

**CHALLENGES IN THE PROVISION OF SEWERAGE SERVICES IN KENOL  
TOWN, MURANG'A COUNTY, KENYA**

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REQUIREMENT FOR THE AWARD OF MASTER OF  
ARTS DEGREE IN GEOGRAPHY OF  
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## DECLARATION AND APPROVAL

### Declaration by the Student

I declare that this proposal is my original work and has not been presented in any other University or Institution for consideration of any certification. This research proposal has been complemented by referenced sources duly acknowledged.

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**MAGE/2017/71264**

### Approval by the Supervisors

This proposal has been submitted for examination with our approval as University Supervisors.

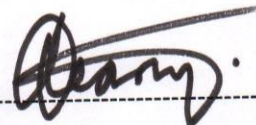
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## **DEDICATION**

I dedicate this work to my wife, Elizabeth Wangui and sons, Gratitude Ng'ang'a, Christian Karemeri and Blessed Njoroge, for their support during my studies.

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First and foremost, I extend my gratitude to God Almighty, for the strength, resources and blessings he has accorded me to enable me to successfully walk through this path of knowledge, an opportunity not readily available to all.

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## ABSTRACT

Emergence of unplanned urban settlements has over decades been a challenge to provision of efficient social services. Globally about 2.6 billion people do not have efficient sanitation services. Most of these challenges are found in third world countries that lack sufficient and adequate drainage and solid waste collection strategies. Most Countries in the sub-Saharan Africa have unplanned or poorly planned settlements that are inadequately maintained; undesigned and poorly planned systems which make it difficult to provide high quality services. Kenol town in Murang'a County emerged as a market centre and a stopover point for vehicle refueling and subsequently grew into an urban settlement with little or no prior planning. There is no documented study that has been carried out to determine challenges being encountered by the Murang'a County government in provision of the sewerage services to the residents of Kenol town. The objective of the study was to evaluate the provision of sewerage services among the residents of Kenol town, Murang'a County. To achieve this objective the study adopted descriptive research design. The specific objectives included; to establish the effect of unplanned settlements in the provision of sewerage services in Kenol town in Murang'a County; to evaluate the effects of financial constraints; to investigate the effects of technological knowhow; to determine the extent to which physical environment affects the provision of sewerage services in Murang'a County. The study population comprised of 44,007 people out of which the target population was 778. The study collected both qualitative and quantitative data from a sample of 264 respondents. The data was collected using interview guides and questionnaires. Collected data was analyzed using SPSS Version 21 by using Linear Regression Analysis to help establish existing relationship between the independent variables (challenges facing provision of sewerage services) and the dependent variable (provision of sewerage services). The study established that there were numerous challenges. These included; unplanned settlements at coefficient value of -2.701 with a p-value of 0.036 which is less than 0.05 indicating that unplanned settlements was a significant factor. Financial constraint was at coefficient value of 0.329 with a p-value of 0.047 which was less than 0.05 indicating that financial constraint as a factor was significant. Technological knowledge had a coefficient value of 5.851 with a p-value of 0.048 which was less than 0.05, indicating that technological knowledge a was significant factor and physical environment with a coefficient value of 20.167 with a p-value of 0.030 which was less than 0.05 indicating that physical environment factor was significant. Thus, the study recommends that the County Government should ensure that all buildings and any other form of settlement are planned. The County Government should allocate more financial resources towards provision sewerage services. The County Government should offer training opportunities for its staff to advance their skills in modern sewerage system. The County Government should formulate a policy which puts strict and punitive measures to any individual who does not adhere to physical planning and sewerage designs while setting up any structure.

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## **LIST OF ABBREVIATIONS AND ACRONYMS**

<b>CBO</b>	:	Community Based Organization
<b>CDPO</b>	:	County Development and Planning Office
<b>DESTW</b>	:	Dandora Estate and Sewerage Treatment Works
<b>JICA</b>	:	Japan International Corporation Agency
<b>KIG</b>	:	Kenya Information Group
<b>KNBS</b>	:	Kenya National Bureau of Statistics
<b>MCA</b>	:	Murang'a County Assembly
<b>MUSWASCO:</b>		Murang'a South Water and Sanitation Company
<b>NACOSTI</b>	:	National Commission for Science, Technology and Innovation
<b>NEMA</b>	:	National Environmental Management Authority
<b>SPSS</b>	:	Statistical Package for Social Sciences
<b>UNESCO</b>	:	United Nations Education Scientific and Cultural Organization
<b>UNICEF</b>	:	United Nations Children's Funds
<b>USEPA</b>	:	United States Environmental Protection Agency
<b>UWSSI</b>	:	Urban Water Supply and Sanitation Initiatives
<b>WHO</b>	:	World Health Organization
<b>WSD</b>	:	Water and Sewerage Department

## **CHAPTER ONE**

### **INTRODUCTION**

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

Sewage comprises 99.94 % water, with only 0.06 % being dissolved and suspended solids (Karen, 1996). The world urban population, according to the world urbanization prospects; the 2007 revision, is projected to double by 2050 from 3.3 billion in 2007 to 6.7 billion. This has an impact on the provision of some vital social services like sewerage and drainage services. A survey carried out by the national sample survey office (NSSO, 2015), showed that about 2907 urban blocks in India (about 56.4%) of the sections in towns have a sewerage network. NSSO survey also showed that 8.6% of the urban wards do not have anyone to clean the toilets. This is brought about by the unsafe disposal of the bulk of human excreta due to surges in population densities in the given urban areas. Clogging may be the end result if it is directed into piped drain.

UNICEF and WHO, (2015) declared sanitation a right for all the people in the universe. About 2.4 billion people don't have access to a fairly improved sanitation. A lot of emphasis should be laid on the need to multiply its access in the world. With the new challenges of the Sustainable Development Goals (SDGs) in the whole world which indeed have to be achieved by 2030, sanitation and hygiene which is available, affordable and enough for all must be made accessible, (United Nations, 2015).

According to WHO, (2016) proper disposal of the human faeces and urine safely and in a hygienic manner is all that is meant by the term sanitation. As per the United Nations (2010), sanitation is the whole organization of collecting, transporting, treating and disposing or re-using human excreta having in mind the required hygiene.

This right should be availed to everyone without discrimination in an acceptable, safe and in a culture that is acceptable universally. (United Nations Economic and Social Council, 2010). Proper disposal of sewage in a hygienic manner minimizes contamination by humans to diseases like diarrhoea by 65%, (WHO and UNICEF, 2000). It also majorly affects the productivity and the enrolment in schools which then have a direct influence on social and economic development as a whole (Mara, *et al.*, 2010). To provide sewerage services to the whole universe is an uphill task. According to UNICEF and WHO, (2015), about 70% of the population in rural areas does not have access to sewerage services. Most of the people without this access are mostly in the rural areas, (United Nations, 2015).

A report by (UNICEF & WHO, 2012) stated that regions provided with sanitation in developing countries are at 49 per cent. Moreover, most countries sub-Saharan Africa have improved sanitation more than half of those who do not have improved sanitation. Similarly, about 1.5 billion Indians and Chinese do not have improved sanitation services. The ever-increasing population in towns, urban areas and cities especially in developing countries is adding pressure on demand for housing and provision of sanitation services. It is also an uphill task to provide these sanitation services to the population that is located in undesignated residential areas like the slums.

Japan has 72% of population's excrete transported in sewers and centralized treatment plants treat it. Sewage from the toilets is transported through pipes to the plants where it is treated. 21% of the excreta in rural areas, suburbs and urban areas such as Tokyo Metropolis are processed using systems called *Johkasou*. Under this system the treatment unit is set up in each house. The accumulated sludge is transported using vacuum trucks. It is then processed at plants which treat sludge. The other 7% excreta is

treated using technology known as night-soil treatment, (Ministry of the Environment, 2015).

Most of the third world countries have inefficient and inadequate drainage and solid waste collection strategies. They have inadequate maintained, un-designed and poor systems which makes it impossible to provide high quality services.

A third of the population in the world uses the onsite sanitation technologies. With good care and management they work efficiently and properly. However, most of the developing countries do not have Faecal Sludge Management, (World Bank Water Supply and Sanitation Program, 2014). This implies that about 42% of excreta are left to flow freely in the environment in urban areas. This in turn brings about other health hazards to the population in general.

A huge chunk of waste is left to the open environment directly. In low income settlement areas this discharge is even worse. Effluents especially from septic tanks are discharged into the open streams and drainage canals. Overcrowding which is brought about by the increasing number of people in urban areas and the growth of towns has triggered the focus to be on the improvement of improved basic sanitation. However, this service calls for heavy investment on provision of trunk sewerage, collection and disposal facilities. These plans are dragged by lack of financial and institutional access. Another hindrance is inability to cope with the speed at which the population is growing at in the developing countries and the scarcity of funds, (WHO/UNESCO, 2006).

In Africa, most of the urban centres have low coverage by sewerage network with less than 10% population of the urban being connected. High cost of connections which require huge investments to provide sewerage services contribute to this low coverage, (Human Development Report, 2006). African countries have not been left out. Ghana,

Ethiopia, and Rwanda have sanitation problems. Rwanda Water and Sewerage Sanitation and Bank Groups contribute towards meeting the international development goals on sanitation. However, insufficient sanitation infrastructure, especially in rural areas influences the sanitary conditions. There are substantial differences while accessing data availability from various sources, due to use of different characterizations by different institutions that provide access to data, (Buller, 2006).

