*: From basic education to technical and institutional issues: Brazil found out that in the world it is estimated that 60% of deaths and 30% of economic loss due to natural disasters is caused by flooding. He also reported observations for the city of Conakry which showed that rates of death and of intestinal infection doubled (to 10.3% and 14% respectively) in the rainy season, aggravated by runoff which becomes a vector for diseases. This was not replicated in most cities and towns of the world. This study is focused on filling this gap by assessing the socio economic effects of storm water on the development of Ongata Rongai town.
- In terms of literature records, there are a number of studies on the subject of urban drainage though there is a failure to see the problem of urban water management in a holistic manner. For example, Parkinson & Mark (2005) and Parkinson *et al*. (2007) focus almost exclusively on storm water drainage – although, to be fair, Parkinson & Mark (2005) do at least acknowledge the importance of "Stakeholder participation and partnerships" and devote a chapter to "Policies and institutional frameworks". The study tries to fill this gap by evaluating the effectiveness of the National Water Policy (2012).

### 2.6 Theoretical and Conceptual Framework

#### 2.6.1 Sustainable Development Theory

Sustainable development is defined as "development which meets the needs of the present without compromising the ability of future generation to meet their own needs"(WCED, 1987). In essence, sustainable development seeks to create and maintain a balance between the

challenges faced in the society and the carrying capacity of natural systems (Brown, 2011). There are three fundamental aspects about sustainable development that have generally been agreed upon across various literatures (Bedsworf & Hanak, 2010; Barbour & Deakin, 2012; FAO, 2006; Ehnert, 2009; The World Commission on Environment and Development, 1987). They include economic, environmental, and social aspects. For a system to be environmentally sustainable, it must maintain a stable resource base, avoid exploitation of renewable resources, and avoid depletion of non-renewable resources. Storm water management has many challenges including environmental and social economic challenges. Effective management which includes both county government and stakeholders would imply reduced storm water challenges hence sustainable storm water management. Ongata Rongai is an area that largely depends on bore holes for residential and institutional water supply. Therefore, clean underground water is important. From a socioeconomic point of view, effective management of storm water has implications of passable roads, smooth operation of businesses, and well planned urban structures.

### 2.6.2 Conceptual Framework

The conceptual framework in figure 2.1 was used to inform the study. Storm water can be managed sustainably or unsustainably depending on the management bodies. Unsustainable storm water management leads to storm water management challenges which are environmental and socio – economic challenges. To curb this, participatory actions from the county government, ministry of public health and stakeholders is called for. Such actions include enactment of the National Water Policy (2012), implementation of public health and sanitation policy, building drainages, construction of sewer line willingness by stakeholders. This entails environmental, social and economic harmony which leads to sustainable storm water management.

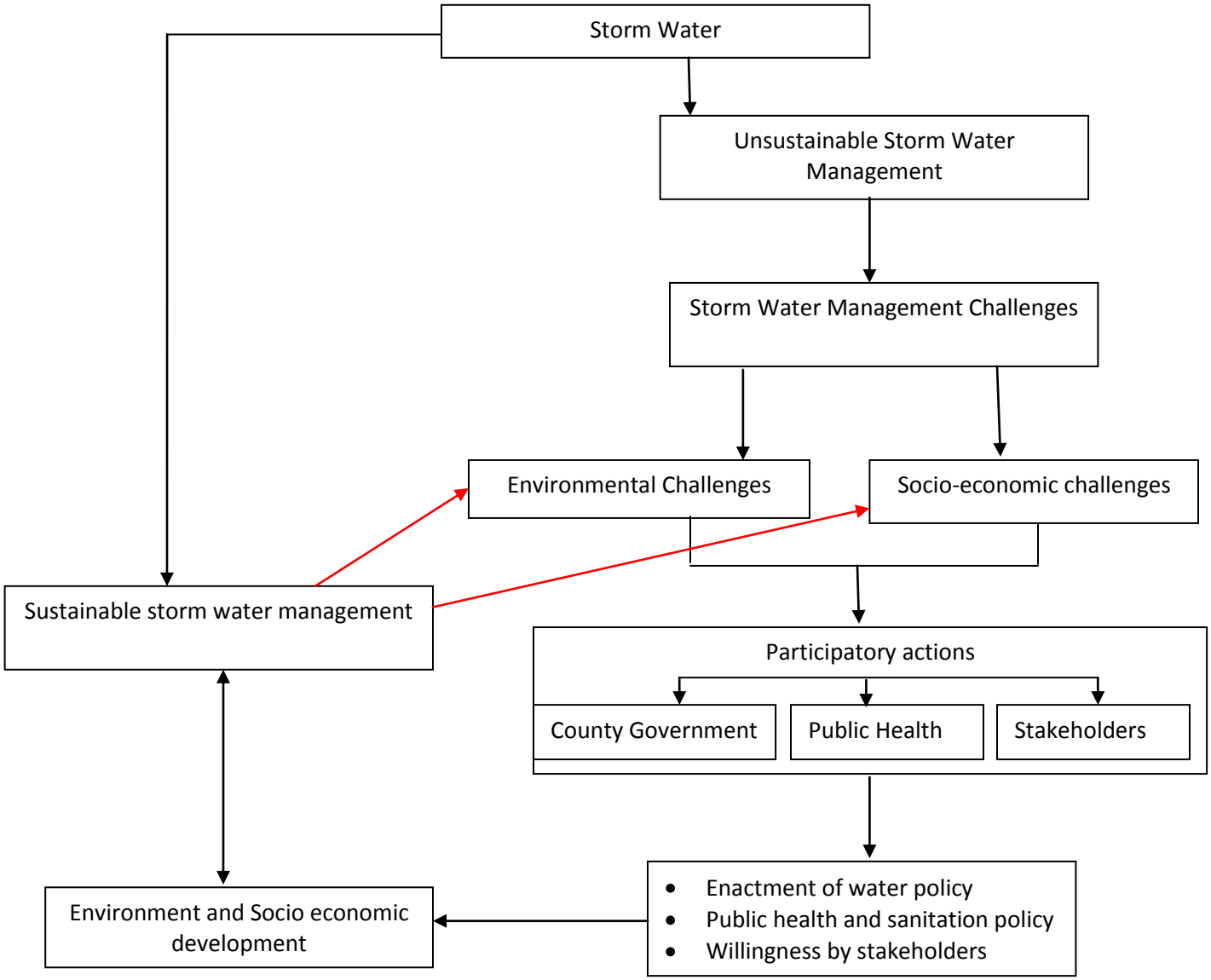



**Figure 2.1: Conceptual framework**. ***Source: Researcher, (2014)***

Action oriented mechanisms of SWM

Reaction mechanisms of SWM

Action and reaction mechanisms of SWM

# CHAPTER THREE: RESEARCH METHODOLOGY

## 3.1 Introduction

This chapter examines the research methods adopted for sourcing data in an attempt to achieve the study objectives and test the hypotheses. The chapter contains the study design, definition of the target population, sample size, sampling techniques, data collection and analysis technique.

## 3.2 Study Design

A survey and an experimental research designs were adopted for the study. Both designs were found to facilitate investigation of the challenges of storm water management within the real- life context of the study area by providing a clear understanding of the variables being studied and reporting the results of storm water challenges and their environmental impacts in Ongata Rongai town.

## 3.3 Study Population

The study was conducted in Laiser Hill sub location in Ongata Rongai town which is part of the Larger Ongata Rongai location. Ongata Rongai town has a population of 41000 (Population census 2009). The study narrowed down to the target population of estimated 2000 households in Laiser Hill sub location which is mostly affected by storm water. The use of households is adopted from Nyariki (2009) who advised for the use of households to draw a sample frame where a large population in village or sub location set up in a developing country like Kenya is sampled.

## 3.4 Sampling Technique

The estimated population of 2000 households at Laiser Hill sub - location was grouped spatially into three clusters depending on their commercial and residential characteristics. The three clusters namely: A (commercial cluster) of approximately 700 households and B (Transition cluster between the commercial and the residential population of the study area), also ranging from 700 households was considered densely populated and cluster C (more Residential cluster) of approximately 600 households.

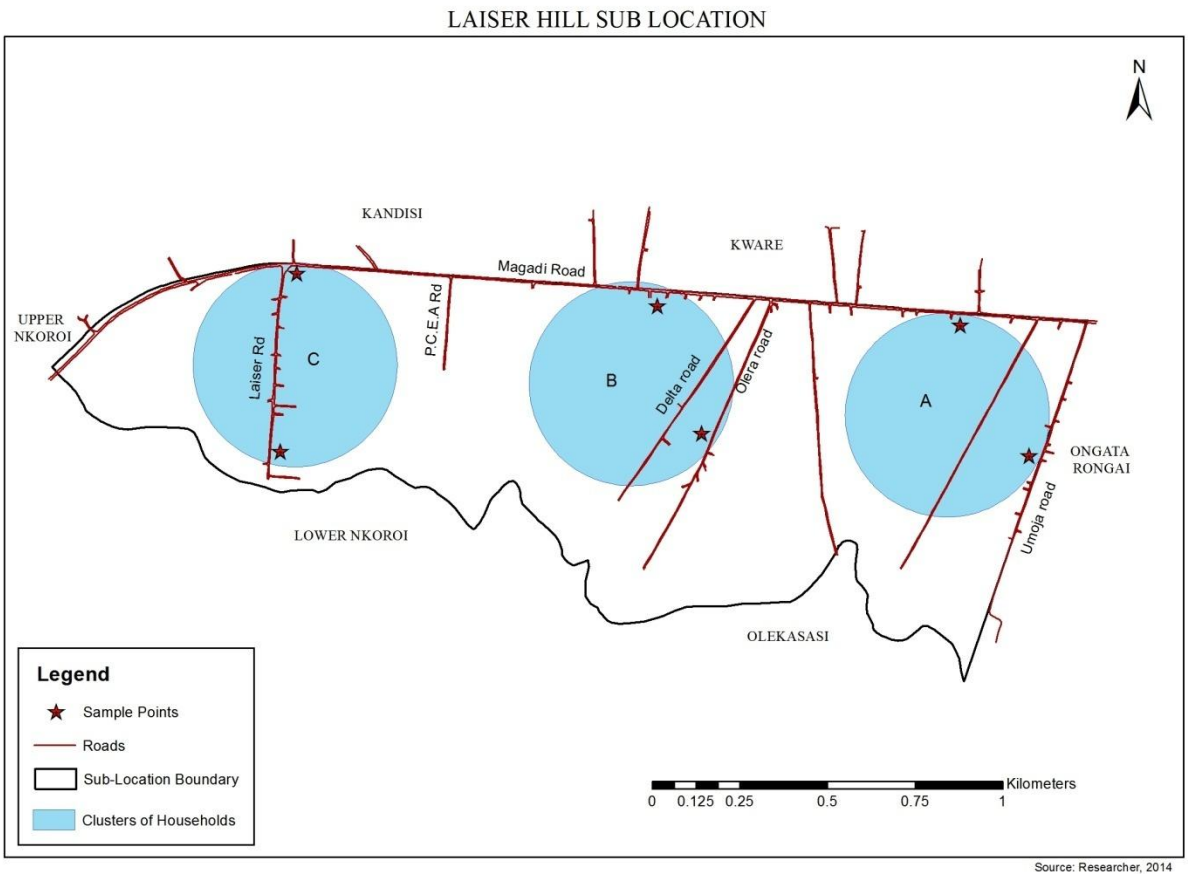



**Figure: 3.1 Map showing clustered points in the study area**

In addition, two points were identified from each cluster as shown in figure 1.3 where storm water believed to be contaminated with sewage was sampled for bacteriological analysis at the National Water and Conservation Laboratory and the Kenya Water Institute (Water Quality Microbiological Laboratories). Six samples each of 1 litre capacity were collected from drains immediately the rains stopped and the control sample of 1 litre capacity was also collected from harvested rain water in a tank for analysis. This sampling technique tested for two variables: lack of an established sewage system and the way sewage is disposed by property owners in Ongata Rongai

### 3.4.1 Sample Size

After establishing the three clusters and their approximate population, the sample size formula of Freund and Williams (1983) was applied to arrive at the sample size. Nyariki (2009) quoted that a known or an estimated population size that is heterogeneous in nature can employ any number

(equal to or) greater than the statistically *large sample* (of 30 sample units) which this study also considered.

$n = \frac{(p(1-p)z^2}{\text{ME}}$(Freund and Williams, 1983) ……Equation 1

Where:

- ME is the desired margin of error 9.7%
- *z* is the z-score, e.g. 1.96 for a 95% confidence interval,
- *p* is our prior judgment of the correct value of *p* 30% of the households
- *n* is the sample size established using the formula

In order to arrive at the sample size, a confidence level of 95% was employed which is the level of certainty of the items collected representing the characteristics of the total population. The margin of error, (the accuracy required by researcher for the estimates made from sample) is 9.7% and with a 30% predetermined number of households to be sampled (Goldstein and Healey, 1995) from each cluster; this yielded a sample size of 90 households to participate in the interviews. This was purely a heterogeneous population (commercial and residential characteristics) and a margin error of 9.7% which was less than the scientifically acceptable (10% margin error) for such a population (Creswell et al, 2007, and Freund and Williams, 1983).

$n = 1.96^2 \times (0.7 \times 0.3) / 0.097^2 = 89.7$

Using this formula, the sample size (n) covered in Laiser Hill sub location was established as 89.7, which was rounded off to 90 households.

A list of households obtained from the location administrative chief was used to randomly select the 90 households sample from the three clusters where adults of above 18 years were sampled. From Cluster A and B 35 households were picked because of their high population density while cluster C zone of low population density, 20 households were picked. After the first household was randomly picked from each cluster, the rest were systematically picked after the $15^{th}$ household until all the required number from each cluster was attained.

### 3.5 Nature of Data

The study used both quantitative and qualitative primary and secondary data.

### 3.6 Sources of Data

#### 3.6.1 Primary Sources of Data

The Primary data was obtained from field observations and field interviews. This was designed to capture information on the three objectives of the study. The survey was carried out at Laiser Hill sub location, in Ongata Rongai sourcing information from 90 questionnaires.

Enumerators were involved in the administration of the questionnaires in the study area with a total of 90 respondents to be interviewed. The ages of the respondents ranged from 18 – Over 61 years old, with each respondent being asked a series of questions which are expected to answered with honesty.

#### 3.6.2 Secondary Sources of Data

Secondary sources of data were obtained from Government published reports such as health reports in the county, Meteorological department and water reports, economic surveys, population census reports, statistical reports and abstracts, development plans and data collected through qualitative and quantitative research.

A systematic study was conducted from already published literature with respect to physical and social – economic environment of Ongata Rongai as they have a pre-established degree of validity and reliability in establishing facts, and to analyze questionnaires so as to reach informed conclusions.

In an attempt to assist in the assessment and significant environmental impacts, various international and local planning guidelines and regulations were carried out by the study and used as reference points. The pertinent national legislation on environment, national regulations and standards, conventions and treaties were part of the secondary sources of data that were used in the study.

### 3.7 Methods of Data Collection

The research instruments utilized in this study included: structured questionnaire, direct field observations and photography of presence or absence of storm drainage facilities, and flooded storm water within the study area.

The researcher pre-tested the research instruments such as the questionnaire to ascertain the tool's capability to collect necessary data. The researcher ensured the tools were both functional reliable and accurate for use. This was first done through a mini pilot study survey so as to determine the correct measures for the concepts being studied.

The questionnaire which was developed during this research was divided into three parts (Appendix 1). They included:

1. A section on general information
2. A section on the socio-economic effects of storm water management challenges
3. A section on the efficacy of the Kenyan water policy in the study area

### 3.8 Methods of Data Analysis

The quantitative data obtained was analyzed using descriptive statistics and inferential statistics with the help of Statistical Package for Social Sciences (SPSS) tool.

The basic initial steps included manual editing of completed questionnaires, data coding where necessary before validation check by computer, data entry, data analysis, and interpretation.

Univariate analysis aimed at generating frequency distribution and descriptive analysis was used to compare environmental pollution through sewage disposal, socio-economic effects of storm water management and the National Water Policy (2012) effectiveness to storm water management in the study area. The data resulting from the frequency distribution was further presented using pie charts, tables, and bar graphs in order to more succinctly present the data needed for this study. Chi Square analysis was used to test the hypotheses because of the relatively large sample size and also to determine the independent variables.

**The chi – square formula:**

$$\chi^2 = \frac{observed\ values\ O - expected\ values\ (E)^2}{expected\ value(E)} \quad \text{.....Equation 2}$$

E=Row total (E) *Column total(c)/Grand total

Degrees of freedom (df) = (c-1) (r-1)

# CHAPTER FOUR: RESULTS AND DISCUSSION

## 4.1 Introduction

The purpose of this chapter is to present responses obtained from various participants in the research project with explanations in discussion form.

## 4.2 Results of Analyzed Data

In chapter one there was an assumption made, that there are environmental and social economic impacts of storm water management challenges. To test these study hypotheses, data was obtained from a household survey in Ongata Rongai, Kajiado County. Data was collected through a questionnaire consisting of three sections. The first section sought to obtain general information of the respondents. The second section sought to obtain data on the social economic effect of storm water management challenges, while the third section obtained data on the policy and legal framework of storm water management and the cost of using exhauster services.

## 4.3 Response Rate

**Table 4.1: Response Rate**

| | Number | Percentage |
|---|---|---|
| Sample Size | 90 | 100 |
| Response Rate | 74 | 82 |

**Source: Researcher (2014)**

A total of 90 questionnaires were distributed to the potential respondents who are the residents of Ongata Rongai, Kajiado County. 74 questionnaires were filled and returned back and therefore, the response rate was found to be 82%.

Based on the satisfactory response, the researcher chose to continue with the data analysis and presentation of the findings. In the following sections therefore, the researcher presents the study findings according to the sections highlighted in the data collection tool.

## 4.4 General Information

This section sought information about the general information of the respondents. Among the questions that were used include, gender, age, education level, and period of residence of the respondents.

### 4.4.1 Gender

This part of the question sought information about gender of the respondent. The results are presented in the table 4.2.

**Table 4.2 Gender of the respondents**

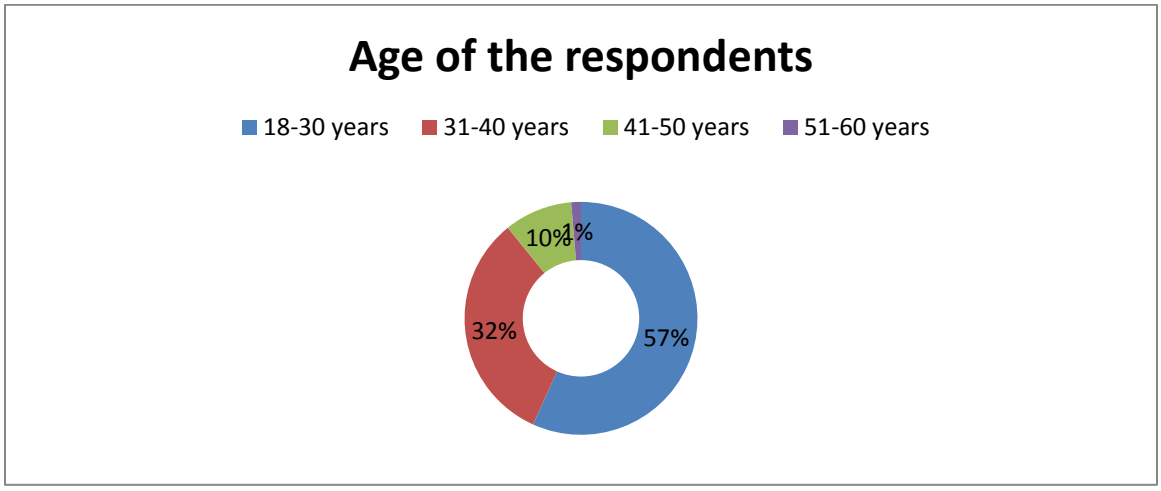
| | Frequency | Percent |
|---|---|---|
| Female | 45 | 61 |
| Male | 29 | 39 |
| **Total** | **74** | **100.0** |

**Source: Researcher (2014)**

Table 4.2 indicates that there were a higher proportion of female respondents as compared to the male respondents in the sample (61 % and 39% respectively). This was projected to the time of the day when the data was collected. Majority of the men in the households were absent probably they had gone for their daily chores. It is also possible that non returned questionnaires were of male respondent. Coping strategies to storm water challenges varies across the gender. Men can withstand flooding effects more than ladies.

### 4.4.2 Age of the Respondents

**Figure 4.1 Age of the respondents**




**Source: Researcher (2014)**

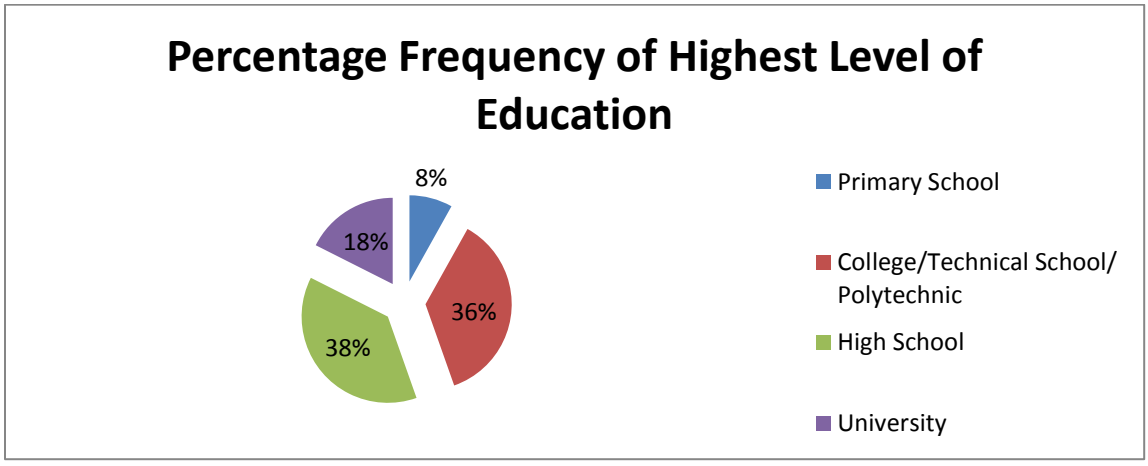
Age distribution was slightly fair with majority of the respondents in figure 4.1 falling between the ages of 18 and 30 represented by 57%. About 10% of the respondents were above 40 years in

age. This could be because of push and pull factors that contribute to youthful urban migration in developing countries like Kenya.

### 4.4.3 Highest level of Education

The respondents' levels of education had four ratings namely: primary, secondary, tertiary, and university. It became clear from the results that the literacy level in Ongata Rongai is high with only 8% having primary level of education. Majority had post-secondary education (54%), comprising of 36% middle level college training and 18% university education while secondary level was 38%. Management strategies of storm water challenges vary with the level of education one has. Learned people are known to have a lot of knowledge that enables them to quickly respond to a problem and find a solution and so to respondents in flooding areas like Ongata Rongai.

**Figure 4.2 Highest level of education of the respondents**




**Source: Researcher (2014)**

This scenario could probably be explained by the activities found in Ongata Rongai such as service institutions (banks, supermarkets, schools, water companies and security firms) which offer employment to school leavers as well as to college and university graduates. The other pull factors to this could be low rates for house rents and food stuff, mainly from agriculture since majority are practicing farming compared to Nairobi. The Ministry of Nairobi Metropolitan Development (2011) projected that, by 2030, Ongata Rongai will have 68% of her population under service industry while the remaining 32% will be working in agriculture, transport and construction sectors.

### 4.4.4 Duration of Residence in Ongata Rongai by the respondents

**Table 4.3 Duration of Residence in Ongata Rongai by the respondents**

| | Frequency | Percent |
|---|---|---|
| Less than 1 year | 4 | 5 |
| 1-5 years | 38 | 51 |
| 6-10 years | 16 | 22 |
| more than 10 years | 16 | 22 |
| **Total** | **74** | **100.0** |

**Source: Researcher (2014)**

Majority of the residents have lived in Ongata Rongai for a period of five years. This is represented by 56% of the respondents as indicated in table 4.3. The proportion of respondents who have lived in Ongata Rongai for more than 5 years was 44%.This could be due to the fact that Ongata Rongai is a residential urban aggregation offering a convenient location for the population working in Nairobi.

### 4.5 An analysis of Bacteriological Composition of Storm Water due to Poor Sewage Disposal

Six samples of water were collected from the study area and tested for the presence of *E coli*, a microbial indicator for human fecal waste. The control sample was collected from a tank containing harvested rain water sampled immediately after rain. The experiment samples were collected direct from drains from two different locations for each of the three clusters. The results showed high levels of *E. coli* in the experiment samples while the control sample had no *E coli* as given in table 4.4 and appendix 8.This could be attributed to the lack of established sewerage system in the study area forcing residents to dispose their septic contents unethically. Flooded storm water also seeps into septic tanks making them to overflow its contents thus flowing into the available storm drain.

**Table 4.4: Summary of the water sample results from the National Water Laboratories and the Kenya Water Institute**

| Water Samples | Results Summary | |
|---|---|---|
| | MPN of coliforms organisms per 100ml | E coli per 100ml |
| Control sample: No. 0911 | 12 | 0 |
| Experiment sample 1: No. 0904 | $2.420 \times 10^6$ | $1.3 \times 10^6$ |
| Experiment sample 2: No 0905 | $2.420 \times 10^6$ | $2.966 \times 10^6$ |
| Experiment sample 3: No 0906 | $2.420 \times 10^6$ | $2.986 \times 10^6$ |
| Experiment sample 4: No 0907 | $2.020 \times 10^6$ | $1.672 \times 10^6$ |
| Experiment sample 5: No 0909 | $2.40 \times 10^6$ | $1.31 \times 10^6$ |
| Experiment sample 6: No 0910 | $2.611 \times 10^6$ | $1.4 \times 10^6$ |

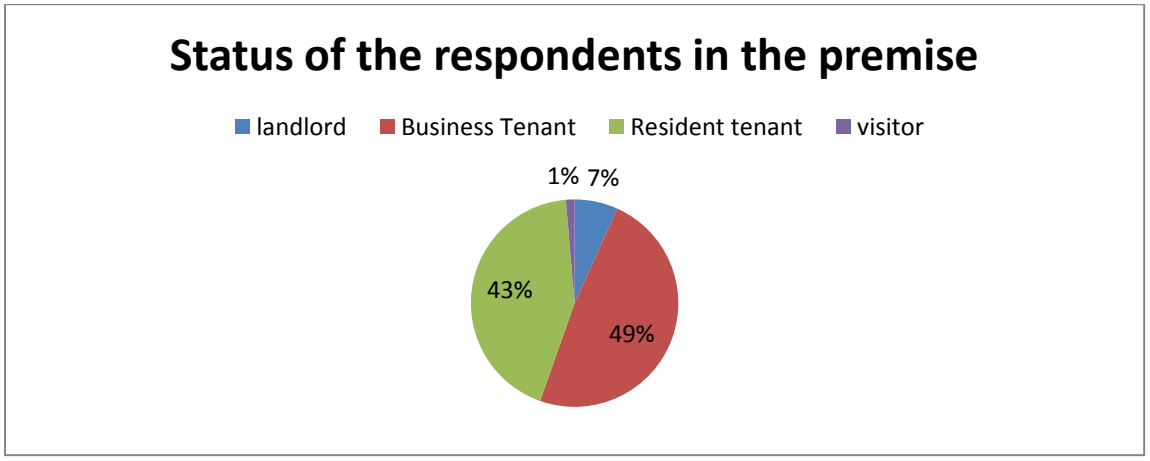
**Source: Researcher (2014)**

E. coli is the leading cause of bacterial diarrhea and deaths among children less than five years in Kenya and in developing countries. This is enhanced by factors such as harsh climatic conditions, poor sanitation, malnutrition and immunosuppression by HIV and AIDS Clarke SC (2001). Safe samples of water should always have nil *E. coli* and coliforms. Thus these samples except for the control are hazardous as they can cause fatal diarrhea.

## 4.6 An Investigation of the Social Economic Effects of Storm Water Management Challenges in Ongata Rongai.

### 4.6.1 Status of the respondents in the premises where they were interviewed

**Figure 4.3 Status of the respondents in the premises where they were interviewed**




**Source: Researcher (2014)**

The status of the respondents had the ratings (Landlord, Resident tenant, Business tenant and visitor). Majority of the respondents were business tenants 49% which was slightly higher than that of resident tenants which was at 43%. Landlords were only 7% while visitors were 1%.This was probably because of the youthful population in town who may not be financially stable to own properties.