In Ghana, about a third of the sewerage supply services is not functional, most of which operate far below capacity. It was projected that 85% of Ghana would be covered by 2015 at a rate of 78%. About 763,698 m<sup>3</sup> of sewage was estimated to be generated in a day by urban areas of Ghana in the year 2000. Only a small percentage of the sewage in towns is collected, and another small percentage is treated. In Accra, approximately 10% is collected from the collected sewerage, (Ghana Environmental Protection Agency, 2001).

A report given in 2001 by the Ghana Environmental Protection Agency indicated that a quarter of treatment plants which totaled 46, all comprising of industrial and municipal treatment plants were functioning properly.

Local governments operate urban sewage treatment plants. In the late 1990s, a biological treatment plant was built at Accra's Korle Lagoon. It has been a challenge to the whole nation, the major concern being when the country will be able to handle sewerage problems, (Kinoti, 2010).

In Uganda, a good example of onsite sanitation technologies is a pit which stores excreta. In Tanzania, 90% of the sewage is catered for by onsite systems of which 23% is left open with no treatment at all, (World Bank Water Supply and Sanitation Program, 2014).

In Kenya, the provision of sewerage services poses a major challenge. This is because of high poverty levels for example in Nairobi, Kibera area where there are broken and open sewers. The sewerage infrastructure was designed in the 1960's, (Omotto of Umande Trust, 1960). Standard Newspaper, (2012) reported that the collapsed sewerage services may force Nairobi City to close down if no measure is taken urgently.

Population increase and pressure has grown to uncontrollable levels therefore making the sewerage system to burst at the seams. The report also says that this system was to serve about a million people but now serving a population that is three times what it was meant to serve, (Standard Newspaper, 2012). The Nairobi City County government is unable to serve the surging population, financial constraints and unplanned settlements which make it unable to provide this essential service. The sewer is less than 30% of the city's total 696 km<sup>2</sup> and only 20% of population connected to sewerage system. Kenya built its first Sewerage system at Kariobangi in Nairobi in 1961. This was just before Kenya got her independence. In Dadora, the second water treatment plant was established in 1980. It was then improved in 1994 as Dadora Estate and Treatment System (DEST). As a result, waste discharge in liquid form reduced significantly. According to The Standard Digital, (2012), in urban areas that do not have sewerage systems, untreated water is still being left to the open fields and environment.

Other inefficiencies like lack of sewerage maintenance and uncollected garbage lead to clogging of the system as a whole. Thus, the targeted benefits are not achieved (Human Development Report 2006, chapter 3). Moreover, due to poor maintenance, the Kariobangi plant stalled in its functioning and raw sewage is discharged to the Nairobi River without any proper treatment, (Kinoti, 2010). According to Davis, (2005), the sewerage services in Kenya have been characterized by many challenges some of which are institutional in nature. The Water and Sewerage Department (WSD) was faced with

a problem of maintaining qualified staff as it would be uncompetitive compared to available parastatals and individually owned firms. The morale of those who remained was said to be low.

Furthermore, cost recovery was low and declining. The devaluation of the Kenyan Shilling in the early 2010s led to high losses because the utility was indebted in foreign currency (Khundrakpam, 2007). Operation and maintenance sustainability of the sanitation system was in danger because of unavailable resources. The laid down plans were not effected as other sources of money had to be sought bearing in mind that time was also moving. Population was also increasing and demand for these services was also increasing. Though there were good plans, they were overtaken by hurriedly crafted mode of implementation on the ground due to the said demand.

The rate of urbanization in Kenya is high. It is rapidly driven by rural-urban migration among other factors (UN-HABITAT and UNEP, 2010). The ever-increasing number of people in towns leads to emergence of unplanned settlements. The need by middle class to develop their own residence has facilitated in the expansion of suburban and peri-urban centres. Most suburban areas are unplanned and developers take advantage of the weak regulatory framework and the inconsistent regulatory capacity of the local authorities, Urban Areas and Cities Act, (2011). WHO and UNICEF facilitated the Environmental Sanitation Programme, (2010) in Kenya to help in developing, establishing better waste disposal methods and create awareness on proper sanitation to the population in the rural areas.

The Kenya Constitution, 2010 provides legal guidelines for sanitation in urban areas. Among the defined rights include adequate housing, adequate sanitation and an environment which is clean and healthy. Sanitation here includes sewerage and drainage

services. In order to achieve a progressive realization of sanitation right, the requirement of The Constitution 2010 is that the state comes up with legislative mechanisms. The already available laws for sanitation are fragmented having sanitation related laws spread out all through various legal instruments. In order to cope up with this gap, the MOH, assisted by the World Bank and UNICEF developed a National Environmental Health and Sanitation Bill (NEHS, 2017). The MOH, 2017 came up with a Prototype County Environmental Health and Sanitation Bill (PCEHS, 2017) which would enable the devolved governments to legislate laws to achieve sanitation right and make sure that there is effective implementation of functions of sanitation and powers bestowed on the county governments. This would enable effective sanitation services provision and regulation of laws in the counties.

In 2015, Murang'a County Assembly received a report from the public participation committee on new planning of Kirathani market. It indicated that some towns like Kenol, Makuyu and Kandara are filth choked with urinals and sewage which are channeled to open drainages. A report tabled to Murang'a County Assembly, (2015), pointed out that sewerage services needed to be expanded and to initiate new ones. It was reported that towns such as Kenol, Kandara, among others are choking with filth. Waste from latrines and urinals, is directed to the open drainages. During the debate session, the motion on resolving the challenges facing the provision of sewerage services in the county was seconded by majority of the members. It was argued that, the sewerage services should equally be considered when the buildings are coming up. It was also reported that in almost all towns septic and dirt collection tanks are installed outside the buildings. In most cases, the overflowing effluent along the roads poses serious environmental degradation problems which include water related diseases, (Kenya Environmental Sanitation and Hygiene Policy 2016-2030).

Kenol town started as a market place and a stopover point for oil refilling of vehicles along Thika and Murang'a road. A Performance Audit Report on provision of sewerage in major towns in Kenya (2018) made some major findings among them challenges of unplanned structures, rapid population growth which leads to raw sewage discharge into the environment. Lack of a legal framework, disjointed and overlapping policies have also been blamed for a challenge in provision of sewerage services in towns.

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

Most of the urban and suburban areas are unplanned and developers tend to overlook on the weak regulatory framework and the poor regulatory capacity of the local authorities. To provide sanitary education and improve methods of waste disposal in rural areas, WHO and UNICEF supported the environmental sanitation programme in Kenya. Sanitation policies in Kenya are formulated by The Ministry of Public Health and Sanitation. Legal framework has been provided by the Kenya government. Kenol has not been able to provide sewerage services that are working efficiently. The town is characterized poor drainage of the sewerage system, pipe blockage, spilling and flooding of wastes in the town. Lack of service delivery, sluggishness, tedious implementation of government policies and programs has made the sewerage services consumers clamour for their right. The study was carried out in Kenol town. The researcher carried it out to evaluate the provision of sewerage services among the residents of Kenol town in Murang'a County, Kenya.

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

The study evaluated the provision of sewerage services among the residents of Kenol town in Murang'a County, Kenya.

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

The objectives that were sought include:

- i. Evaluate the effect of unplanned settlements in the provision of sewerage services in Kenol town in Murang'a County
- ii. Establish the effects of financial constraints in provision of sewerage services in Kenol town in Murang'a County
- iii. Investigate the effects of technological knowhow on the provision of sewerage services in Kenol town in Murang'a County
- iv. Determine the extent to which physical environment affects the provision of sewerage services in Kenol town in Murang'a County

### **1.5 Research Hypotheses**

The null hypotheses that were tested by the study include;

*H<sub>01</sub>*: There is no statistically significant relationship between unplanned settlements and provision of sewerage services in Kenol town of Murang'a County.

*H<sub>02</sub>*: There is no statistically significant relationship between financial constraints and provision of sewerage services in Kenol town of Murang'a County.

*H<sub>03</sub>*: There is no statistically significant relationship technological knowledge on provision of sewerage services in Kenol town in Murang'a County.

*H<sub>04</sub>*: There is no statistically significant relationship between physical environment and the provision of sewerage services in Kenol town in Murang'a County.

### **1.6 Justification of the Study**

Kenol town is a fast-growing town and essential services are missing. These services include sewerage services which were planned for but not put in place, according to the MCA 2015. Challenges influencing their provision therefore needed to be established to significantly assist Kenol town or any other town in the counties in the provision of sewerage services more efficiently and effectively. The findings may also assist in

proper management of sewerage services delivery to Kenol residents and any other fast growing urban centre in the country.

### **1.7 Significance of the Study**

The findings may be beneficial to the Murang'a County government since it may establish the challenges in its inefficient sewerage service provision. Based on the study findings, the senior managers in the County government may help the Murang'a South sub-county Water and Sanitation Company (MUSWASCO) to streamline the sewerage services and help them improve the sewerage performance in the County. It may also be used by future planners in other counties and countries. The study may also be of benefit to the consumers as the solutions to the challenges faced in the provision of these sewerage services may be found hence efficient services will be offered. The residents may also benefit as their environment may improve in hygiene and cleanliness. Other fast-growing towns in the counties may also benefit if they are faced with the same challenges.