### 4.6.2 How Sewage Waste is Disposed by Owner of the Premise

**Table 4.5 How sewage is disposed by owner of the premise**

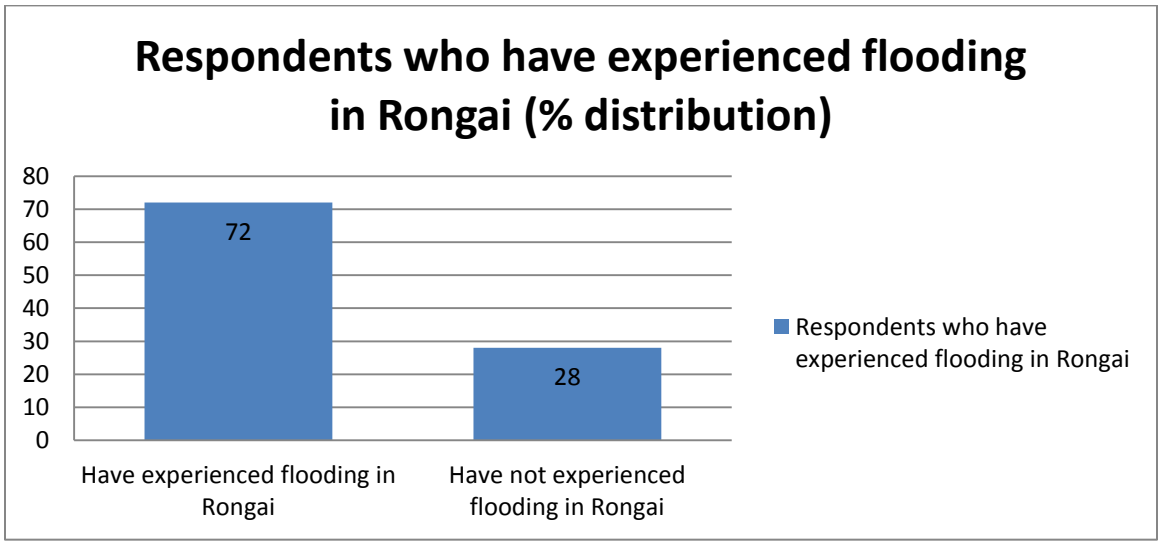
| | Frequency | Percent (%) |
|---|---|---|
| Disposed in a sewer line | 4 | 5 |
| Use the services of sewer exhauster | 48 | 65 |
| Allowing sewers to overflow in the surrounding area | 13 | 18 |
| Using sewer as farm manure | 1 | 1 |
| Don't know | 8 | 11 |
| **Total** | **74** | **100.0** |

**Source: Researcher (2014)**

Options of sewage disposal methods in the premises were given where majorities of the respondents (65%) indicated that they or their landlords use sewer exhausters to dispose septic tank contents. Only 18% allow sewers to overflow into the surrounding area, while 1% use sewer as manure and 5% of the respondents indicated that there is an existing sewer line for disposing sewer waste into the river. This is not true because there is no known sewage line in Ongata Rongai. The answers might have come from visitors or tenants who are new in the study area. Some also fear stating the truth because they fear the repercussions that come with such unhealthy disposal of sewage. A cross tabulation of sewage disposal methods and status of respondents in the premise indicate that 80% of landlords use the services of sewer exhausters, while only 20% of landlords allow sewers to overflow in the surrounding area. About 30% of resident tenants indicated that sewers are allowed to overflow into the surrounding area by their landlords. This could be the percentage believed to be polluting storm water through improper sewage disposal

### 4.6.3 An Investigation of whether Flooding is a Problem in Ongata Rongai

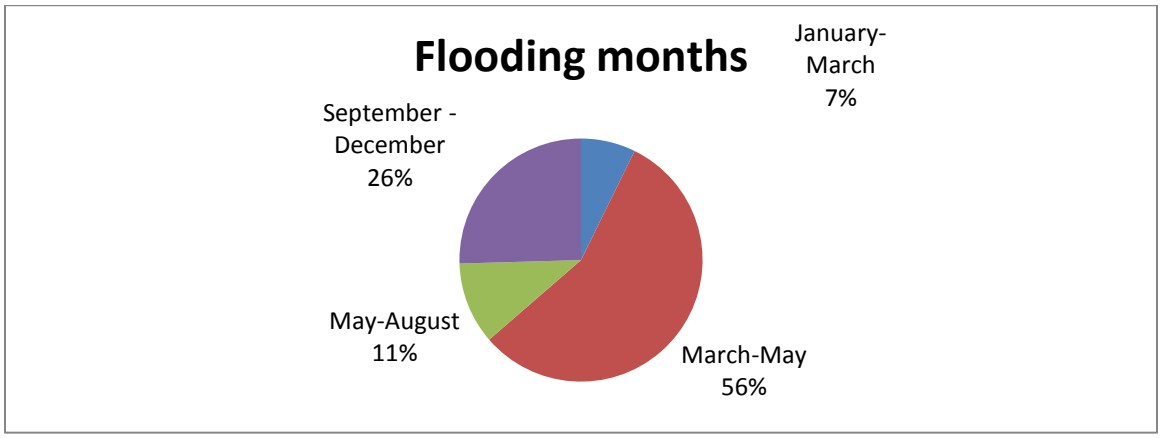
**Figure 4.4 Respondents who have experienced flooding in Ongata Rongai (% distribution)**




**Source: Researcher (2014)**

The respondents were asked whether they have experienced flooding in Ongata Rongai or not. Majority of the respondent indicated that they have experienced flooding in the area with 72% indicating that flooding is a problem in the area as. This compliments with the meteorological report of annual high rainfall of 844 mm in figure 1.5 and appendix 4, which shows that there is a bimodal rainfall pattern in the area. The black cotton soils in Ongata Rongai that poorly drains water and also the location of the town in upper Kajiado plains within the Athi drainage basin has further complicated the flow of storm water runoff thus the flooding. The 28% who have not experienced flooding in Ongata Rongai as indicated in figure 4.4 could be those who have been residence for duration of less than a year.

**Figure 4.5: Flooding months**




**Source: Researcher (2014)**

The results on the flooding months as given in Figure 4.5 shows that 56% of the respondents indicated that they usually experience flooding in the period between March and May, while 26% of the respondents indicated that they usually experience flooding in the period between October and December. This coincides with the long and the short rainy seasons respectively. The respondents further indicated that these two periods always record the worst flooding months in Ongata Rongai. These results are a reflection of the monthly rainfall data of Ongata Rongai, obtained from the Ngong' and Wilson Meteorology stations as seen in figure 4.6.

**Table 4.6: A comparison of mean, maximum, and minimum rainfall values between Ngong and Wilson stations from 1984 - 1993**

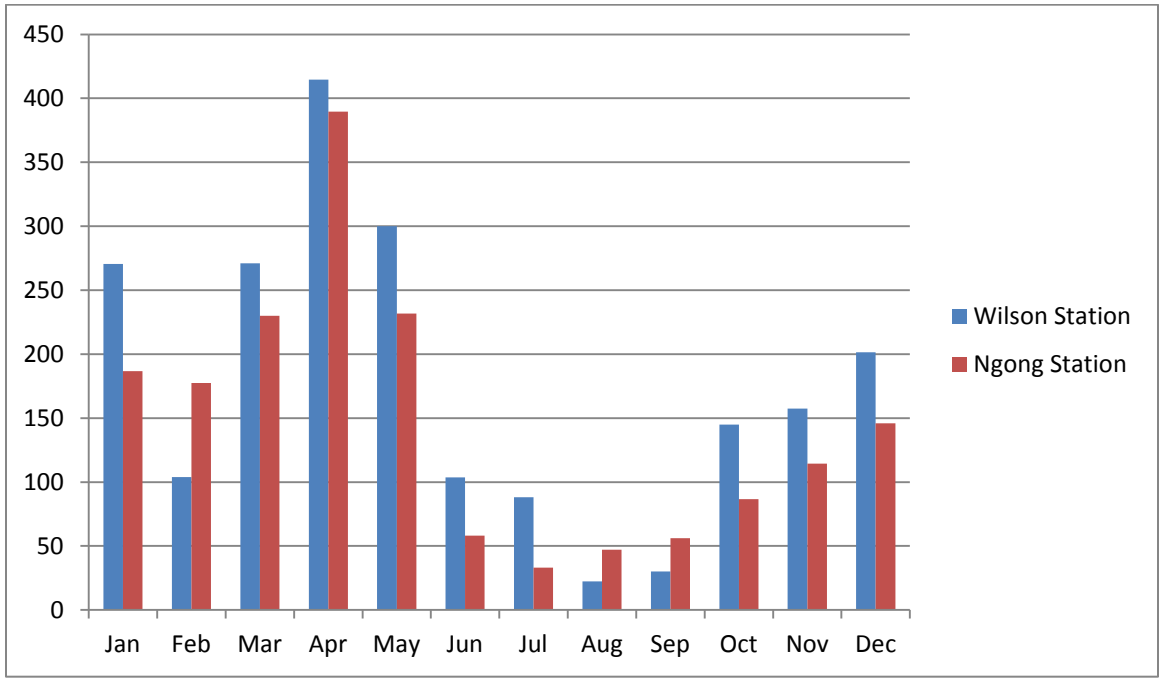
| Rainfall Variables | | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | Wilson Station | 61.9 | 31.02 | 88.8 | 214.9 | 122.1 | 33.8 | 24.3 | 10.1 | 10.9 | 39.6 | 110.5 | 99.4 |
| | Ngong Station | 70.9 | 59.3 | 77.9 | 189.7 | 148 | 26.5 | 20.7 | 13.7 | 17.9 | 32.9 | 70.1 | 71.8 |
| Max | Wilson Station | 270.4 | 104 | 271 | 414.6 | 300.1 | 103.6 | 88.1 | 22.4 | 30.2 | 144.8 | 157.3 | 201.4 |
| | Ngong Station | 186.8 | 177.5 | 229.9 | 389.6 | 231.8 | 58.1 | 33 | 47 | 56.1 | 86.5 | 114.5 | 146 |
| Min | Wilson Station | 0 | 0 | 5.3 | 9.6 | 1.6 | 2.8 | 0 | 1 | 0 | 1.9 | 66.7 | 25.8 |
| | Ngong Station | 3.6 | 12 | 14.1 | 2.1 | 58.4 | 2.2 | 0 | 0 | 0 | 0 | 42.2 | 20.2 |

**Source: Kenya Meteorological Services, 2014**

There is rainfall variation in the two stations: Ngong and Wilson's for all the parameters that is mean, maximum and minimum rainfall recorded between 1984 and 1993 with Wilson's recording slightly higher rainfall. Measures towards management of storm water challenges takes

into consideration factors such as rainfall intensity experienced in the area: mean, maximum and minimum monthly rainfall which this study has highlighted.

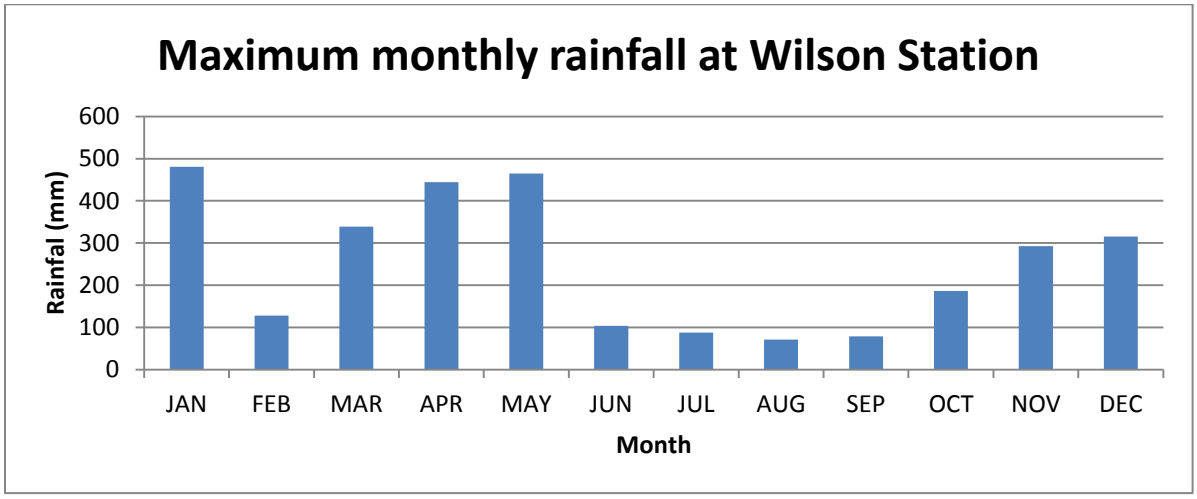
**Figure 4.6: Comparison of maximum monthly rainfall between Ngong' and Wilson Stations from 1984-1993**




**Source: Kenya Meteorological Services, 2014**

The rainfall pattern exhibits a bimodal distribution in the two rainfall gauging stations. The wet seasons are between March – May (long seasons) and between October and December (short seasons) for both stations. It is clear that the Wilson's station receives slightly higher rainfall than the Ngong' D.O.S office meteorological stations. These stations record the rainfall intensity that generates the runoff that is believed to cause storm water management challenges in Ongata Rongai. Some of these challenges include flooding, environmental pollution due to poor sewage disposal, water borne diseases and damage to infrastructure. The comparison of the rainfall data from the two stations is significant for accuracy and control purposes.

**Figure 4.7: Maximum monthly rainfall between 1980 – 2013**




**Source: Kenya Meteorological Services, 2014**

The rainfall data from the Wilsons station was available from 1980 - 2013 unlike from Ngong station which was available from 1984 – 1993. This data shows two distinct rainfall seasons long (between March - May) and short (between October - December) seasons experienced in the study area. There is rainfall throughout the year though with variability and this explains the flooding experienced in the study area during these seasons.

### 4.6.4 Investigation of the Social Economic Effects of Storm Water Management Challenges in Ongata Rongai

**Table 4.7: Summary of the responses of social economic effects of storm water management challenges in Ongata Rongai**

| | Strongly disagree | Disagree | Neutral | Agree | Strongly Agree | Binary scale | |
|---|---|---|---|---|---|---|---|
| | | | | | | No | Yes |
| Traffic jam | 5 | 8 | 8 | 26 | 53 | 13 | 79 |
| Stalled vehicles | 3 | 11 | 19 | 27 | 40 | 13 | 67 |
| Sewage disposal in storm water runoffs | 4 | 7 | 12 | 32 | 43 | 11 | 75 |
| Flooding | 8 | 7 | 10 | 35 | 39 | 15 | 74 |
| Business closure | 12 | 15 | 18 | 24 | 31 | 27 | 55 |
| Sickness | 7 | 8 | 8 | 22 | 55 | 15 | 77 |
| Inability to go to work | 12 | 10 | 20 | 27 | 31 | 22 | 58 |
| Reduced income | 11 | 5 | 8 | 30 | 46 | 16 | 76 |
| Low Customer turnout | 10 | 3 | 10 | 23 | 55 | 13 | 78 |
| Destruction of goods and properties | 11 | 10 | 11 | 27 | 42 | 21 | 69 |

**Source: Researcher, 2014**

The second objective of the study was to assess whether storm water management challenges affect the social economic development of the study area. A summary of the investigation of the socio – economic effects of storm water and from binary scale results, majority of the respondents agree that storm water management challenges lead to: increased traffic jam, stalling of vehicles, mixture of sewage with storm water runoffs, flooding, business closure, sickness, inability to go to work, reduced income, low turnout of customers, and destruction of goods and properties. However, the proportion of the respondents who agreed that storm water management challenges leads to business closure and inability to go to work was relatively weak, at 54% and 58% respectively as compared to other said economic parameters that turned between 67% – 79%. This could probably be because of the typical youthful population in the town who are determined and are aggressive to make a living despite all odds like flooding. From the results, most of the respondents believe that storm water management challenges affect their social and economic aspects of life as given in Table 4.7.

### 4.6.5 Investigation of the Storm Water Management Challenges in Ongata Rongai

**Table 4.8: Summary of responses of Storm Water Management challenges in Ongata Rongai**

| | Strongly disagree | Disagree | Neutral | Agree | Strongly Agree | Binary scale | |
|---|---|---|---|---|---|---|---|
| | | | | | | No | Yes |
| Lack of a sewage system | 4 | 5 | 5 | 18 | 66 | 9 | 84 |
| County government failure | 3 | 7 | 11 | 26 | 54 | 10 | 80 |
| Poor planning | 1 | 7 | 5 | 26 | 61 | 8 | 87 |
| Lack of awareness | 19 | 8 | 15 | 23 | 34 | 27 | 57 |

**Source: Researcher, 2014**

The results in table 4.8 gives a summary of the investigation of storm water management challenges in Ongata Rongai. From the binary scale results, majority of the respondents agree that lack of a sewage system, failure by the county government, poor planning, and lack of awareness (80% - 87%) are some of the major challenges of storm water management in the area. However, the proportion of those who agreed that lack of awareness is a challenge to storm water management was relatively weak, at only 57%. This could be because of the origin of Ongata Rongai as a satellite town along Magadi road which did not give room for proper urban planning and infrastructure input.