### **1.8 Scope of the Study**

The study population included both commercial and domestic sewerage service consumers in Kenol town. A list of households within Kenol town formed the sampling frame. The county population statistics from KNBS, (2009) was relied upon to help in the selection of household respondents.

The coefficient of variation was used to obtain the sample. It was in the range of  $21\% \leq c \leq 30\%$ . According to Nassiuma (2002) the acceptable range of standard error is  $2\% \leq e \leq 5\%$ . In order to ensure a higher variability a 30% coefficient of variation was utilised. To ensure a minimal error a 3% standard error is applied, (Nassiuma, 2002).

In order to achieve good findings, recommendations and deductions, a good number of clients were involved. General findings were generated from the information got from the consumers.

### **1.9 Limitations of the Study**

The study faced a challenge in methodology as not all the respondents were interviewed. A sample size represented the entire population where some were not available when the data was being collected. The techniques that were used in data collection limited the study by getting irregular responses from different respondents. Another limitation was experienced when analysing data due to inconsistent data entries and formats.

### **1.10 Delimitation of the Study**

The study used a sample that was acceptable to cater for those who were not available. To avoid irregular responses, piloting was done well in advance to correct any errors that might bring about such responses. Validity and reliability were ensured through use of research instruments that could be verified and relied upon. Finally, correct data analysis techniques were employed to achieve the best results.

### **1.11 Assumptions of the Study**

The study assumed that the challenges that affect the provision of sewerage services to respondents in Kenol town included unplanned settlements, financial constraints, technological knowhow to the sewerage services consumers and the residents in the town and physical environment. It also assumed that the data collection instruments were substantially valid and measured what was intended to be measured.

## 1.12 Operational Definition of Key Terms

- Detached Maisonette:** It is a free-standing house which is meant for a single-family and does not have a common wall with any other structure.
- Financial Constraints:** refers to challenges which sewerage companies face in terms of allocations of financial resources to sewerage services.
- Free Standing Stone House:** A house that is set apart or not attached to anything or any house.
- Informal Shack:** Any roughly built, unpleasant, poorly constructed or poorly furnished building.
- Physical Environment:** refers to the way areas where sewer lines are to be constructed are designed.
- Prefabricated house:** A house built in standard components fitted together on a site.
- Sewage:** The water that is discharged after use from home or industries, and that which is cleared away through pipes to a waste water treatment plant.
- Sewerage System:** The sewerage system is responsible for the transportation and conveyance of the sewage from the households to the sewage treatment plant.
- Storey building:** Building in multiple floors
- Technology:** Knowledge and tools used to improve a pre-existing problem.

**Unplanned Settlements:** refer to settlements which are constructed without adhering to the laid down physical planning designs.

**Urban Areas:** It is an area which is occupied by a high number of people and which has an expansive set of human made features that are different from other areas surrounding it.

**Urbanization:** Urbanization is a process by which an increasing proportion of the population in a given location lives in urban settlements.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

Reviews which are based on the objectives of the research are presented in this chapter. It presents literature on sewerage services, waste and sewage management. It also covers theories that are closely related to urban planning and provision of sewerage services and water as a resource and its contribution to well-being of mankind. The chapter gives a comprehensive conceptual framework, problem statement and background of the study.

#### **2.2 Empirical Literature Review**

Empirical literature review was based on the influence of unplanned settlements, financial constraints, technology knowledge and physical environment on provision of sewerage services.

##### **2.2.1 Unplanned Settlements and Provision of Sewerage Services**

Globally, according to UNICEF and WHO, (2015) a high number of population (68% to 70%) cannot access sewerage services due to rapid development of unplanned settlements and mushrooming shacks in cities and urban areas. Slums or informal settlements are majorly inaccessible and provision of the basic services is practically unavailable. The areas that would otherwise be used as pathways for the laying out the sewerage systems are occupied. No allowance is available for the establishment of any infrastructure.

According to UN Habitat (2015), unplanned settlements or informal settlements are places inhabited by residents without security of tenure, areas which do not have the

basic services and the houses do not conform to plan and regulations laid by the institutions.

The population growth in the United States of America, (USA) has rapidly grown especially in the nineteenth century, (UNDP, 2016). Less than 5% of all the population in America lived in cities in 1820. This percentage increased to about 16% by 1860 and by 1880, the population had shot up to 22.5%. Some cities in America like New York increased tenfold, Boston's eightfold and Washington, D.C. increased fivefold. As the population increased, vital services became inadequate and the capacity to hold it was not there. New homes which were sometimes unplanned could not be handled or monitored effectively and therefore capacity limits could be reached.

A report given by Vikram, (2016) indicates that India and many developing countries' have 33-37% urban population living in slums or in unplanned settlements. These dwellers stay in uncondusive environments with no sewerage systems. They also face demolition without prior notice. There has been a problem of making the unauthorised houses legal in order to improve sewerage provision to the residents and consequently improve their living conditions. The government, however, is working hard to offer these sewerage services to house owners to enhance quality of service. Toilets are also being offered and efforts are being made to decentralize sewerage systems. Smallbore sewers and inceptor tanks carry the liquid waste and solid waste respectively the main pipeline for disposal. Time to time de-sludging and periodic removal of solids from these tanks is done for proper management at the local level. Vikram, (2016).

The removal of wastewater (greywater also called sullage) from urban areas is termed as urban drainage. Sulluge includes all wastewater mainly from basins, washing machines and baths. According to McDonough & Braungart, (2002) there is no waste at

all and waste from one stage is an input for another stage. Unplanned and informal settlements are as a result of poor migrants move to the towns to look for a place where they can build a shack for free. They settle on the open land which is just near a town and consequently readily take any wage given wherever they get a job. They waste a lot of time while accessing their places of work. The settlement on such land is illegal which means that there is no planning hence there are no services that are offered. There are no plots that are demarcated and allocated to these settlers, (McDonough & Braungart, 2002). Moreover, there is no structured drainage system and sanitation. In general, many problems are associated with unplanned and informal settlements such as poor drainage and sanitation which can easily be solved by proper planning; funding and good engineering which also entails proper use of the modern technologies.

According to Kinoti (2010) most of the consumers acknowledged the problems involved in sanitation are part of life in the urban areas. This is not so when there is disease outbreak and the times of epidemics. To do away with these conditions brought about by discharges into the streets, the residents build privy vaults and cesspools.

Infrastructure is an organized and a systematic framework that strengthens the ability of the community to achieve its mandate of laying a foundation for individuals to contribute to development and ensure that there is social equity (Davis, 2005). It can also be said to be a trust upon which each and every individual relies and aspires to advance and tap daily socio-economic opportunities. This is beneficial to every individual when it works efficiently whereby the end product is seen on the development of the whole community. On the contrary when it works below the laid standards and expectations, everybody pays for it expensively, (Akinola, 2002).

Several countries world over have started using treated sewage as a resource especially the Middle East countries.

According to Kandiah, (1994), a well and clearly thought out sewage reuse strategy transforms the effluents to an environmentally sound and a viable economic resource. Thus, governments are expected to develop, control and establish policies on sewage reuse. This should be within national plan and national effluent use policy water resources. The governments and local authorities that are mandated with the treatment and disposal of sewage responsibilities must allocate the costs among other factors in establishing the relevant infrastructure for the effective system for sewage reuse such as irrigation.

In South Africa, 13.4% of the population resided in informal dwellings or shacks, StatsSA (2009). Here, residents survive in temporary shelters which are generally made of scavenged corrugated galvanized iron, plastic materials, cardboard or timber sheeting material. There is hardly any drainage in such urban areas resulting into environments that are much polluted with sewage (green water and also faecal matter). These informal settlements and unplanned structures in South Africa are mostly as a result of the poor migrants in to the towns.

Chirisa (2017) suggested that more decentralized and centralized sewerage services are needed. It is also necessary to introduce the recovery of nutrients and improved substances control into sewerage services in the major developed cities. Localized sanitation is increasingly growing in use in developed cities. The approach to the provision of services dramatically changes in future as the systems are smaller in size thus requiring less capital and funding for them to be installed. Decentralized systems

are therefore better in solving problem of demand in improving and expanding the services (Buller, 2006).

This is reserved to county governments. For example, Nairobi County government is mandated to see to it that the city is clean at all the time. This endowment has ascertained that it is a difficult endeavour to most county governments due unavailable resources and the high degrees of corruption.

Interestingly, some communities have organized themselves to form CBOs and youth groups with an aim of managing the waste and get some income. This has led to creation of employment opportunities. The plant gets its raw material from the dump site.

Likewise, Green Loop International Company (GLI) which is found in Kikuyu town recycles plastic wastes. The Green Loop International collects and recycles plastic wastes. This in turn helps in providing a good and clean environment as well as in job creation (Water Impact Report, 2015). Kenyan urban areas have been growing at an average rate of 4.3% annually (KNBS 2005 -2016 period). The inadequate potential combined with economic difficulties has hindered the design of solutions to the challenges brought about by rapid urbanization.