### 4.6.6 Investigation of alternative Solutions to Storm Water Management Challenges in Ongata Rongai

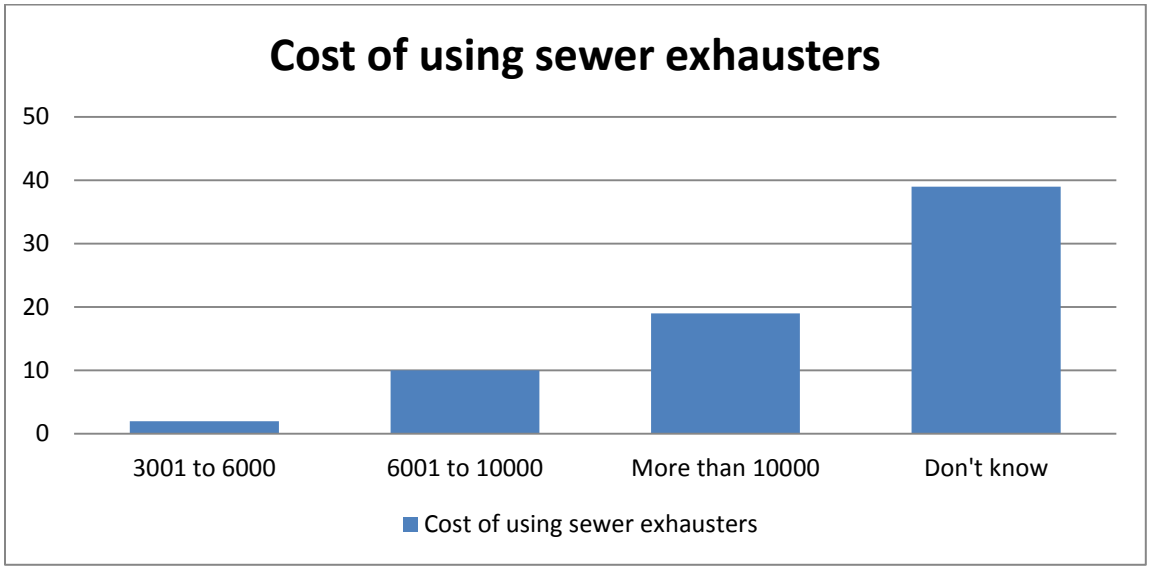
**Table 4.9: Summary of the responses of alternative solutions to storm water management challenges in Ongata Rongai**

| | Strongly disagree | Disagree | Neutral | Agree | Strongly Agree | Binary scale | |
|---|---|---|---|---|---|---|---|
| | | | | | | No | Yes |
| Unblocking the existing drainages | 7 | 3 | 10 | 30 | 50 | 10 | 80 |
| Constructing new drainages | 3 | 5 | 3 | 31 | 57 | 8 | 88 |
| Insuring property | 24 | 8 | 26 | 24 | 18 | 32 | 42 |
| Relocation of residents | 42 | 14 | 16 | 7 | 22 | 56 | 29 |

A summary of the investigation of alternative solutions to storm water management challenges in Ongata Rongai was sought and is presented in table 4.9. From the binary scale results, majority of the respondents agreed that constructing new drainages and unblocking the existing drainage systems (88% and 80% respectively) will significantly help to solve the challenge. Insuring of properties and relocation of residence were not considered as helpful alternatives as majority of the respondents were either neutral about these options or did not agree to them. This is because insurance comes with a cost which the respondents are not ready to meet. There is also fear for business relocation as this affects customer turn out for the business tenants and resident tenants fear for other relocation consequences such as schooling children being transferred from one school to another.

### 4.6.7 Cost of Using Sewer Exhausters

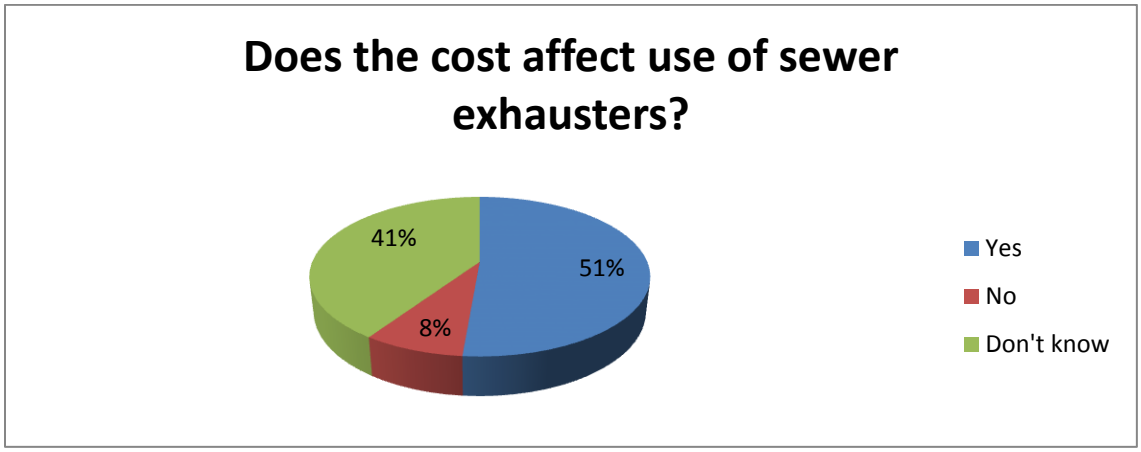
**Figure 4.8: Cost of using sewer exhausters**




**Source: Researcher (2014)**

Majority of the respondents do not know the cost of using sewer exhausters. For the respondents who knew the cost of using sewer exhausters, 61% indicated that it costs more than KES 10,000 on an annual basis while only 39% indicated that it costs less than KES 10,000 per year as given in figure 4.8. This depends on factors such as the number of tenants in a premise, usability of these exhauster services, number of septic tanks per premise, type of structure (flat, bungalow, maisonette) as the demand for exhauster services varies with these factors.

**Figure 4.9: An investigation into whether the cost affects the use of sewer exhausters**




**Source: Researcher (2014)**

The respondent's opinion on whether the cost of use of exhauster services affects its use was sought in figure 4.9 and majority of the respondents (51%) indicated that the cost of using sewers is too high and it does affect the use of the service in the area. This group could probably be landlords or tenants who have taken this responsibility on their own to empty their septic contents or those who are aware though not having used it. 41% percent of the respondents do not know whether cost is a major factor that affects the use of sewer services, while only 8% indicated that the cost is reasonable and it does not affect the use of sewer services in the area.

**Table 4.10: A cross tabulation of the cost of using sewer exhauster services and an investigation into whether the cost affects the use of the services**

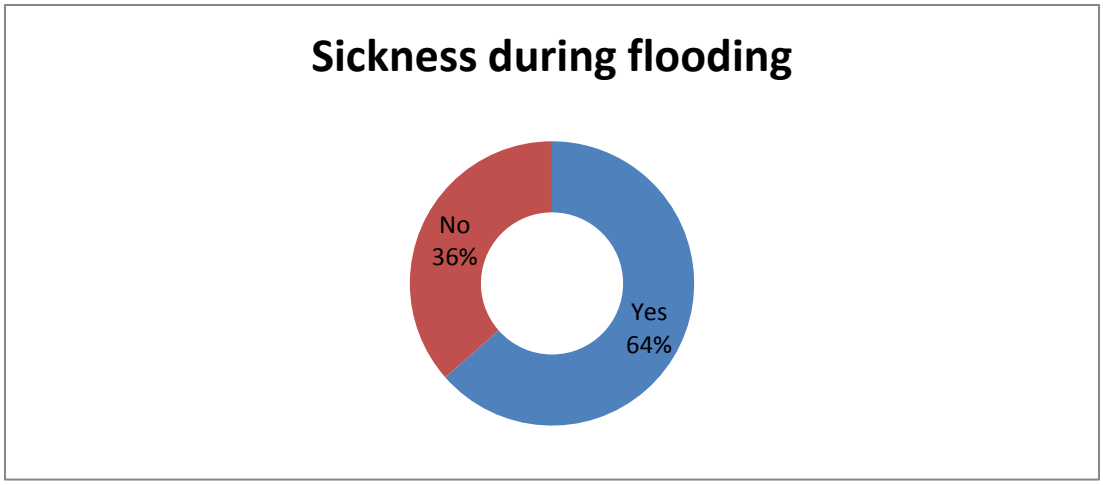
| | | | Cost of the sewer exhauster service | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1001 to 3000 | 3001 to 6000 | 6001 to 10000 | More than 10000 | Don't know |
| The cost affects use | Yes | Count | 2 | 2 | 8 | 17 | 9 |
| | | % count | 50.0% | 100.0% | 80.0% | 89.5% | 23.1% |
| | No | Count | 0 | 0 | 1 | 2 | 3 |
| | | % count | 0.0% | 0.0% | 10.0% | 10.5% | 7.7% |
| | Don't know | Count | 2 | 0 | 1 | 0 | 27 |
| | | % count | 50.0% | 0.0% | 10.0% | 0.0% | 69.2% |
| Total | | Count | 4 | 2 | 10 | 19 | 39 |
| | | % count | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

**Source: Researcher (2014)**

A cross tabulation of the results of cost of sewer exhausters services and the results of whether the cost affects the use of the services indicated that 89.5% of the respondents who said that it costs more than KES 10,000 per annum to use sewer exhausters were of the opinion that the cost is expensive and it does affect the use of the services in the area. It could probably be this reason that there is poor sewage disposal as supported by the overwhelming number of complaints and court cases as given in Appendix9 and the presence of high coliform and *E. coli* load in storm water which is presented in Table 4.4 and Appendix 8.

### 4.6.8 An investigation of Whether the Respondents have Fallen Sick or have Witnessed a Household Member Falling Sick During Flooding Seasons

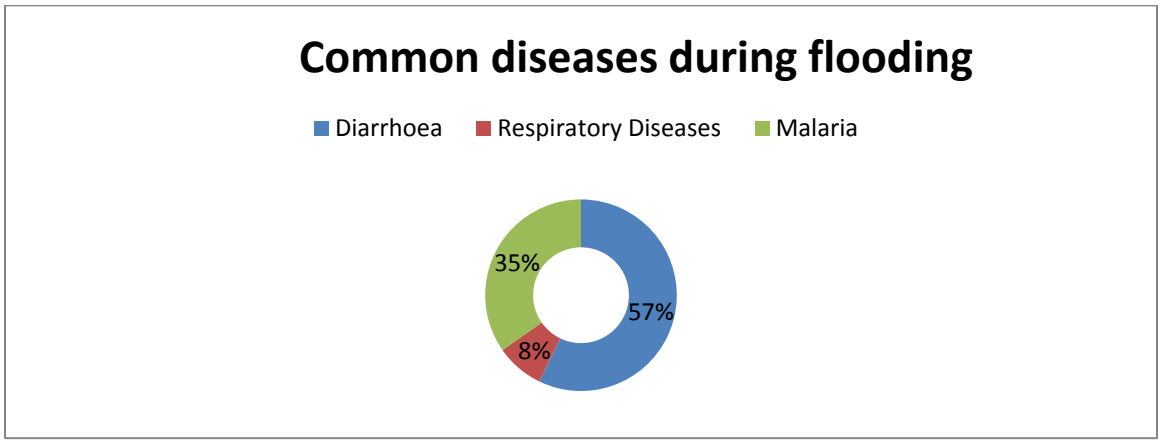
**Figure 4.10: An investigation into whether the respondents or any member fall sick during flooding seasons**




**Source: Researcher (2014)**

Majority of the respondents indicated that they have experienced sickness or seen a member of their household fall sick during the flooding season at 64%.This implies that at least during the rainy season there is a member of the household who falls sick and this indicates a serious social problem which needs to be contained. Sickness due to water borne diseases is stated to be among the socio economic effects of storm water management challenges in the study area

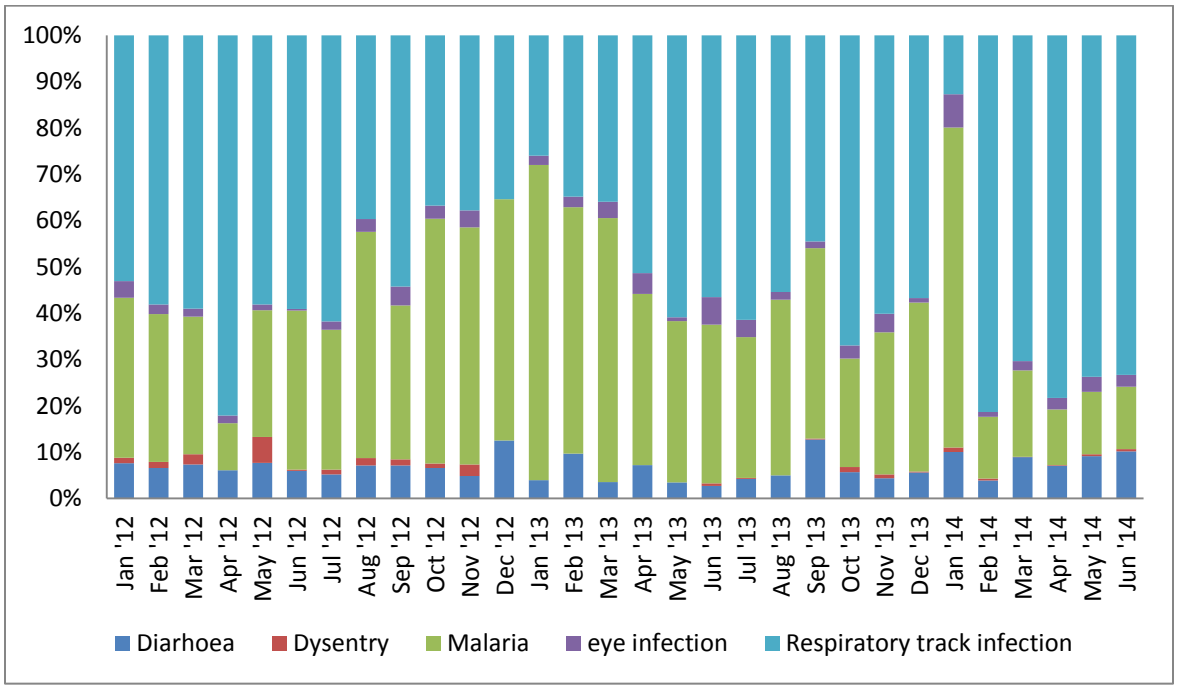
**Figure 4.11: Common diseases during flooding seasons**




**Source: Researcher, (2014)**

Ratings of common diseases during the rainy season indicated that malaria and diarrhoea are the most common diseases that affect them and members of their households during the flooding months at 35% and 57% respectively as indicated in figure 4.11. This is also given in appendix 6 that shows the health records data of diseases common during the rainy season in Ongata Rongai between 2012 and 2014. During rains it is believed that the storm water distributes microbes by transporting it around in floods and run offs. This is even worse when there is no adequate and proper storm drains as is the case in Ongata Rongai.

**Figure 4.12: Secondary records from Saitoti dispensary (Mbagathi), Ongata Rongai, for diseases related to storm water between 2012 and 2014**




Source (Ongata Rongai Saitoti (Mbagathi) dispensary, 2014)

Figure 4.12 shows results of the secondary data of common diseases during the rainy season received from Ongata Rongai Saitoti (Mbagathi) dispensary. The results shows the percentage number of cases recorded per month of common diseases associated with storm water management challenges, including respiratory tract infection, eye infection, malaria, and diarrhoea. From the results, malaria, respiratory tract infection and diarrhoea are the most common illnesses in the area. The results also show that these illnesses have high recordings during the flooding months or the rainy seasons as given in Appendix 6. In as much as the precursor to sicknesses is poor sanitation and other immune factors, poor storm water

management is also a contributing factor as the runoff from the storm water accelerates the spread of pathogenic microbes during the rainy seasons.

**Table 4.11: Summary of the responses of the social economic effect of sicknesses resulting from flooding**

| | Binary scale | |
|---|---|---|
| | Yes | No |
| Lost employment | 47 | 53 |
| Stopped going to school | 79 | 21 |
| Income reduced significantly | 77 | 23 |
| Business closed | 57 | 43 |

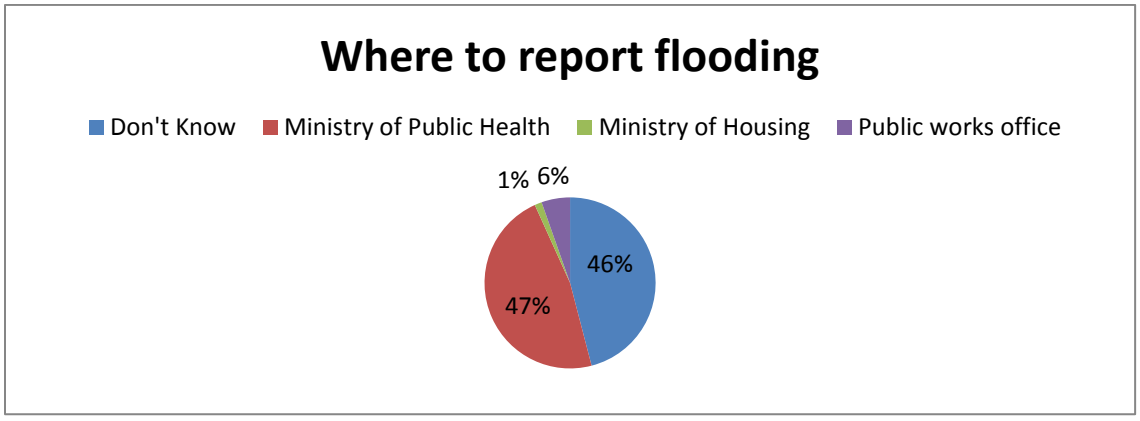
**Source: Researcher (2014)**

Sickness affects somebody's mobility as well as activities to be carried out: loss of employment due to prolonged sickness, loss of schooling hours, significant reduction of income and business closure are among the responses given by the respondents as shown in figure 4.11. When one is sick their daily chores is affected and in more severe cases one is forced to look for finance to meet hospital bills.

## 4.7 An Investigation of the Effectiveness of the National Water Policy 2012 and Legal Framework in Managing Storm Water in Ongata Rongai

### 4.7.1 An Investigation of where Flooding Incidences are Reported in Ongata Rongai

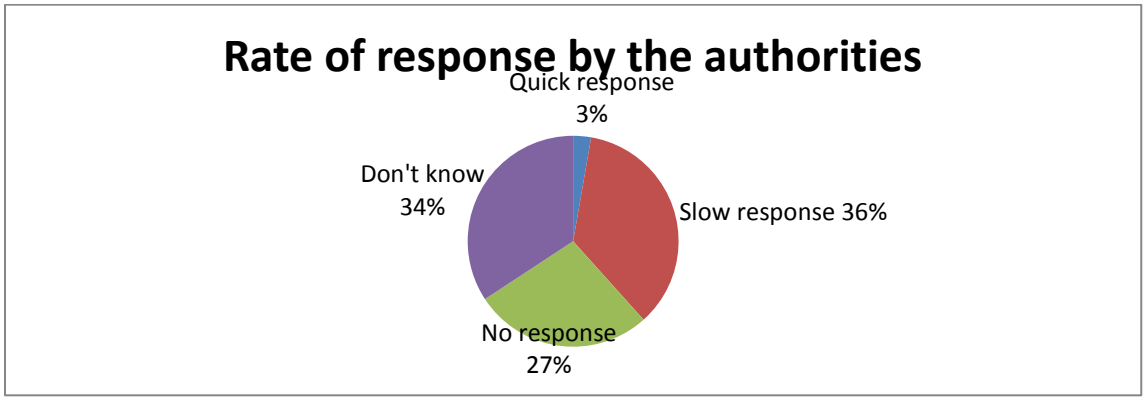
**Figure 4.13: An investigation of where flooding incidences are reported in Ongata Rongai**




**Source: Researcher (2014)**

From figure 4.13, most of the respondents (47%) indicated that flooding incidences are reported to the ministry of public health. This is supported by complaints and court cases which were between the accused and the ministry of health who are in the docket of ensuring sustainable public health through implementation of the health policy. However, the proportion of those who do not know where to report flooding incidences was equally high at 46%. The respondents who indicated that flooding incidences are reported to the ministry of housing and public works office were 1% and 6% respectively.

**Figure 4.14: The rate of response by authorities when flooding incidences are reported in Ongata Rongai**

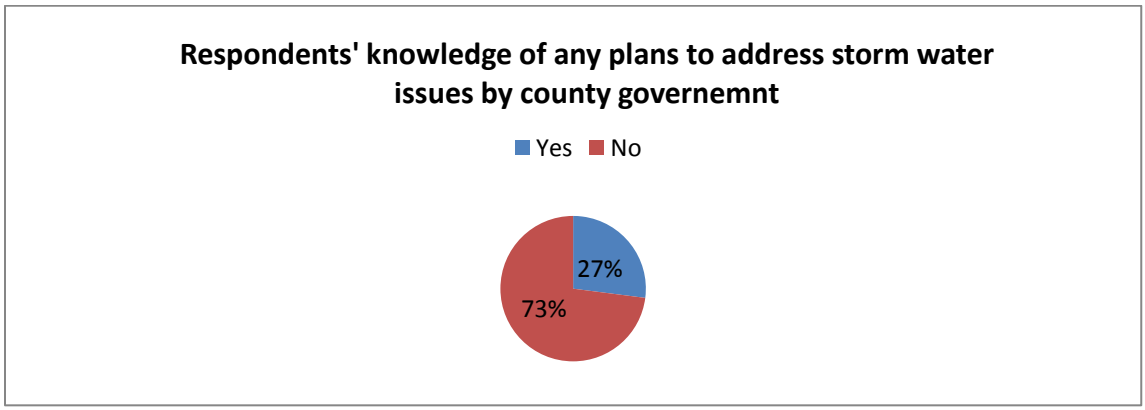



**Source: Researcher (2014)**

From the results in figure 4.14, a good number of the respondents indicated a slow rate of response and no response by authorities at 36% and 34% respectively when contacted about storm water challenges in Ongata Rongai. Only 3% indicated that the authorities make a quick response when contacted about storm water management challenges in the area. Poor response rate could be a clear indication of poor participation and lack of team work between the county government and its residents.

### 4.7.2 An investigation on plans by the county government to address storm water management issues in Ongata Rongai

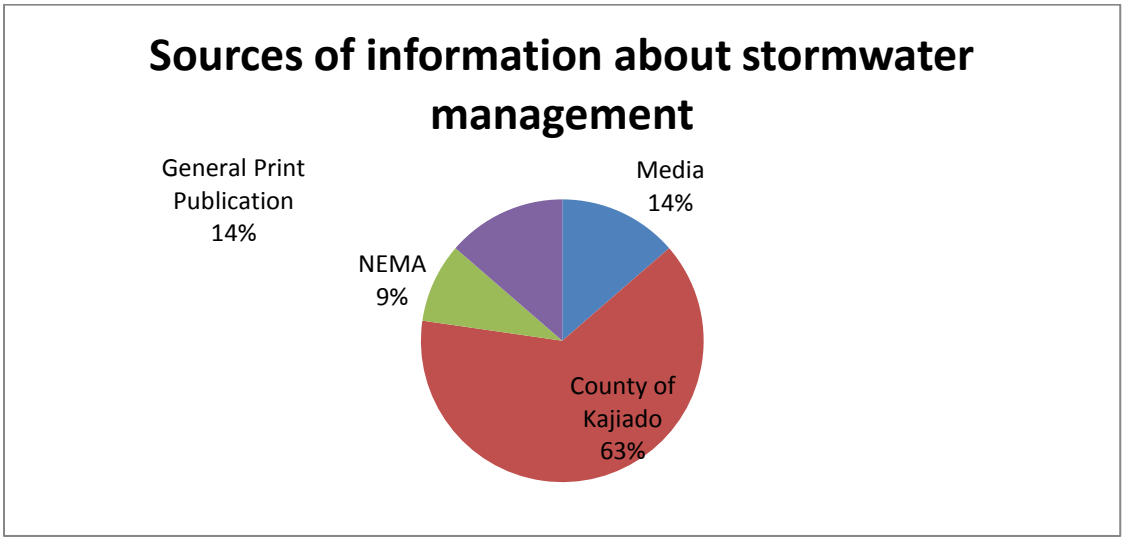
**Figure 4.15: An investigation on plans by the county government to address storm water management issues in Ongata Rongai**




**Source: Researcher (2014)**

Majority of the respondents 73% were not aware of any plans by the county government to address storm water issues in the area. Only 27% of the respondents are aware of some plans by the county government to address storm water issues in the area as shown in figure 4.15. The small proportion that was aware of some plans by the county government to address storm water management challenges indicated that some of the plans include: construction of sewages lines, construction of drainages along the feeder roads, construction of dams, improvement of roads (especially Magadi Road), and planting of trees to prevent floods. This high number of respondents who are not aware of any plans by the county government to address storm water management challenges could be because of lack of involvement in most development issues.

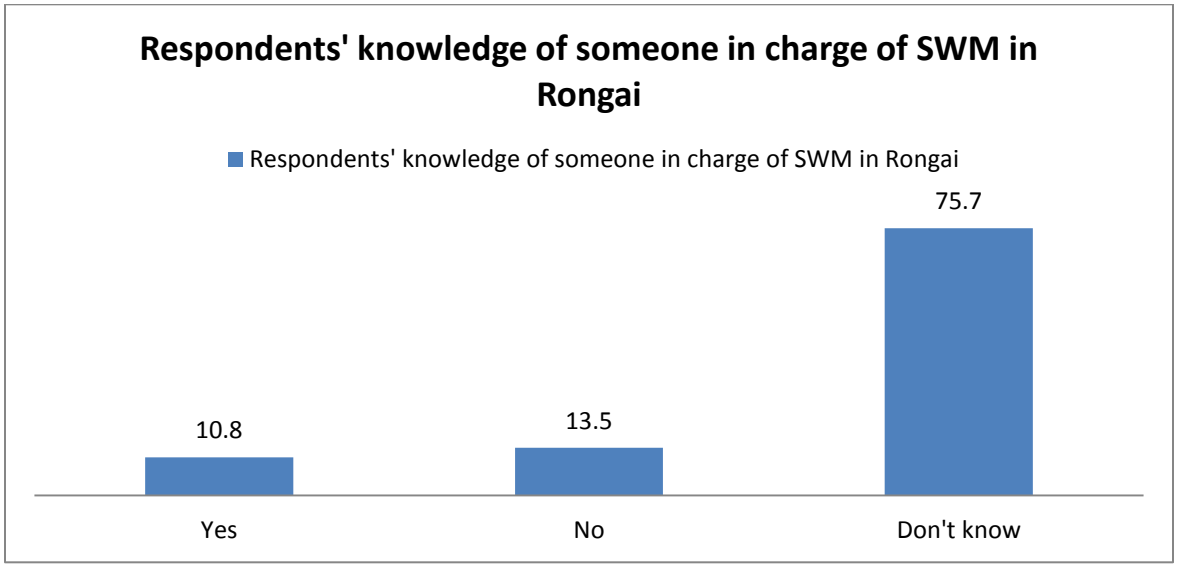
**Figure 4.16: Sources of information about storm water management issues in Ongata Rongai**




**Source: Researcher (2014)**

Sources of information about the county government plans to address storm water management challenges in Ongata Rongai was sought from the respondents who were aware. Majority of the respondents indicated that they got the information about plans to address storm water management challenges in Ongata Rongai from the county government of Kajiado. This was represented by 63% of those who said they are aware of plans by the county government to address storm water management issues. 28% of the respondents indicated that they got the information from either print or electronic media, while only 9% got the information from the National Environment Management Authority as given in figure 4.16. This probably indicates the type of governance in Kajiado County where there is some democracy and commitment that is yet to be fully implemented.

**Figure 4.17: Respondents' knowledge of someone in charge of SWM in Ongata Rongai**




**Source: Researcher (2014)**

The results in Figure 4.17 shows that (76%) of the respondents do not know anyone in charge of storm water management issues in Ongata Rongai. This result resonates with the earlier indication that quite a significant number of the respondents are not aware of where to report flooding incidences in Ongata Rongai. Only 11% of the respondents are cognizant of the person in charge of storm water management in Ongata Rongai. Majority of them indicated that county government representative on public health is the one in charge of storm water management. This could be due to the young devolution process that still needs time to become effective.

**Table 4.12: Summary of the respondent's willingness to pay some fee for addressing storm water management challenges in the area**

| | | Frequency | Percent | Valid Percent |
|---|---|---|---|---|
| Valid | Yes | 54 | 73.0 | 75.0 |
| | No | 18 | 24.3 | 25.0 |
| | Total | 72 | 97.3 | 100.0 |
| Missing | System | 2 | 2.7 | |
| Total | | 74 | 100.0 | |

**Source: Researcher (2014)**

Majority of the respondents (75%) are willing to pay some fee to specifically address storm water management challenges in the area as indicated in figure 4.12. The willingness to meet

some cost in managing storm water challenges could probably be an indication of residence who are ready to participate in developing their county through involvement.

**Table 4.13: A cross tabulation the frequency of payment and the amount the respondents are willing to pay**

| | | | Payment frequency | | Total |
|---|---|---|---|---|---|
| | | | Yearly | Monthly | |
| Amount willing to pay | Less than 200 | Count | 22 | 21 | 43 |
| | | Expected Count | 20.3 | 22.7 | 43.0 |
| | | % within amount willing to pay | 51.2% | 48.8% | 100.0% |
| | 201-400 | Count | 2 | 6 | 8 |
| | | Expected Count | 3.8 | 4.2 | 8.0 |
| | | % within amount willing to pay | 25.0% | 75.0% | 100.0% |
| | More than 400 | Count | 1 | 1 | 2 |
| | | Expected Count | .9 | 1.1 | 2.0 |
| | | % within amount willing to pay | 50.0% | 50.0% | 100.0% |
| Total | | Count | 25 | 28 | 53 |
| | | Expected Count | 25.0 | 28.0 | 53.0 |
| | | % within amount willing to pay | 47.2% | 52.8% | 100.0% |

**Source: Researcher (2014)**

A cross tabulation of the frequency of payments and the amount the respondents are willing to pay in table 4.13, revealed that 52% of the respondents are willing to pay an amount of Kshs 200 on yearly terms while only 48 percent prefer to pay Kshs 200 on monthly terms. Both responses of monthly and yearly are encouraging towards the sustainable storm water management as the residents are willing to live in a sustainable urban area at a cost.

### 4.8 Hypothesis Testing

The study used Chi-Square to test the research null hypotheses because the study required the test of independence of variables, the observations collected and recorded were on random basis and the overall number of items was reasonably large, more than 50 which is scientifically acceptable. Under the Chi-Square, if the calculated value is greater than the critical value at 0.05 significance level, the null hypothesis is rejected.