Informal settlements are in the lowest strata in the poor class of houses. They can be singled out from the others because they are poorly structured and are generally semi permanent. Their walls are made of mud or even timber with the roofs having diverse material such as grass, polythene papers or hard cartons. Some of them are not even planned hence they are faced with the problems of sewerage and sanitation accessibility and supply, Urban Water, Sanitation and Solid Waste Services, (2017)

Unprecedented growth of urban areas has led to poor living standards which are caused by degradation of the environment and inefficiencies in economy. They grow without proper physical development plans and so in Kenol town in Murang'a county. Moreover, most urban developmental plans when done have been reactionary and only 30% of urban centres in Kenya are actually planned for. This is hugely due to fast population growth and planning capacity which is not adequate. Those county governments which have planning units are 4 out of 175 and they include Eldoret, Kisumu, Mombasa and Nairobi.

This has resulted in most towns struggling and dealing with mushrooming settlements that are not planned, all kinds of pollution, traffic menace, very expensive and inefficient transport system.

Kenya is at present characterized by urban slums which do not have proper sanitation.

The high and fast urban growth rate has given forth some challenges both, social and economic. Due to the ever increasing population much strain on the already available infrastructure such as housing and health facilities is felt. There is a rise in congestion in towns, increased number of informal settlements which leads to low quality life and poor living standards. About 15% of the population in urban centers lives in informal settlements, KNBS, (2009).

The informal settlements house is projected to accommodate to over 60% of urban population (Republic of Kenya, 2012). It is therefore the role of the government and its institutions to construct an elaborate plan for harvesting and or disposal of the sewage. Sewerage supply, other than capital, energy and communication is a very vital infrastructural requirement if sustainable development is to be achieved.

According to Water Impact Report, (2015), sewerage supply enhances human health and is very important for development of industries and commercial sectors. Economic development is mainly hindered by severe water shortage which directly influences people's health in certain areas. Life in urban areas is greatly supported by water resources. When this resource is properly utilized, it generates some interest on it in the universe.

### **2.2.2 Financial Constraints and Provision of Sewerage Services**

According to a survey, KSSF, (2016), most of the countries in the world are faced with the challenge of funds to establish and provide sewerage services and systems. They are forced to look for donors, grants and funding institutions like the World Bank. This takes time hence there are inconveniences when providing these basic services.

Sewage is a resource that can be of value to urban and suburban agriculture. As suggested by Hussein *et al*, (2014), some 50 countries covering about 20 million hectares use raw or partially treated sewage to irrigate them. Assessments have been done on the use of sewage in some countries including; Pakistan, China, India, Vietnam, Mexico and Jordan. These assessments indicate that in Pakistan for example, 32,500 ha are irrigated directly with sewages, whereas 73,000ha in India are irrigated, and, at least 9000 ha are irrigated in Vietnam (Gayathi, 2008). Although there are several benefits of sewage reuse, there equally challenges associated with sewage reuse.

In Japan, a sanitation policy caters for financial arrangements supports establishment, running and the overall cost of maintenance, (Japan Sewage Works Association. 2011). Studies by the Sewerage Finance Research Committee (1961), on the appropriate cost-sharing on sewage works revealed that the national subsidy should be more than half of the construction cost. The rest of the finances should come from the bonds given by the

local government. The owners of the lands where sewerage systems are carried out bear the construction cost which is termed as the beneficiary payment.

The local government's general account budget pays for the maintenance cost; while on the other hand, sewerage service cost is paid by the one who utilizes the service.

Though there were scarce sewerage plants to be implemented then due to scarcity of finances, the Sewerage Finance Research Committee (2011) recommended a system which was affordable to all the people in order to maintain a certain level of living standard was recommended. In addition, the people themselves bear the burden since the sewerage system is under the public sector and therefore a public facility. The cost of constructing the sewerage is subsidized appropriately from the public funds. Japan's government is mandated to promote sewerage establishment while the devolved governments implement the projects associated with the sewerage systems. Sewerage services user in Japan generally amount which is cheaper than many cities in abroad. The user pays charges summed up from standing charge and the charges of the water availed to the user. (Saitama City Cleansing Operation Summary, FY 2012 and 2013.)

However, people would over reuse sewage to support their livelihoods and generate considerable value in urban agriculture. Another significant aspect of sewerage service is sewage reuse. According to JICA, (2014), sewage reuse or recycling in a given area will be influenced by the following factors; more water resources, economic considerations, the will to preserve instead of coming up with water resources, quality of the water, potential use of recycled water, the public policies and the strategy of sewage discharge.

Furthermore, according to the WHO, (2015) standards and guidelines, it is not recommended to reuse raw sewage, but that treated to safe healthy standards. These

factors raise the operations and maintenance costs of any sewage management and reuse project.

The high price of reclaiming the sewage to usable waters versus the price farmers and other people are willing to spend makes it prohibitive. Survey of municipalities in California indicated that lack of funding is the major constraint of water reuse. The survey established that although major municipalities have set up projects for sewage reuse, smaller ones have not due to lack of funds. (KSSF, 2016-2020).

Inadequate finances also play a major part in the provision of sewerage services in various ways. Lack of funds limits the ability to hire as well as retain staff. It also controls the salaries of the workers and the benefits therein, IWA (2014). Educational facilities are faced with the problem of hiring quality and well versed teaching staff and the equipments lack in total. UNESCO-UNEVOC (2012) acknowledges that solutions for sewerage challenges hugely are influenced by the provision of trained human resources. Levels of training and qualifications of the staff in sewerage sectors on the other hand vary from one country to another.

In Africa and Asia, sewage reuse is a common practice while sewage recycling is common in developed world: water scarce countries like Australia and regions with harsh restrictions on effluents disposal such as Italy and densely populated countries like Germany, as reported by Marsaleck (2002). According to Radcliffe, (2004) when planning, water reuse should not be left out. This is because water supply developments reduce with the rise in the cost of waste disposal, (Devi, 2009). According to Githuku (2009), in 2006 and 2007, about half of the sewage produced in Nairobi is used in treatment plants while the other 50% is used in its raw form for cultivation. The study

also indicated that areas like, Maringo, Soweto, Mailisaba, Kibera, Kahawa, and Kariobangi South with over 100,000 households cultivate using raw sewage.

About three quarter of the produce grown in these areas especially vegetables are sold; marketing is usually done on the farm while the rest is consumed at home. It is claimed that farmers use sewage because it is rich of nutrients and provides the moisture necessary for plant growth.

The process involves digging of canals that transport the sewage to the farms and even block sewage lines carrying sewage from the residential estates (Kaluli, 2011). According to JICA, (1998), most Kenyan towns having more than 100,000 residents such as Nairobi and its environs, have the possibility of producing enough sewage for industrial use. However, most of these towns do not have sewerage services. NEMA, on the other hand does not recognize the re-use of sewage as a possibility, (Kaluli, 2011). Financial resources could well be an impediment in both developed and developing regions.

Sometimes, the cost of discharge of effluents would be out of reach, whereas in other areas, the cost of collection and treatment of sewage could determine the extent to which sewage is reused. In order to effectively harvest the sewages for reuse it is necessary to have an elaborate infrastructure as well as systems to treat the water before reuse. However, the high cost of setting up this infrastructure can be a hindrance to the reuse. This is especially so for small to medium size communities and the urban poor who lack the resources but have the willingness to reuse the water for economic development.

In most developing countries like Kenya, lack of funds to set up sewerage collection services in urban and suburban areas has led to developers building septic tanks for

collection of all the domestic and commercial / institutional sewage which quite often overflow. In some areas there is totally no collection system for the sewage. The water therefore gets into open channels and fields.

According to WASREB, (2015), most companies do not have established sewerage systems. As a result most consumers are unable to access sewerage services and cannot earn any income to the company. Groundwater can be polluted by methods like onsite sanitation method which include septic tanks and pit latrines. Some companies do not have their own facilities neither do they have any control over the designs they have, mode of operations, and how to maintain them. In rare cases the laid down rules, guidelines and design standards are followed in almost all the countries, (Roche & Obeng, 2014).

To have 100% accessibility as given in the Vision 2030, a good investment has to be offered. Foreign donors fund more than half the funding on the sector, (WASREB, 2015). The internally generated resources help in costs recovery for it to be sustainable. Their profits are as a result of thorough collection and management of all the revenue that is got.

In order for these companies to show their strength on service delivery and indicate whether the consumers of these services are satisfied or not, effective collection of this revenue must be an indicator, (Sambu & Tarhule, 2013). The consumers of these services must be willing to pay always for whatever small service is provided.

The sharing formula of the National revenue which is guided by the Commission on Revenue Allocation has not considered much needed funds by the big urban centers in the counties. This has contributed to crisis in infrastructure funding and sanitation services to big cities and upcoming densely urban centers.

This makes it hard to effectively harvest the sewage for reuse. Like in most towns, Kenol town Murang'a South sub-county for example the sewage that runs in the open channels along the roads is used by the youth to wash vehicles but most of it runs down to the streams or open field. Other financial constraints include the cost of electricity to run the equipment such as pumps to convey the water to a place of application. Moreover, these pumps are of special design to be able to handle the dirt in the sewage and are more expensive than the ordinary fresh water pumps. The operation of this equipment also requires competent personnel, where maintenance requires finances.

### **2.2.3 Technological Knowledge and Provision of Sewerage Services**

Globally, staff inadequacy in the sewerage treatment facilities is evident. In developed countries of the world, this is attributed to the high number of the aging workforce and diminishing experience in the job due to retirement. More so, the younger generation is unwilling to join this sector (WWAP, 2016).

A third of the population in the world uses the onsite sanitation technologies. When management of this technology is properly done proper functioning too is essential. There is much difference between centralized waste water treatment and the onsite sanitation technologies when faecal sludge is eliminated. The chain consists of containing faecal sludge then draining it before it is transported to the treatment site after which it is safely disposed. For this to work effectively, a carefully thought out and organized management should be employed in order to protect both the public and the environmental health.

Studies by World Bank Water Supply and Sanitation Program 2014) show that there is a crisis in the faecal sludge. The excreta in some cities in America (Latin), Africa, Asia (South and East) had 64% as reported by WBWSSP, (2014).

World Resources Institute, (2013) established that about one and two thirds of the solid waste generated remains uncollected. As a result, waste which is not collected is mixed with excreta. This cause flooding during rainy season due to blocked drainage system.

Europe established sewage management efforts which were soon adopted by the U.S government. The European cities constructed centralized sewerage systems in large scale. They proved successful as they removed sewage from urban areas. Engineers from U.S. made consultations with the European designers who had successfully done theirs when they were designing and installing theirs. As stated earlier, the acceptance of the reuse of sewage is greatly influenced by peoples' religious and socio-cultural factors.

Kitakyushu and Tadotsu town of Japan represent cities where a framework which enable for advancement of the sanitation in the country are sealed and implemented. Enabling tools like structuring management and linking of different institutions are done to aid in polling the resources from the government together. This is done with the main aim of prioritizing sanitation creating a good room for the modern technological innovations. Due to the high need of the sewage treatment, the environmental engineering development by the private as well as public departments has been improved. As Japan supplied the developed sewerage technologies outside its borders, heavy investments were needed too. Other countries benefited from the export of technologies through improvement of the environment.

There are several technological options which are applied in order to treat sludge from onsite sewerage structures as well as recycling it, Omiya Purification Center (2001). The end product is used by the consumers to improve the soil in the house gardens. Moreover, a treatment separation process which involves a membrane with high

capacity is adopted to prevent effluent discharge to the river. This is known as the membrane technology which is required to get the quality of effluent below 5 mg/l. Furthermore, the Omiya Purification Center which uses the technology requires very little footprint which is of benefit when setting up such kind of facility in an area where land is scarce as the cases are in the urban areas. Other technologies include treatment through biological means, precipitation process using chemicals, treatment using and by use of activated carbon absorption process, OECD (2013).

In Brazil, social-economic differences in inter-urban and intra-urban add weight to the problem of making sanitation services universal. It is a technical challenge to avail sewerage services to areas where there are unplanned settlements or informal structures are common. These problems can be solved amicably by adhering to the rates given and careful and consistent interpretation of the law. Illegal connections to the sewerage systems should be addressed and the staffing should also be looked into.

Separate sewerage systems should be replaced with combined sewerage systems and consequently work using the little finances to collect sewage away from the people.

According to IWA (2014), UNESCO-UNEVOC (2012) and WWAP (2016) found that challenges such as sewerage systems operations and their upkeep are faced with shortage of staff especially in the developing countries. These countries are also not able to provide the much demanded human power for the provision of sewerage services.

Further, IWA (2014) points out that the curriculum that is being used to cover sanitary engineering in the Universities requires to be improved. This includes also vocational training in relation to sanitation and sewerage.

Sewerage supply facilities and networks adopted automation and ICT in the early fifties. Developed countries are nowadays using modern sewerage supply plants which are fully automated.

According to Davis, Bagozzi and Warsaw, (2001) they are making use of ICT through the use of regulated operated pumps, coordinating withdrawals from various origins and dams and lastly controlling of purification in facilities that reclaim sewages. Pumps with varied speeds were brought into the market which had driven with adjustable frequencies. They provided high-level regulation of pressure and discharge systems for water and energy saving. This technology has increasingly been used due to increased oil prices in the last decade.

Use of ICT has also been increasing as there is anticipation of hiking oil prices in future. Their supply has also increased. The appliances that have been installed have translated to 20-30% of energy being saved. As a result, there is increased efficiency in pumping units and in the balancing of withdrawals. Moreover, there is elimination of fluctuations and pressure surges. (Tjandraatmadja et al., (2005). In the government facilities, which are largely the public sector, supply of sewerage services is lagging behind in managing their supply and consumption.

Improved performance will always be as a result of system technology and support of its adoption by consumers and the management, (Karanja & Nyambura, 2014). Payments by the government facilities consumers for the services rendered are not done, (Renzetti & Dupont, 2004). In countries like Israel, every consumer is served with a sewerage meter. Sewerage consumption by the government and households is now being measured and the uses are invoiced according to the sewerage consumed rate. This done due to increased shortages of sewerage facilities in the world.

The use of excreta as fertilizer in Africa is seriously objected whereas, in Japan and China the excreta is regarded as economically suitable for use as fertilizer, (Hani, 2009). Treated sewage reuse is thus gaining acceptance in several parts of the world. Generally, sewage reuse is customary in areas with limited sources of water, or for other economic reasons. For example, in Islamic states, sewage reuse is acceptable, as long as it is cleaned of impurities (*najassa*). This is generally due to economic reasons, more than cultural preference. In order to achieve general acceptance of sewage reuse for any project, active public involvement is ultimate (Crook, 1992). There is need to involve the relevant authorities and potential users for the public acceptance.

A proper protocol of information exchange between the involved parties ensures that everyone embraces the sewage reuse and that the users' needs are significantly fulfilled and that the community's concerns of health, safety, ecological and others are considerably attended.

An empirical study conducted by Mackay and Hurlimann, (2003) projected that the greatest opposition to sewage reuse come from people of ages 50 years and above.

Some human activities generate waste. How this waste is managed lays the big question. The waste management mechanisms employed may pose an environmental risk or otherwise. It is therefore important to employ appropriate and safe waste management measures in places where human activities are concentrated like towns. This fact has been realized in many countries but implementation of the appropriate measures to ensure its complete realization poses the challenge.

According to MOH, (2016) the sewage that is effectively treated nationally is only 5%. Only 60% of the sewage enters sewer lines and reaches the treatment areas. The capacity to operate these sewage plants that treat sewage is around 16%. This is greatly

attributed to inefficient and inadequate maintenance and operational rates. Moreover, rates when connecting to sewerage systems are low.

In developing countries the scarcity of the staff is the worst problem regarding to trained, qualified technicians and engineers. In addition, the economies of these countries don't have enough professionals, appropriate know how, work experience and special skills in the needed field for sanitation services, (IWA, 2014).

Uganda has a pit latrine which is an example of an onsite sanitation technology which has a pit under it where excreta are stored as faecal sludge, (Strande *et al.*2014). In addition, FSM problem can be solved by use of the Shit-Flow Diagram SFD, Sandec (2015). This method has been set up and experimented in more than 40 countries in the world. The findings for instance in Tanzania indicate that the excreta that is managed under onsite systems is about 90% while only 23% of it is left to the surrounding untreated, (Eawag / Sandec, 2015).

In Kenya there is the urban sanitation policy network which was established by the Kenya Constitution (2010), Kenya Vision 2030 and the Kenya Environmental Sanitation and Hygiene Policy (KESHP) 2016-2030. The Kenya's Vision 2030 was formulated in 2007 and updated in 2012. Its main aim is that by 2030 universal sanitation will have been provided. KESHIP too aims to have had sanitation for all which is improved and not just doing away with defecation in the open by 2030. Moreover, it aims at increasing investment in the public sector by 0.7% (from 0.2% to 0.9%) of the GDP by 2030. This policy encourages the adoption of low-cost technologies in urban areas and in informal settlement areas. It emphasizes and gives the ranges of these technologies from sanplats and cartridge-based toilets to conventional sewerage. Collection and disposal of the solid waste is emphasized by use

of systems which are sustainable from where people reside to areas where they do business.

Unavailability of the modern technologies in Nairobi has lead to various problems both to the residents and the sewerage companies. New technologies have not been adopted. Systems have not been set as per the needs of the residents. Most of the available sewerage pipes burst due to an ability to hold the amount that is fed to them, (UN Habitat, 2015). These pipes are not only dangerous to the environment but also pose a health risk to the population in general. In flat areas, flooding is common. The flooded sites in turn become breeding grounds for mosquitoes and other vectors. Like in the case of Dandora dump site Nairobi Kenya, most of the collected solid waste is usually dumped in lands in uncontrolled manner. These poor ways of managing the waste has created serious environmental and health problems, (Kinoti, 2010).

In other towns there is no modern technology being adopted yet there is notable growth in population. Towns are expanding at a very high rate and therefore proper planning, use of technology and engineering needs to be enhanced.

#### **2.2.4 Physical Environment and Provision of Sewerage Services**

The physical environment influences the systems to be installed at a particular area. According to WHO/UNESCO, (2007), systems are set everywhere in the world following some conclusions from the weather patterns, topography, climate of a place, type of soil, vegetation among others in order to establish a system that fits the area. This ensures that they are durable and that they serve the purpose they are intended to do, (Van Vuuren, 2010).