#### 4.8.1 Hypothesis One

$H_0$: Bacteriological composition of storm water does not significantly indicate poor sewage disposal in Ongata Rongai. The variables used to test this hypothesis included lack of a sewage drainage system and the way sewage is disposed by property owners in Ongata Rongai.

**Table 4.14: Summary of chi-square analysis of hypothesis one testing**

| | Value | df |
|---|---|---|
| Pearson Chi-Square | 5.124 | 1 |
| N of Valid Cases | 74 | |

**Source: Researcher (2014)**

The results in table 4.14 show that the calculated chi-square value is 5.124, which is greater than the critical (tabulated) value of 3.841, at 0.05level of significance and at 1 degree of freedom. As a result, the null hypothesis is rejected because there is a significant evidence to conclude that storm water management is affected by poor sewage disposal in Ongata Rongai

### 4.8.2 Hypothesis Two

$H_0$: Storm water management challenges do not significantly affect socio- economic development of Ongata Rongai town.

The variables used to test this hypothesis included poor planning as a storm water management challenge and reduced income as social economic effect of storm water management challenges

**Table 4.15: Summary of chi-square analysis of hypothesis two testing**

| | Value | df |
|---|---|---|
| Pearson Chi-Square | 5.399 | 1 |
| N of Valid Cases | 74 | |

**Source: Researcher (2014)**

The results in table 4.15show that the calculated chi-square value is 5.399, which is greater than the critical (tabulated) value of 3.841, at 0.05 level of significance and at 1 degree of freedom. As a result, the null hypothesis is rejected because there is a significant evidence to conclude that storm water management challenges affect the social economic development of OngataRongai

### 4.8.3 Hypothesis Three

$H_0$: The effectiveness of the National Water Policy 2012 does not significantly affect storm water management and pollution control in the study area.

The variables used to test this hypothesis included the rate of response by authorities to flooding incidences and county government failure as a storm water management challenge.

**Table 4.16: Summary of chi-square analysis of hypothesis three testing**

| | Value | df |
|---|---|---|
| Pearson Chi-Square | 4.555 | 1 |
| N of Valid Cases | 74 | |

**Source: Researcher (2014)**

The results in table 4.16 show that the calculated chi-square value is 4.555, which is greater than the critical (tabulated) value of 3.841, at 0.05 level of significance and at 1 degree of freedom. As a result, the null hypothesis is rejected because there is a significant evidence to conclude that the implementation of the National Water Policy (2012) significantly affects the management of storm water in Ongata Rongai.

# CHAPTER FIVE: SUMMARY OF THE FINDINGS, CONCLUSION AND RECOMMENDATION

## 5.1 Introduction

This chapter consists of three sections, namely, summary of the findings, conclusions, and recommendations following that order. The initial section provides a summary of the important elements of the study that includes the study objectives, methodology, and the findings. The following subsequent section discusses the major findings of the study with regards to the specific objectives. Section three discusses the conclusions based on the specific objectives, while using the results and the findings that are obtained in the fourth chapter. The last sub-section provides the recommendations for improvement based on the specific objectives. It also provides the recommendations for further studies.

## 5.2 Summary of the Findings

The general objective of the study was to investigate the environmental challenges and effects associated with storm water management in Ongata Rongai, with the aim of recommending sustainable ways of storm water management applicable to the town. The individual aspects of storm water management challenges that were investigated included the analysis of bacteriological composition of sewage in storm water due to poor sewage disposal, assessing the social economic effects of storm water management in the development of Ongata Rongai town, and evaluating the effectiveness of the National Water Policy (2012) in enhancing storm water management and pollution control.

To expand on the theoretical background set out in chapter one, a literature review was done in chapter two. The concept and issues relating the environmental impact of storm water management challenges were explained and chapter three highlighted the research methodology adopted to obtain the data for the study. The study adopted an experimental and a survey research design in order to get the necessary data, and this helped in the primary data collection that facilitated in the achievement of the research objectives.

From the findings, the study established that bacteriogical composition of storm water in the area is contaminated with human fecal waste. From the analysis, a high coliforms and *E coli* load were detected in the experiment sample while the control sample had no traces of *E coli*. This is

very alarming because even a single E coli in water is as dangerous as ten numbers of *E coli* since Enteropathogenic (EPEC) and Diarrheagenic (DEC) *E coli* among other strains are the leading cause of diarrhoea in children under five in Kenya and most developing countries (Clarke, 2001).

The study also established that sewer, waste water, and storm water drainages are a huge problem in Ongata Rongai as sewer line does not exist and residents have to resort to the unreliable use of sewer exhaust services to dispose sewage once septic tanks are full. Another significant proportion of residents allow sewers to overflow in the surrounding area. This finding is supported by the Kloss Rolf (2009) which reported that Kenya experiences inefficiency in sewer and drainage systems within urban settings, and the secondary data from the Ongata Rongai Saitoti (Mbagathi) dispensary shows that water borne diseases such as diarrhoea and dysentery are among the highly recorded cases of storm water related illnesses at the hospital during the flooding season. .

From the findings, the study established that there is a significant association between storm water management challenges and social economic development of the study area. To confirm that storm water runoff is a problem in Ongata Rongai, 72% of the respondents indicated that they have experienced flooding due to storm water management challenges in the area and as a result, their social and economic lives have been significantly affected. The findings are supported by Novatech (2001) who says that storm water management challenges lead to social economic effects such as floods. He further argues that storm water flooding contributes to 30% of economic loss in the world. The study established that flooding in Rongai occurs mainly during the long (March – May) and short rainy (October – December) seasons. 56% of the respondents indicated that flooding is worse during the long rainy season while 26% indicated that flooding occurs during the short rainy season. These findings were backed by secondary data from the Ngong' and Wilson Airport Metrological Stations as in figure 1.5 and appendix 5.

The study found a significant relationship between implementation of National Water Policy 2012 and management of storm water in the study area. The study looked at key aspects of objective two of the National Water Policy (2012) were evaluated to establish the level of storm water management and pollution control in and their implementation in the study area. The study found that the public are not informed or involved in storm water management issues in the area.

This finding is supported by Debo and Reese (2003) who argue that local authorities like our county government and other relevant organizations should recognize the importance of public involvement in planning and water management. When communities become involved in planning, this fosters shared responsibility between authorities and the public, and also ensures the incorporation of public opinion.

A significant proportion of the respondents, 46%, do not know where to report incidences of flooding. Similarly, a greater proportion of the respondents, 76%, do not know anyone in charge of storm water management in the area. This shows the significance of those lacking awareness and how less involved the residents of Ongata Rongai are in issues to do with storm water management. Majority of the respondents further indicated that they are not aware of any plans by the county government to address storm water issues in the area. The authorities in charge of storm water related issues were also reported to show laxity in their response rate. Some variables were analysed using Chi - square to test the null hypotheses. This led to the rejection of the null hypotheses and the adoption of the alternate hypotheses.

### 5.3 Conclusion

The purpose of this study was to address storm water management challenges and their environmental impacts in Ongata Rongai town by employing three objectives and hypotheses testing. An exploratory literature review was conducted from both global and local sources. Accurate data was obtained from both secondary and primary sources by the utilization of both experimental and survey research design. There was 82% response rate whose results led to the rejection of the null hypotheses. Discussions of the study's results sought thereafter to provide recommendations on the best ways of improving storm water management in study area.

Major conclusions based on the research findings are: the research has consistently shown that storm water management challenges affect the social and economic life of the residents living in Ongata Rongai. Among the major storm water management challenges include lack of established sewerage system which is a precursor for the poor sewage disposal experienced in the area. This is supported by significant levels of bacteria isolated from storm water sampled. Blocked storm water drainages, poor planning of the town, and failure by the county government to properly implement the National Water Policy 2012 are among storm water management challenges experienced in the study area.

## 5.4 Recommendations

This section gives recommendations that the researcher feels are important in formulating guidelines for improving storm water management in Ongata Rongai and in Kenya at large.

### 5.4.1 Recommendation for policy makers

The polluter pays principle should be implemented to make the party responsible for producing pollution to pay for the damages done to the natural environment and other affected parties. Landlord and property owners in Ongata Rongai who fail to dispose sewer and waste water appropriately should pay for the damages caused to the environment and individuals since they are significant stakeholders in effective implementation of policies. The policy makers should always contact monitoring and evaluation of key storm water management issues so as to determine progress.

This research has also established that provision of adequate drains and sewerage systems in urban centres can curb the storm water management challenges, this research further recommends to policy makers the addition and implementation of the provision of adequate urban drainage and sewerage facilities in the new development concept of sustainable development as it was missing in the Millennium Development Goals.

### 5.4.2 Recommendation for Future Research

This research though it forms a basis to storm water management and challenges in Ongata Rongai, it only covered a cross section of storm water management issues and their environmental and social economic impacts in Ongata Rongai. The researcher therefore recommends that a more in depth research should be carried out to identify more of the storm management challenges and their impacts. Due to inadequate resources, this research did not look at rain water harvesting as one way of managing storm water, this is therefore left out for future research.

### 5.4.3 Recommendation for Improvement

Ongata Rongai has inadequate storm water drains with the existing drainages clogged with litter and waste as given in appendix 7 and a looming lack of established sewerage system thus there is need for construction of new drainages and unblocking of the existing ones.

Knowledge and involvement are key components of storm water management. The Government (central and county), county agencies and organizations should launch campaigns to educate the public about storm water pollution and how they can collectively participate.

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## APPENDICES

**APPENDIX 1: Research Questionnaire**

**University of Nairobi**

**Department of Geography and Environmental Studies**

**Name: Agnes Jemuge Maleyo**

**Year: 2014**

Dear respondent,

I am a student at the University of Nairobi and I am conducting a research on Storm water management challenges and their environmental impacts in Ongata Rongai. This research is a requirement for the award of M.A in Environmental Planning and Management. Your answer will be treated with confidentiality and used only for academic purposes.

**Section 1: General Information**

Date……  Questionnaire number…….

Location……  Sub location……

a. Your gender

☐Female  ☐Male

b. Your Age (years)

☐ 18 - 30  ☐ 31 - 40  ☐ 41 - 50  ☐ 51 – 60  ☐ 61 – and over

c. Highest level of education

☐Primary School  ☐College/Technical School/Polytechnic

☐High School  ☐University

☐ Others (please state)_____

d. How long have you lived in Rongai town

☐ Less than 1 year  ☐ 1 – 5 Years

☐ 6 – 10 Years  ☐ More than 10 Years

***Section 2: Socio – Economic Effects of Storm water Management Challenges***

1.

a. What is your status in this premise/residence?

□ Land lord ☐Business tenant

□ Resident Tenant □ Visitor

b. From the options given below, tick how you or your landlord disposes sewage waste (Septic tank contents)

☐ There is a sewer line that releases the sewage in the river

☐ I/(s)he uses the services of sewer exhausters if it gets full

☐ When the sewer tanks get full, I/(s)he allows them to overflow in to the surrounding area

☐ I/(s)he uses the sewer as manure for farms

☐ I don't know

2.

a. Have you ever experienced flooding in your area?

□ Yes □No

b. If yes, which months do you experience flooding?

☐January-March ☐ March - May

☐ May – Aug. ☐ Sep - Dec

c. When did you experience the worst flooding?

☐January-March ☐ March - May

☐ May – Aug. ☐ Sep - Dec

d. For how long was the flooding event?

……

3.

a. Did you detect any sanitary sewer odours from the flood water?

☐Yes ☐No

b. What is the source?

☐Sewer ☐septic tank contents

4. Please state the level in which you agree or disagree with the following socio economic effects of storm water management challenges in Ongata Rongai? (Strongly disagree =1, disagree = 2, neutral =3, agree = 4, strongly agree = 5)

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Damaged infrastructure and roads due to flooding leading to traffic jam | | | | | |
| Vehicles stalled in the water or mud during flooding | | | | | |
| Sewage and waste water disposal in storm water runoffs | | | | | |
| Flooding | | | | | |
| Business closure | | | | | |
| Sickness and diseases | | | | | |
| Inability to go to work/ school | | | | | |
| Reduced income | | | | | |
| Low turnout of customers | | | | | |
| Destruction of goods and property | | | | | |

5. Please indicate the level in which you agree or disagree with the following statements about leading causes of storm water management challenges in Ongata Rongai. (Strongly disagree =1, disagree = 2, neutral =3, agree = 4, strongly agree = 5)

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Lack of sewage system | | | | | |
| County government failure | | | | | |
| Poor planning | | | | | |
| Lack of awareness | | | | | |

6. Please state the level in which you agree or disagree with the following available alternatives to the flooding problem in Ongata Rongai? (Strongly disagree =1, disagree = 2, neutral =3, agree = 4, strongly agree = 5)

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Unblocking of the existing drainages | | | | | |
| Constructing additional drainages | | | | | |
| Insuring properties | | | | | |
| Relocation of residents | | | | | |

7. What is the cost of using exhaust services to empty a septic tank in a year

   ☐Less than a 1000 ☐1001 to 3000 ☐3001 to 6000

   ☐6001 to 10000 ☐More than 10,000 ☐don't know

8. Does the cost affect the use of exhaust services in this area?

   ☐Yes ☐No ☐don't know

9. Have you or is there any member of your house hold who fall sick within the flooding season?

   ☐Yes ☐No

   a. If yes to the above, what disease do you or they suffer from?

      ☐Diarrhoea ☐Respiratory disease

      ☐Malaria ☐Eye infection

10. Did the sickness affect you or them in any of the following ways?

| | Yes | No |
|---|---|---|
| I/ they lost employment | | |
| I/they stopped going to school | | |
| My/ their income reduced significantly | | |
| My/ their business closed | | |

***Section 3: Policy and legal frameworks (To be filled by stakeholders)***

1. a) Where do residents report flooding incidences in this County?

   ☐Don't know ☐Ministry of public health

   ☐Ministry of Housing ☐Public works office

   b) What is the rate of response?

   ☐Quick ☐Slow

☐No response don’t know

2.

a. Are you aware of any plans by the county government to address the storm water management challenges in this town?

☐Yes ☐No

b. If yes, what was the source of this information you received? (Please check all that apply)

☐Media ☐County of Kajiado

☐NEMA ☐General Print Publication

c. State some of the plans

……

……

3.

a. Is there someone in charge of storm water related issues in this town?

☐Yes ☐No ☐Don’t know

b. If yes who? .....

c. Have you approached this concerned party/person?

☐Yes ☐No

4.

a. Suppose the County government introduces a service fee to manage storm water, do you support?

☐Yes ☐No

b. If yes how much are you willing to be charged?

☐Less than 200 ☐201 – 400 ☐More than 400

c. How often?