Centralized water-carriage sewerage systems were preferred, (Pickford, 2001). The water-carriage sewerage systems were more viable for a long period of time.

Centralized sewerage system in a good and proper physical environment saves the maintenance and capital costs of sewerage services as compared to the privy vaultcess pool system. It was thus agreed that this WCSS had very many benefits and had the lowest cost over a long period of time when compared to other forms of disposal.

This economic reasoning was praised by sanitary engineers, city councils and health groups. Pickford, (2001) also noted that because of the convenience of the sewerage services the public was in favour of its implementation. Most the work involved in maintaining WCSS was done away with by the home owner. Disposal of permitted wastes and its collection is done in the least offensive and obstructive manner. The elected officials indirectly secured funds for the construction of centralized water carriage sewerage system after they respected the public opinion. WHO/UNESCO, (2007) pointed out that systems which collect and dispose sewage transport it through inhabited areas and cities to sewage treatment plants to prevent and protect the public from diseases and health respectively.

The main reason for sewage treatment is to control excessive pollution of water before it is discharged to surface waters. Focus also rested on the treatment of sewage, how raw sewage is delivered to natural water bodies like oceans and rivers where it would be diluted and dissipated satisfactorily. Rivers were made a form of natural sewage disposal by the early human inhabitants who occupied and settled near water sources. The sewerage treatment plants received the sewage from the sewerage system by gravity. In low lying areas sewage is conveyed by vacuum pumps. Pipeline sizes range from six inches pipes (150 mm) to tunnels lined with concrete up to 10m in diameter.

Sewage from the community can be collected by a STEP system (Septic Tank Effluent Pumping). This system is also called Effluent Sewerage System. According to

WHO/UNESCO, (2007) a collection tank is buried to separate liquid effluent from solids at each home. Moreover, the liquid is pumped through pipes with small diameter ranging from 1.5" to 4" for treatment downstream. There are other pipes which are laid below the ground surface along the contour of the land which carry pressurized waste. Vacuum systems and low-pressure pumps also collect sewage. A small grinder pump is used as it is a low-pressure system. The grinder pump installed at every connection point of a building or a business. A study conducted by UNDP in the nineteenth century showed that rapid urban population growth was noted in the U.S. Of all the Americans, less than 5 percent settled in towns in 1820. That percentage rose to 16 percent by 1860 and to 22.5% by 1880. It is also noted that there was a considerable growth in United States' major cities from 1820-1880.

The increased amount of sewage could not be handled by the then existing privy vault-cesspool system. An alternative management strategy which was 'The Centralized water carriage sewers system was promoted to cope with the ever-increasing population. Urbanization has some advantages and disadvantages especially when there is rapid population increase in certain small towns. The adoption of urban lifestyles implies that agricultural activities which are major resource in rural areas are abandoned.

In South Africa, there have been challenges in the sewer expansion some of which are technical in nature. Van Vuuren, (2010) pointed that there had been a challenge in installing settled systems when there was a shift from septic tank system to the latter (settled sewer network). This implied that an awareness campaign which would target local institutions and houses had to be initiated. An approach that would suite the idea had also to be carefully sought out. According to Van Vuuren, (2010) an approach drive by professionals such as engineers was the most appropriate. The interviews

which were later conducted in 2012 September revealed that convectional gravity systems were preferred to settled sewerage systems.

Storm water illegal connections to the main collections by sewerage services users created also a problem on the settled sewerage system, (Burger, 2012). These connections which are not allowed are a risk to the settled sewer system because conventional sewerage systems have small diameters and are never designed for storm water. They usually have a less carrying capacity than the convectional systems. Concerns were also raised on the cleanouts or the points where the structures would be set for easy access to minimize storm water ingress, Nel, (2010). Consequently, following the reports from the inspection points, a lot of papers, rags and sand were seen in the pump stations during servicing per month in the informal settlements, Nel (2010).

In Kenya, there are no actual records on the amount of sewage production due to little or no data on domestic, commercial and industrial sewage production. The increasing population in the urban areas put more demand on water use and rapid spread of waterborne diseases, create widespread sewage disposal problems. The sewage originates from the kitchen, bathrooms, toilets and industrial activities among other activities.

According to Environmental and Social Impact Assessment Study, (2013) physical environment entails the general terrain or the topography, the overall precipitation, general wind speed, temperature ranges, types of soils, the geology of the place, the already available water sources and the type of flora in the area. The other form of environment is the social environment which carries the general population, concentration of health institutions like hospitals, dispensaries and local health centres and finally educational facilities like schools. Lastly, the built environment is also under

the environment and includes the constructed roads. All these influence the establishment of the sewerage systems and service provision, (Environmental and Social Impact Assessment Study, 2013).

According to United Nations Development Programme, (2014) environmental justice is vital. It aims at promoting people's quality of life. It also means the changing relationship between the services of the ecosystem, pollution and poverty which make sure that the poor don't suffer from the impact of the environment. Environmental justice curbs all the power abuses relating to the natural resources. It helps in coming up with new ways of sustainably securing the quality of life for the future generations' following the law and empowering the poor socially, (UNDP, 2014).

In Kenol town, this sewage is discharged into septic tanks, open fields and roadside channels. The sewage that is discharged into open fields and channels or even open ponds, produce foul smell, form breeding sites for mosquitoes, is risky to children as well as a likely source of outbreak of waterborne diseases such as typhoid, cholera, diarrhea and others. Inadequate systems, poor provision of services and inefficient sewage management system in towns has resulted into surface water pollution, groundwater pollution and poor environmental health conditions.

The health risks posed by the poor management of sewage at large in urban areas impact to most on the poor who often inhabit low lying and marginal areas, for example the wetland along the polluted drainage channels. The biggest challenge experienced in developing countries is that there is very small scale of institutional arrangements for sewage reuse policies and in some cases, the policies may not be well established and lack of clear guidelines (Urban Areas and Cities Act, 2011). It is vital to establish realistic, achievable and enforceable policies in order to ensure sustainable management

and reuse of the sewage. Moreover, establishment of unrealistic standards and regulations will lead to aversion among the stakeholders.

For instance, “the cost of treating sewage to high microbiological standards could be so exorbitant that use of raw sewage is allowed to occur unregulated”, so as to meet throughput goals, as established by Fatta (2005). The strict policies established should harmonize between safeguarding the consumers as well as other stakeholders’ livelihoods.

In most of countries the standards and conventions adopted are based on international practices. While in developing countries, these policies are vital that the conditions of the country at hand are taken into account.

In accordance with the Kenya’s National Policy on Environment, (2012), on waste management, the government would come up with a combined waste management strategy which is aimed at promoting the use of instruments of economy. This strategy helps to encourage the establishment of facilities and guidelines for cleaner production, manage waste recovery, recycling and reuse, (Ministry of Environment and Mineral Resources, 2012). This policy statement is quite general and does not clearly define the concept of sewages reuse.

Currently NEMA does not recognize sewages reuse as reported by Kaluli (2011). Thus, in Kenya, no person is allowed to do some irrigation using sewage. He or she can only do so if complete compliance to quality guidelines is adhered to according to NEMA (2006). Babin (2005) indicated that institutions such as the Environmental Directorate (in Australia) guarantees public health protection by providing proper of sewage. They also offer advisory services on the intensification of land use on sewerage land. This

further ensures controlled management and reuse of sewages without adverse effects to both farmers and consumers of the products.

Provision of sewerage services is one of the major issues for decentralized governments. Kenya is governed in a devolved system. This implies the prospect of many towns and cities to grow rapidly at the County levels. Proper planning in the provision of sewerage services is therefore very paramount so as to balance between the high populations at the small urban centres, the social-economic and ecological conditions at any town.

### **2.3 Theoretical Framework**

A theory according to Mugenda and Mugenda (2003) is defined as a combination of ideas and relationships that are thought to be within ideas. Two theories were used in this study. The theories are Technology Acceptance Model (TAM) and the Brett Frischmanns Economic Theory of infrastructure (BFET). In addition, according to Kombo and Tromp, (2006), theoretical framework is a variety of concepts that are related and are based on theory. The study applied the following theories.

#### **2.3.1 The Technology Acceptance Model**

In relation to technology, Technology Acceptance Model, Davis, (1986) was used. It formed the base whereby the influences of the external variables on belief, use intentions and ease to use were sought. This model posits the attitude, perceived easy use of the system and usefulness. Many factors influence ones actual use of technology directly or indirectly. These factors include perceived ease of use of the system and usefulness, attitude and intentions in terms of users' behaviour. This model was adopted to comprehensively explain the importance of information in improving efficiency in sewerage services provision. This model enabled the study to show and explain how the

sewerage services consumers' behaviour influences the ease at which the services are availed to them.

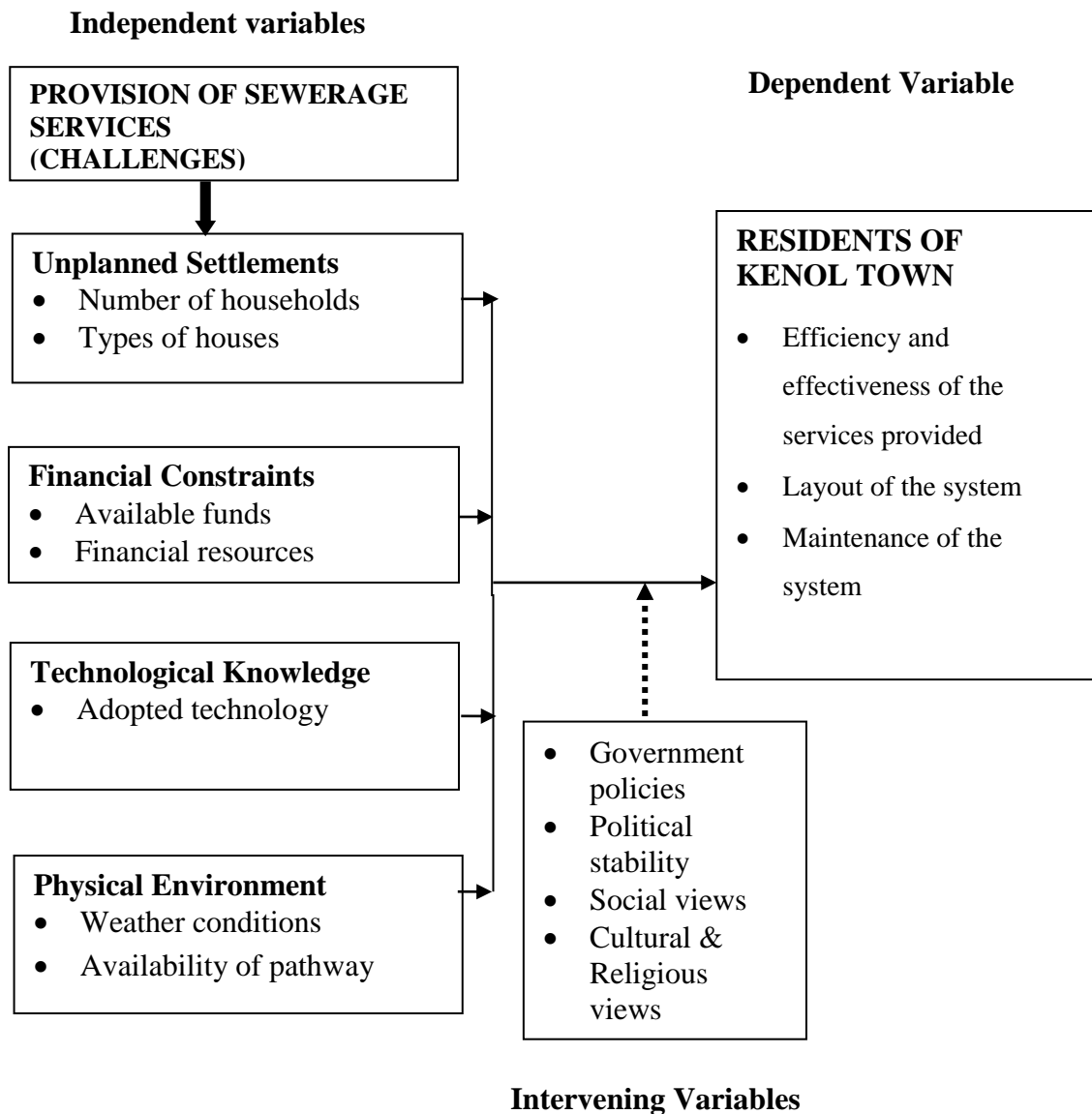
### **2.3.2 The Brett Frischmann's Economic Theory of Infrastructure**

This explains a good and a detailed concept on how various resources are managed. This provided the public with a provision to them on compulsory and without discriminating anybody. It also proposes an inclusion by right to a scheme on resource management whether it is a private property or not. According to Frischmann it would be conducive if open access was allowed in maximizing the production of goods for the public and non-market continuously.

When the owner is given property right there are benefits of shared use and reuse which do not reach the users downstream due to inefficient signals about demand. Fundamental infrastructure, according to The Frischmann theory should be shared. This theory was important in the study as it helped to address current management issues, ideas and structural organization structure in order to effectively provide sewerage services.

### **2.4 The Conceptual Framework**

It explains that the provision of sewerage systems is dependent on unplanned settlements, financial constraints, technological knowledge and physical environment. Intervening variables that also influence in the provision of sewerage system are policies of the government, political stability, social views and cultural and religious views. Figure 1.2.1 depicts the variables to be involved in the study. The dependent variables depended on the outcome caused by the independent variables. In this case, the conceptual framework for this study sought to sketch a roadmap on the challenges in the provision of sewerage services in Kenol town, Murang'a County.



**Figure 1: The Conceptual Framework of the Present Study**

### 2.5 Summary of Literature Review and Research Gaps

Mirika (2016) carried out a study in Nairobi County on efficiency of waste water treatment. Another study was carried out by Odira (2015) on challenges in provision of proper sanitation in Nairobi City. However, no study has been carried out on evaluation of the provision of sewerage services among the residents of Kenol, Murang’a County and this formed the bases of this study.

## **CHAPTER THREE**

### **RESEARCH DESIGN AND METHODOLOGY**

#### **3.1 Introduction**

This chapter presents a description of the research methodology that was used which was broken down into: Research Design, location of the study, population target, and technique used in sampling, sample size, tools used in research, study piloting, validity and reliability of the study, techniques in collection of data, analysis of data and considerations on good ethics.

#### **3.2 Research Design**

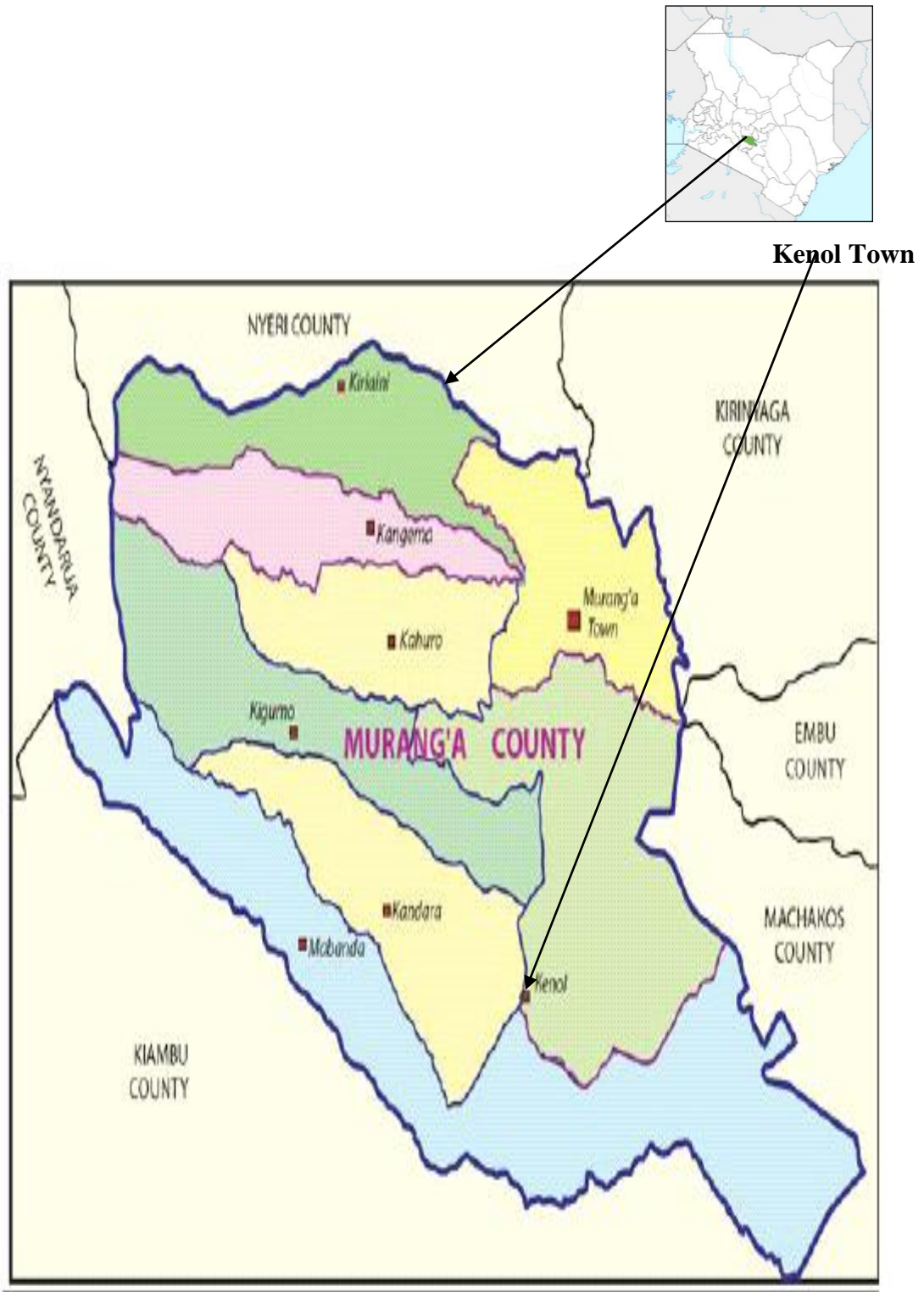
For an in-depth exploration of this phenomenon, this study adopted a descriptive research design. This determined the challenges in the provision of sewerage services in Kenol town in Murang'a County. Data was gathered within a period of three months starting from 21<sup>st</sup> March to 30<sup>th</sup> June 2019. Descriptive design was reasoned to be suitable for this study because it framed out the backdrop regarding examining the challenges in providing sewerage services taking case of Kenol town, in Murang'a South sub-county. Qualitative approach made available in-depth explanations and quantitative approach on the other side makes available the hard data required to meet the required objectives, (Mugenda & Mugenda 1999).