☐Yearly ☐Monthly

**APPENDIX 2: Research Time Schedule**

| **Activity** | **Dates** |
|---|---|
| Proposal writing | Jan 2014 |
| Submission of proposal | May 2014 |
| Defence of proposal | May 2014 |
| Forwarding of proposal to graduate | May 2014 |
| Registration as research student | June 2014 |
| Commencement of field work | July 2014 |
| Data Analysis | Aug 2014 |
| Defending the project work | Oct 2014 |
| Writing of the final draft | Oct 2014 |
| Submission of the final draft | Nov 2014 |

**APPENDIX 4: Monthly Rainfall (mm) At Wilson Station for the Period 1980-2013**

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 90.5 | 8.6 | 51.7 | 105.3 | 454.1 | 19.1 | 1.7 | 8.8 | 5.9 | 18.2 | 197.2 |
| 1981 | 3.7 | 2 | 106.3 | 323.4 | 144.9 | 30.7 | 9.6 | 30.4 | 43.9 | 41.7 | 40.2 |
| 1982 | 2.4 | 14.1 | 31.2 | 192.9 | 164.4 | 8.4 | 13.5 | 3.1 | 15.9 | 186.4 | 220.1 |
| 1983 | 1.8 | 128 | 43.4 | 137.1 | 38 | 31 | 22.5 | 29.8 | 3.6 | 63.6 | 22.4 |
| 1984 | 7.6 | 1.6 | 5.3 | 87.3 | 1.6 | 5 | 12.8 | 22.4 | 13.9 | 144.8 | 123.9 |
| 1985 | 0 | 91.2 | 88 | 188.8 | 59.7 | 32.4 | 50.2 | 3.1 | 22.5 | 20.6 | 67.5 |
| 1986 | 17.1 | 0 | 65.2 | 284.5 | 300.1 | 3.7 | 0.5 | 1.6 | 1 | 22.8 | 157.3 |
| 1987 | 40.6 | 13.6 | 23.9 | 278.7 | 109 | 71.2 | 15.7 | 8.4 | 15.2 | 1.9 | 125.3 |
| 1988 | 78.5 | 28.4 | 181.2 | 322.7 | 151.1 | 103.6 | 7.3 | 13.1 | 30.2 | 9 | 66.7 |
| 1989 | 95.7 | 25.1 | 65.1 | 277.4 | 168.3 | 2.8 | 59.2 | 19.5 | 11.1 | 45.8 | 103.5 |
| 1990 | 46.2 | 28.8 | 271 | 171.9 | 107.6 | 17 | 6.6 | 11.1 | 6.2 | 34.7 | 102.6 |
| 1991 |  | 2.4 | 151.9 | 114.2 | 144.2 | 30.6 | 2.6 | 1 | 4 | 28.5 | 149.6 |
| 1992 | 1.5 | 15.1 | 27.4 | 414.6 | 56.8 | 22.6 | 88.1 | 8.7 | 4.9 | 37.5 | 80.1 |
| 1993 | 270.4 | 104 | 9.2 | 9.6 | 122.9 | 49.4 | 0 | 12.8 | 0 | 50.2 | 128.8 |
| 1994 | 12 |  | 54.5 | 172.3 | 133.3 | 73.6 | 10.2 | 40 | 2.3 | 69.4 | 230.9 |
| 1995 | 46.6 | 65.4 | 136.5 | 80.2 | 122.3 | 85.1 | 18.1 | 22.1 | 22.2 | 117.2 | 127.3 |
| 1996 | 6.9 | 40.2 | 135.5 | 95.3 | 60.1 | 77 | 13.2 | 24 | 3.8 | 5.3 | 161.5 |
| 1997 | 0 | 0 | 15.8 | 318.1 | 130.7 | 6.9 | 7.4 | 27.2 | 0 | 102.1 | 275.3 |
| 1998 | 434.4 | 112.2 | 75 | 84.8 | 464.6 | 63.4 | 62.9 | 13.2 | 11 | 0 | 58.9 |
| 1999 | 3 | 0 | 126.6 | 156.3 | 10.6 | 1.5 | 4.2 | 31.9 | 17.8 | 33.2 | 242.3 |
| 2000 | 9.8 | 0 | 32.7 | 85.4 | 52.7 | 54.9 | 3 | 4.2 | 23.5 | 43.9 | 140.3 |
| 2001 | 480.7 | 6.3 | 339.2 | 104.7 | 87.4 | 66.1 | 35 | 16.7 | 15.9 | 66.9 | 212.4 |
| 2002 | 63.2 | 13.1 | 82.2 | 141.1 | 117.6 | 0 | 6 | 3.3 | 25.6 | 75.5 | 109.3 |
| 2003 | 31.5 | 4.2 | 26.6 | 195.5 | 368.3 | 8.5 | 0.6 | 60.3 | 60.3 | 52.1 | 106.9 |
| 2004 | 49.2 | 63.3 | 88.2 | 295.3 | 79.8 | 6 | 0 | 0 | 11.1 | 58 | 121.8 |
| 2005 | 49.2 | 14.5 | 30 | 157.1 | 285.2 | 6.6 | 0 | 5.8 | 15.8 | 27.5 | 73.6 |
| 2006 | 9.2 | 42.3 | 143.2 | 249.8 | 89.2 | 9.2 | 3.9 | 28.1 | 67.5 | 26.3 | 293 |
| 2007 | 53.3 | 104.9 | 21.6 | 176.1 | 60.3 | 75.4 | 19 | 21.9 | 63.5 | 29.7 | 87.3 |
| 2008 | 51.6 | 24.7 | 172.6 | 95.1 | 19.1 | 1.4 | 40.1 | 6.9 | 64.7 | 133.3 | 248.3 |
| 2009 | 59.4 | 15.3 | 19.4 | 83.1 | 111.5 | 52 | 11.4 | 0.1 | 6.9 | 84.6 | 91.3 |
| 2010 | 73.5 | 116.6 | 256.7 | 106.6 | 186.9 | 48.5 | 1 | 23.9 | 34.8 | 117.6 | 79 |
| 2011 | 10.4 | 77.8 | 144.6 | 46.8 | 45.4 | 102.2 | 10.7 | 71 | 33.4 | 145 | 202.3 |
| 2012 | 0 | 17.6 | 3.1 | 444.4 | 182.1 | 33.1 | 30 | 35.5 | 19.3 | 80.6 | 153.5 |
| 2013 | 26.2 | 0.0 | 143.5 | 264.8 | 22.3 | 38.7 | 11.4 | 47.6 | 78.6 | 0.5 | 58.8 |
| Mean | 64.43 | 35.80 | 93.19 | 184.15 | 136.83 | 36.40 | 17.01 | 19.34 | 22.24 | 58.07 | 137.04 |
| Maximum | 480.7 | 128 | 339.2 | 444.4 | 464.6 | 103.6 | 88.1 | 71 | 78.6 | 186.4 | 293 |
| Min | 0 | 0 | 3.1 | 9.6 | 1.6 | 0 | 0 | 0 | 0 | 0 | 22.4 |

**Source: Kenya Meteorological Services, 2014**

**APPENDIX 5: Monthly Rainfall (mm) At Ngong Station for the Period 1984-1993**

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1984 | 6.9 | - | - | 66.3 | - | - | 26.5 | 16.0 | 23.8 | 86.5 | 55.1 | 37.0 |
| 1985 | - | 177.5 | 121.8 | 207.0 | 58.4 | 30.4 | 31.1 | 0.8 | 0.5 | 19.2 | 101.5 | 31.7 |
| 1986 | 17.9 | - | 32.1 | 247.7 | 186.1 | 2.2 | - | 1.3 | 7.3 | 32.5 | 114.5 | 62.9 |
| 1987 | 3.6 | - | 27.6 | 209.8 | 102.4 | 42.3 | - | - | 20.8 | 3.0 | 81.5 | 20.2 |
| 1988 | 121.4 | 12.0 | 133.4 | 316.1 | 176.3 | 58.1 | 8.9 | 24.8 | 21.4 | 11.2 | 53.3 | 90.4 |
| 1989 | 133.5 | 31.9 | 31.3 | 123.3 | 244.7 | 5.2 | 23.7 | 24.4 | 56.1 | 45.7 | 59.9 | 95.7 |
| 1990 | 92.3 | 28.0 | 229.9 | 302.7 | 153.5 | 2.6 | 32.5 | 1.0 | 27.0 | - | 42.2 | - |
| 1991 | - | - | - | 32.1 | 231.8 | 36.8 | 10.0 | 47.0 | - | - | - | 95.8 |
| 1992 | 4.9 | 52.8 | 14.1 | 389.6 | 121.8 | 19.4 | 33.0 | 0.0 | 4.1 | 64.6 | 59.1 | 66.5 |
| 1993 | 186.8 | 47.2 | 32.9 | 2.1 | 77.1 | 41.7 | 0.0 | 8.0 | 0.0 | 0.0 | 63.7 | 146.0 |
| | | | | | | | | | | | | |
| Mean | 70.9 | 59.3 | 77.9 | 189.7 | 148 | 26.5 | 20.7 | 13.7 | 17.9 | 32.9 | 70.1 | 71.8 |
| Max | 186.8 | 177.5 | 229.9 | 389.6 | 231.8 | 58.1 | 33 | 47 | 56.1 | 86.5 | 114.5 | 146 |
| Min | 3.6 | 12 | 14.1 | 2.1 | 58.4 | 2.2 | 0 | 0 | 0 | 0 | 42.2 | 20.2 |

**Source: Kenya Meteorological Services, 2014**

**APPENDIX 6: Health Records Data at Ongata Rongai Dispensary from January 2012 – June 2014**

| | Jan '12 | Feb '12 | Mar '12 | Apr '12 | May '12 | Jun '12 | Jul '12 | Aug '12 | Sep '12 | Oct '12 | Nov '12 | Dec '12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Diarrhoea** | 47 | 45 | 50 | 30 | 61 | 51 | 49 | 31 | 38 | 7 | 4 | 6 |
| **Dysentery** | 7 | 9 | 15 | 0 | 44 | 2 | 10 | 7 | 7 | 1 | 2 | 0 |
| **Malaria** | 212 | 218 | 201 | 50 | 216 | 292 | 284 | 213 | 177 | 56 | 42 | 25 |
| **eye infection** | 22 | 14 | 12 | 8 | 10 | 3 | 17 | 12 | 22 | 3 | 3 | 0 |
| **Respiratory tract infection** | 326 | 397 | 400 | 403 | 459 | 502 | 582 | 173 | 289 | 39 | 31 | 17 |
| | | | | | | | | | | | | |
| **2013** | | | | | | | | | | | | |
| **Diarrhoea** | 2 | 17 | 5 | 8 | 4 | 5 | 18 | 12 | 63 | 65 | 51 | 30 |
| **Dysentery** | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 13 | 10 | 1 |
| **Malaria** | 34 | 93 | 81 | 41 | 40 | 63 | 129 | 91 | 203 | 268 | 360 | 194 |
| **eye infection** | 1 | 4 | 5 | 5 | 1 | 11 | 16 | 4 | 7 | 32 | 47 | 5 |
| **Respiratory tract infection** | 13 | 61 | 51 | 57 | 70 | 104 | 261 | 133 | 220 | 767 | 705 | 302 |
| | | | | | | | | | | | | |
| **2014** | | | | | | | | | | | | |
| **Diarrhoea** | 42 | 48 | 155 | 115 | 118 | 124 | | | | | | |
| **Dysentery** | 4 | 5 | 1 | 2 | 5 | 6 | | | | | | |
| **Malaria** | 288 | 163 | 325 | 195 | 174 | 165 | | | | | | |
| **eye infection** | 30 | 13 | 35 | 40 | 42 | 31 | | | | | | |
| **Respiratory tract infection** | 53 | 997 | 1222 | 1271 | 950 | 895 | | | | | | |

**Source: Ongata Rongai Saitoti (Mbagathi) Dispensary (2014)**

**APPENDIX 7: Photographs of blocked drainage system in Ongata Rongai, Kware market, with SW believed to be contaminated with sewage**


**Source: Researcher (2014)**

Date taken (August 27, 2014)

Poorly drained storm water on an access road making it impassable

**Source: Researcher (2014)**

Date taken (August 27, 2014)

## APPENDIX 8: Results of water samples obtained from WRMA and Kenya Water Institute

| | WATER RESOURCES MANAGEMENT AUTHORITY | |
|---|---|---|
| | **TITLE:** Water Sample Analytical Certificate - Bacteriological Results | **REF. NO : F/9/1/6** |
| | | **ISSUE NO : 01** |
| | **DEPARTMENT:** Technical | **REV. NO : 00** |
| | **ISSUED BY:** DTCM | **DATE OF ISSUE: 15th April 2013** |
| | **AUTHORISED BY :** TCM | **PAGE** : 1 OF 2 |

**SERIAL NO** .....  **Sample No** 0904

**Name of Customer:** Agnes Maleyo  **Address:** .....

**Purpose of sampling:** Research  **County:** Kajiado

**Date Sampled:** 27/08/14  **Date Received:** 27/08/14

**Source:** Laiser Hill Estate (Drainage System) 1  **Date Compiled:** 08/09/14

**Is it protected?** No

**If so, how?** -

*(Is it completely covered, or sides only?)*

**Is there a pump?** No

**If so, how long has it been in use?** -

**Has it been overhauled recently?** No

**EXACT SITE SAMPLE TAKEN FROM** Direct from the drains

*(i.e. tap in kitchen, through cistern or direct from the mains)*

**IS IT A CHLORINATED SUPPLY?** *(Indicate Residual Levels)* No

*POSSIBLE SOURCE OF CONTAMINATION*: -

**EXAMINATION RESULTS**

**MPN of Coliforms organisms per 100 ml** $2.420X10^6$

***E. Coli* per 100ml** $1.3x10^6$

**Legionella ssp per 100ml** -

**Other Micro-organisms** -

| | WATER RESOURCES MANAGEMENT AUTHORITY | |
|---|---|---|
| | **TITLE:** Water Sample Analytical Certificate - Bacteriological Results | **REF. NO : F/9/1/6** |
| | | **ISSUE NO : 01** |
| | **DEPARTMENT:** Technical | **REV. NO : 00** |
| | **ISSUED BY:** DTCM | **DATE OF ISSUE: 15th April 2013** |
| | **AUTHORISED BY :** TCM | **PAGE** : 2 OF 2 |

**Name of Analyst:** JORAM KIHUMBA **Signature** Jkihumba

**Comments by Head of Laboratory**

*Research*

**Name:** KENNETH K'OREJE
**Ag: ATCM-Central water Testing Laboratories**

**Signature:** **Date** 18/9/14

**ISSUED BY:** .....

**(DEPUTY TECHNICAL COORDINATION MANAGER)**

**APPROVED BY:**.....

**(TECHNICAL COORDINATION MANAGER)**

| WATER RESOURCES MANAGEMENT AUTHORITY | |
|---|---|
| **TITLE:** Water Sample Analytical Certificate - Bacteriological Results | **REF. NO : F/9/1/6**<br>**ISSUE NO : 01** |
| **DEPARTMENT:** Technical | **REV. NO : 00** |
| **ISSUED BY:** DTCM | **DATE OF ISSUE: 15th April 2013** |
| **AUTHORISED BY :** TCM | **PAGE** : 1 OF 2 |

**SERIAL NO** .....  **Sample No** 0905

**Name of Customer:** AGNES MALEYO  **Address:** .....

**Purpose of sampling:** RESEARCH  **County:** KAJIADO

**Date Sampled:** 27.08.2014  **Date Received:** 27.08.2014

**Source:** GARLANDS APARTMENTS (DRAINS) 2  **Date Compiled:** 3.09.2014

TIME 7.00 AM

**Is it protected?** NO

**If so, how?** -

*(Is it completely covered, or sides only?)*

**Is there a pump?** NO

**If so, how long has it been in use?** -

**Has it been overhauled recently?** No

**EXACT SITE SAMPLE TAKEN FROM** Direct from Drains

*(i.e. tap in kitchen, through cistern or direct from the mains)*

**IS IT A CHLORINATED SUPPLY?** *(Indicate Residual Levels)* No

***POSSIBLE SOURCE OF CONTAMINATION*:** -

**EXAMINATION RESULTS**

**MPN of Coliforms organisms per 100 ml** $2.420\times10^6$

***E. Coli* per 100ml** $1.966\times10^6$

**Legionella ssp per 100ml** .....

**Other Micro-organisms** .....

| WATER RESOURCES MANAGEMENT AUTHORITY | |
|---|---|
| **TITLE:** Water Sample Analytical Certificate - Bacteriological Results | **REF. NO : F/9/1/6** |
| | **ISSUE NO : 01** |
| **DEPARTMENT:** Technical | **REV. NO : 00** |
| **ISSUED BY:** DTCM | **DATE OF ISSUE: 15th April 2013** |
| **AUTHORISED BY :** TCM | **PAGE** : 2 OF 2 |

**Name of Analyst:** JORAM KIHUMBA **Signature** Kihumba

**Comments by Head of Laboratory**

*The water is highly contaminated bacteriologically.*

**Name:** KENNETH K'OREJE
**Ag: ATCM-Central water Testing Laboratories**

**Signature:** **Date** 15/9/14

**ISSUED BY:** .....

**(DEPUTY TECHNICAL COORDINATION MANAGER)**

**APPROVED BY:**.....

**(TECHNICAL COORDINATION MANAGER)**

| | WATER RESOURCES MANAGEMENT AUTHORITY | |
|---|---|---|
| | **TITLE:** Water Sample Analytical Certificate - Bacteriological Results | **REF. NO : F/9/1/6** |
| | | **ISSUE NO : 01** |
| | **DEPARTMENT:** Technical | **REV. NO : 00** |
| | **ISSUED BY:** DTCM | **DATE OF ISSUE: 15th April 2013** |
| | **AUTHORISED BY :** TCM | **PAGE** : 1 OF 2 |

SERIAL NO .....  Sample No 0906

Name of Customer: Agnes Maleyo  Address: .....

Purpose of sampling: Research  County: Kajiado

Date Sampled: 27/08/14  Date Received: 27/08/14

Source: Magadi Road (Port-hole)  Date Compiled: 08/09/14

**Is it protected?** No

**If so, how?** -

*(Is it completely covered, or sides only?)*

**Is there a pump?** No

**If so, how long has it been in use?** -

**Has it been overhauled recently?** No

**EXACT SITE SAMPLE TAKEN FROM** Direct from Port-hole

*(i.e. tap in kitchen, through cistern or direct from the mains)*

**IS IT A CHLORINATED SUPPLY?** *(Indicate Residual Levels)* No

*POSSIBLE SOURCE OF CONTAMINATION*: -

**EXAMINATION RESULTS**

**MPN of Coliforms organisms per 100 ml** $2.420X10^6$

***E. Coli* per 100ml** $1.986x10^6$

**Legionella ssp per 100ml** -

**Other Micro-organisms** -

| WATER RESOURCES MANAGEMENT AUTHORITY | |
|---|---|
| **TITLE:** Water Sample Analytical Certificate - Bacteriological Results | **REF. NO : F/9/1/6** |
| | **ISSUE NO : 01** |
| **DEPARTMENT:** Technical | **REV. NO : 00** |
| **ISSUED BY:** DTCM | **DATE OF ISSUE: 15th April 2013** |
| **AUTHORISED BY :** TCM | **PAGE** : 2 OF 2 |

**Name of Analyst:** JORAM KIHUMBA **Signature** Jkihumba

**Comments by Head of Laboratory**

*Research*

**Name:** KENNETH K'OREJE
**Ag: ATCM-Central water Testing Laboratories**

**Signature:** **Date** 18/9/14

**ISSUED BY:** .....

**(DEPUTY TECHNICAL COORDINATION MANAGER)**

**APPROVED BY:**.....

**(TECHNICAL COORDINATION MANAGER)**

KEWI/ISO/LAB/FB/102

# KENYA WATER INSTITUTE

**P.O. BOX 60013, NAIROBI**

Tel 607425
Fax.606718

## BACTERIOLOGICAL ANALYSIS REPORT

**Sample no**: 0910
**Date& time received : 27/09/ 2014 at 1300 Hrs**
**Client/s :**. Point I near Magenche.
**Submitted by**: Agnes Maleyo, University of Nairobi.

**REASON FOR SAMPLING**: Investigation for presence of bacteria
( if is suspected of causing ill)
(State if well, spring, stream or public). Surface Water
Is it protected?.
If so, how? ....
(Is it completely covered or sides only?)
Is there a pump?... If so how long has it been in use :
Has it been overhauled recently?
**EXACT SITE SAMPLE TAKEN FROM:**
(Drains)

**POSSIBLE SOURCES OF POLLUTION...**
(If so, where?.....general from human feacal and animal waste)
**IT IS CHLORINATED SUPPLY** (No)
**EXAMINATION RESULTS**
Total coliforms organisms: **1611/100mls**
E-Coli Feacal coliform...**14 /100mls**

**COMMENTS:** The water sample has general enteric bacteria ( *enterobactericiae*) with danger E.Coli also detected.. Bacteria eradication is necessary.

Water Quality Microbiological Laboratories.
**KENYA WATER INSTITUTE**

KENYA WATER INSTITUTE
DIRECTOR
P. O. Box 60013-00200,
NAIROBI

KEWI/ISO/LAB/FB/102

# KENYA WATER INSTITUTE

**P.O. BOX 60013, NAIROBI**

Tel 607425
Fax.606718

## BACTERIOLOGICAL ANALYSIS REPORT

**Sample no**: 0909
**Date& time received : 27/09/ 2014 at 1300 Hrs**
**Client/s :**. Point II near Laiser Hill
**Submitted by**: Agnes Maleyo, University of Nairobi.

**REASON FOR SAMPLING**: Investigation for presence of bacteria
( if is suspected of causing ill)
(State if well, spring, stream or public). Surface Water
Is it protected?.
If so, how? ....
(Is it completely covered or sides only?)
Is there a pump?... If so how long has it been in use :
Has it been overhauled recently?
**EXACT SITE SAMPLE TAKEN FROM:**
(Drains)

**POSSIBLE SOURCES OF POLLUTION...**
(If so, where?.....general from human feacal and animal waste)
**IT IS CHLORINATED SUPPLY** (No)
**EXAMINATION RESULTS**
Total coliforms organisms: **2400/100mls**
E-Coli Feacal coliform...**131 /100mls**

**COMMENTS:** Water has tested positive with general coliform and E.Coli. Treatment is advisable.

Water Quality Microbiological Laboratories.

**KENYA WATER INSTITUTE**

KENYA WATER INSTITUTE DIRECTOR P O Box 60013-00200, NAIROBI

KEWI/ISO/LAB/FB/102

# KENYA WATER INSTITUTE

**P.O. BOX 60013, NAIROBI**

Tel 607425
Fax.606718

## BACTERIOLOGICAL ANALYSIS REPORT

**Sample no**: 0911
**Date& time received : 27/09/ 2014 at 1300 Hrs**
**Client/s :**. Control Sample
**Submitted by**: Agnes Maleyo, University of Nairobi.

**REASON FOR SAMPLING**: Investigation for presence of bacteria
( if is suspected of causing ill)
(State if well, spring, stream or public). Rain Water harvested in a tank
Is it protected?.
If so, how? ....
(Is it completely covered or sides only?)
Is there a pump?... If so how long has it been in use : N/A
Has it been overhauled recently?
**EXACT SITE SAMPLE TAKEN FROM:**
(Water tank)

**POSSIBLE SOURCES OF POLLUTION...**
(If so, where?.....general from human feacal and animal waste)
**IT IS CHLORINATED SUPPLY** (No)
**EXAMINATION RESULTS**
Total coliforms organisms: **12/100mls**
E-Coli Feacal coliform...**0 /100mls**

**COMMENTS:** No E.Coli is detected though traces of general coliform present. A simple treatment is advisable .

Water Quality Microbiological Laboratories.
**KENYA WATER INSTITUTE .**

DIRECTOR
KENYA WATER INSTITUTE
P.O. Box 60013-00200,
NAIROBI

**APPENDIX 9: Complains and Court Cases on Sewerage Discharge in Ongata Rongai**

Appendix II

# MINISTRY OF PUBLIC HEALTH & SANITATION.

*When replying please quote ref. No. & date.*
**Ref. No PH/RON/ CORR/6/2013/04**

**PUBLIC HEALTH OFFICE,**
**ONGATA RONGAI,**
**P.O. BOX 15546-00503,**
**MBAGATHI.**

**17th May, 2013.**

The District Public Health Officer,
Kajiado North District,
P.O. Box 99,
Ngong Hills.

Dear Sir,

RE: WASTE WATER DISPOSAL CONCERN IN ONGATA RONGAI

Following the spate of waste (sewerage) water reported directly to your office by groups of people (residents) and individuals, the Public Health staff in Ongata Rongai deliberated on the matter during the weekly CME held on 22nd April, 2013. The following observations were seen to complicate the challenge;

1) Lack of proper drainage system.
2) Blocked open drains.
3) Poor soil structure, mainly rocky and black cotton soil which does not drain easily.
4) Diverse conservation methods used:
   i) Faulty/non functional conservancy tanks.
   ii) Actual capacity of tanks used are considered small, and unable to contain waste water generated from occupancies.
5) Irrigation pipes (sub soil) drains are still used in residential plots. A historical carry over practice firmly in areas where land is plenty. Present state in Ongata Rongai now is different.
6) High water table.
7) Uncontrolled change of user which disregards physical planning procedures.
8) Prolonged historical patronage and political interference in the immediate past.
9) Lack of sewerage system and
10) Hostile residents (corporate or otherwise).

In view of the above officers felt that quick actions through closures or legal action may not offer sustainable solution to the current crisis but rather a multi-sectoral approach should be pursued to include other players on the ground primarily the local government, resident associations, administration, physical planning, security etc.

We therefore ask for your intervention in combating this challenge by engaging authorities at your level (and above possibly through the Chief Public Health Officer) in quest to offering a permanent solution to this challenge.

Yours faithfully,

David N. Kitonyi
P.H.O 1/C Ongata Rongai

MINISTRY OF PUBLIC HEALTH AND SANITATION
Date: 17.05.13
ONGATA RONGAI PUBLIC HEALTH DEPARTMENT

**MINISTRY OF HEALTH**

REF: PH/RON/G CORR/6/2014/4/01

PUBLIC HEALTH OFFICE,
ONGATA RONGAI,
P.O.BOX 15546-00503,
MBAGATHI.

15TH APRIL, 2014

THE SUB COUNTY PUBLIC HEALTH OFFICER,
KAJIADO NORTH,
P.O.BOX 99,
NGONG HILLS.

Received
15/04/2014

DISTRICT PUBLIC HEALTH OFFICER
Date.....
P.O. Box 99 - 0028,
NGONG HILLS
KAJIADO NORTH DISTRICT

Dear Sir,

**RE: SEWERAGE AFFAIR IN ONGATA RONGAI TOWNSHIP: A RESPONSE**

Please find report on the above matter for your perusal and action.

Yours Faithfully,

David N. Kitonyi
**Divisional PHO I/C Ongata Rongai.**

C.C

- Assistant County Commissioner – Ongata Rongai
- National Environmental Management Authority, Headquarters (Att. Legal/ Enforcement)
- County Director of Environment - Kajiado
- Managing Director, Oloolaiser Water Company – Ongata Rongai
- O.C.P.D – Ongata Rongai
- Community Policing – Ongata Rongai
- Residents Associations (2)

**RE: SEWERAGE AFFAIR IN ONGATA RONGAI TOWNSHIP: A RESPONSE**

**Synopsis**

Ongata Rongai Township is currently being argued about as the fastest growing township in East and Central Africa. It is an administrative division under the now Kajiado North Sub-County in Kajiado County with a total population 2015 projection 52, 513 (GOK: Kajiado County Development Profile, Ministry of Devolution and Planning May, 2013. Pg 11) and hence a major urban area just 25 minutes drive neighboring the Nairobi Metropolis. An urban area qualifies to be a town if it has a population of at least 10, 000 (GOK: Cities and Urban Areas Act, 2011).

It hosts key National major players in Health, Education, Business Banking and Micro finance Institutions just to mention but a few.

With this, potential, the town has continued to develop basically adopting conservancy sanitation methods best suited for rural towns. The unprecedented population movement, settlement and development since 2007 is bearing a burden on the sanitation level that has slumped to an all time low.

This in turn has led to unfair criticism and bashing on Public Health Staff in the division hence the need to put the record clear. It is my hope that this report will get fair consideration in all matters that it raises. From his point of view, the writer concludes with a way forward to remedy the situation.

## I. COMPLAINTS

The Divisional Public Health Officer Ongata Rongai receives a lot of complaints on liquid waste disposal challenge. At the moment the number of written complaints that I receive is at par with those that are both reported verbally and through text messages. Attached find four such cases (herein marked Appendix 1).

Our action on such cases has been to advice on various models/ options that could contain the menace including adopting diverse methods of conservancy storage where applicable. In extreme situations the office opted for total premises closure, evictions and remedies through court orders.

## II. THE CURRENT SCENARIO

The Public Health Staff in the division deliberated on this matter during the weekly Continuous Medical Education whose minutes were captured in a letter forwarded to the District Public Health Officer, Kajiado North (herein marked Appendix II). It's noteworthy that during the period, the transitional political climate in the area and the Nation at large may not have been conducive to address the matters contained in the letter. I aver that the matters raised in this note should be tackled clearly if we are to solve the current sewerage crisis in Ongata Rongai.

## IV. NEMA ACTIVITIES

On occasions this office has worked as a team to enable NEMA fulfil its tasks in the area, a *prima facie* case is captured in the minutes (herein appearing as Appendix IV) where the Divisi-onal Public Health Officer Ongata Rongai represented the Kajiado North Sub County P.H.O. Mr. Macharia.

## SUGGESTED SOLUTIONS AND WAY FORWARD

1. County Government to immediately revoke the contents of the communication to Bweya Institute of Environmental Health (Herein marked Appendix V)
2. The Kajiado County Government in liaison with the Water Authority for the area in question to give a protocol (if need be publicize to the residents) on how/ when this facility is actualized and implement the summary of remedies as contained in the ruling of Miscellaneous Civil Application 118 of 2004, republic vs. Peter K. Waweru (it's the opinion of the Public Health Officer Ongata Rongai Division that total sewerage works for the town cannot be done in isolation of Ngong – Kiserian town axis and therefore finds the ruling informative)
3. The National Environmental Management Authority to temporarily stop issuing in Ongata Rongai and adjacent towns (Nkoroi e.t.c) Effluent Discharge Licenses as is the case in Appendix VI unless they have sufficient machinery to enforce compliance. This may include availing periodic supervisory test results to relevant organs and offices where concerned.
4. The National Environmental Management Authority to immediately effect the minutes of a meeting which took place at its headquarters (and here in marked Appendix IV).
5. Public participation forum and initiatives be organized to sensitize the community on action/ series of action (s) that have been taken to help in finding a solution to this challenge and be fronted by local leaders openly.
6. Ongata Rongai Public Health Office is open to explore other suggested options presented and ready to work with like minded people who wish well about our town using the available resources on this matter.