#### **3.3 Study Location**

Kenol Town is an urban centre in Murang'a County. Administratively, Murang'a South has four divisions namely Maragua, Kigumo, Makuyu and Kandara divisions. Murang'a South also has four local Authorities which are Maragua, Kandara and Makuyu Town Councils and Maragua County Council. It lies between latitudes 0<sup>0</sup> 43' 0.01" N and longitude 37<sup>0</sup> 08' 60.00" East. It borders Thika to the South, Machakos County to the East, Nyandarua to the West and Kirinyaga to the North East.

It is located at 1586 m above sea level. The study area is located in Kimorori sub-location in Makuyu location, Makuyu division. The town is also shared the Makuyu Town Council and Maragua County Council. Kenol town is strategically located along the busy Nairobi- Nyeri highway (A2 class road) and Kenol - Murang'a road (C71 class road) thus close proximity to the city of Nairobi, the capital of Kenya. These two major roads have played a central role in giving Kenol town a more significant locational advantage than demographic or environmental variables in determining the economic potential and its social organization, (KeNHA, 2017).

Kenol's climate is warm and temperate with wet summers and very little rainfall during winter. Its annual average temperature is  $19.6^{\circ}\text{C}$  and 966 mm as the average rainfall. The driest month is July with 13 mm and March's average precipitation is 227 mm. The month with the lowest temperature is July with  $17.6^{\circ}\text{C}$  while March is the warmest month with  $21.0^{\circ}\text{C}$  and annual range temperature of  $3.4^{\circ}\text{C}$ . (KIG, 2015)



**Figure 2: Map of Murang'a County**

### 3.4 Target Population

The population of Kenol town according to CDPO, Murang'a, (2012 is 44,007 people. These include traders, farmers who are adjacent to these towns and all those who live and work in various work stations and institutions within Makuyu and Kenol towns. The target population was domestic and commercial consumers of sewerage services, management employees of Murang'a South Water and Sanitation Company and workers of Murang'a South Water and Sanitation Company based at Kenol town. Majority of domestic sewerage service consumers live in rental houses while commercial sewerage service consumers own and manage institutions and businesses like hotels and schools within the town. The management employees of Murang'a South Water and Sanitation Company comprised of the company managers, accountants and secretaries. The company workers consisted of both permanent and casual employees of the Sewerage Company.

**Table 1: Target Population**

<b>Category</b>	<b>Frequency</b>	<b>Percentage</b>
Murang'a South Water and Sanitation Company Employees	15	1.93%
Domestic sewerage services consumers at Kenol town	715	91.90%
Commercial sewerage services consumers at Kenol town	48	6.17%
<b>Total</b>	<b>778</b>	<b>100.0%</b>

**Source: Murang'a South Sub-County (2015)**

### 3.5 Sampling Procedures and Techniques

In this section, the study presents the procedures that were followed to determine the sample size and how the determined sample size was distributed among different categories of respondents.

#### 3.5.1 Sample Size Determination

The total target population was 778 (CDPO, 2012). It is from this target population of 778 that a sample size of 264 was derived using the Yamane formulae (Yamane, 1967);

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

n = Target population

N = total population

e = desired level of precision

N = 778

e = 0.05

$$n = \frac{778}{1 + 778(0.05^2)}$$

$$n = \frac{778}{1 + 778(0.05 \times 0.05)}$$

$$n = \frac{778}{1 + 778(0.0025)}$$

$$n = \frac{778}{1 + 1.945}$$

$$n = \frac{778}{2.945}$$

n = 264

### 3.5.2 Sampling Techniques

The study used stratified sampling method, where each section separated by the tarmac roads was treated as a stratum. There are four sections and therefore there were four strata. Murang'a South Water and Sanitation Company (MUSWASCo) management employees, Sub County Office workers and Sub County Commissioner's Office workers were in one stratum. Kenol Hospital and Kenol Academy were in their stratum. Golden Palm Hotel and Kenol Computer College were in their strata respectively. For the domestic sewerage services consumers, the researcher used a simple random method where numbers were assigned. Every 3<sup>rd</sup> domestic sewerage service consumer in each of the strata was picked as a respondent. This made a total of 200 domestic sewerage service consumers.

**Table 2. Sample Size Distribution**

	<b>Institution</b>	<b>Frequency</b>	<b>Percentage</b>
1	MUSWASCo Management Officers	15	5.68%
2	Domestic sewerage service Consumers	200	75.76%
3	Kenol Hospital Employees	7	2.27%
4	Sub County Office Employees	7	2.65%
5	Sub County Commissioner's Office Employees	8	3.03%
6	Golden Palm Hotel Employees	10	3.79%
7	Kenol Academy Staff	12	4.54%
8	Kenol Computer College Staff	5	1.89%
	<b>TOTAL</b>	<b>264</b>	<b>100.0%</b>

**Source: Researcher (2018)**

### **3.6 Research Instruments**

Data was collected using questionnaires and interview guides. The instruments included:

#### **3.6.1 Questionnaire for Consumer of Sewerage Services**

Primary and secondary data were collected for this study. This method was very useful particularly in collecting primary data because it is possible to gather abstract information of all types from the respondents. It was more efficient and economical when compared to all other methods. Questionnaire method of data collection was also used on 200 domestic sewerage services consumers and commercial sewerage services consumers. The study used both open and closed ended questions. The latter was only useful when confirming whatever the answer was “yes” or “no”, for diversity of each theme and draw inferences from this data. For quantitative analysis, linear regression analysis as used in statistical package for social sciences was used for analysis.

#### **3.6.2 Interview Guides for MUSWASCo Officers and Company Workers**

Interview guides were used to collect data from the sub-county director and the water and sewerage company manager. 12 MUSWASCo officers and 45 company workers were interviewed. According to Cohen and Manion (1989) is initiated by the interviewer between two or more persons for a certain reason to obtain the required information for the research. It is directed to the content and guided by research objectives. Interview was preferred due to study’s interest in challenges in the provision of sewerage services in Kenol town. Interview is interactive in nature. McMillan and Schumacher (1997) say that interview guide questions are selected early in advance. The information is got through holding discussions between the researcher and interviewee. The use of a wide range of questions and various techniques help in getting

the best answers and results. Participants were invited to give ideas on the challenges in the provision sewerage services and to propose solutions to the challenges.

### **3.7 Pilot Testing**

The questionnaire was validated through a pilot test using sample of 20 respondents from Murang'a South Water and Sanitation Services Company (MUSWASCo) and domestic and commercial sewerage services consumers. According to Cooper and Schindler, (2003), 10-30% of the target population can be used. This confirmed structure reliability, the meaning of questions and the sequence of the probes. The sampled population was used in the pilot to avoid unreliable results and ensure uniform meaning and clarity of instruments to all respondents. Those who were interviewed did not take part in the actual study.

#### **3.7.1 Validity of Research Instruments**

Interview guides and questionnaires and were used for the purpose of comparison. A pilot study was also conducted to twenty Maragua MUSWASCo sewerage service consumers. They were not part in the study. The respondents were invited for a discussion and explained to them the study purpose. The collected data were processed, analysed and interpreted.

#### **3.7.2 Reliability of Instruments**

Reliability, according to Joppe (2000) can be defined as the consistency and accuracy of representation of the findings over time and of a total population which is being studied. The research instrument is said to be reliable if the findings can be generated under similar methods over and over again from a given study. Reliability is used in order to generate understanding. Stenbacka (2001) used dependability to emphasize and improve qualitative research. Examination of raw data, process notes and data reduction products

help in verifying the data consistency in line with research guidelines (Golafshani, 2003). In order to achieve reliability of the data and the findings collected, internal checks on the quality of data collected will be carried out by the researcher.

This was done by selecting a sample size which was representative of the target population and carrying out the research consistently allowing participants sufficient opportunities to cover relevant ground, to portray their experiences and viewpoints in a safe environment.

### **3.8 Data Collection Procedures**

An introductory letter was obtained from The School of Postgraduate Studies of Mount Kenya University and Authorization Letter and research permit from National Commission for Science, Technology and Innovation. An authorization letter from the County Commissioner and County Director of Education, Murang'a, was also secured. These letters introduced the research team to the respondents in Maragua and Kenol towns. After obtaining the pre-perquisites permits, appointments were booked with the respondents to conduct interviews to collect prerequisite data for the study. The researcher administered questionnaires to the sewerage services consumers in Kenol Town with the help of a research assistant who was trained for two days on the contents of the questionnaires and what was expected from the respondents. The duly filled questionnaires were collected and stored for analysis. At the same time, the researcher conducted interviews among MUSWASCo Management Officers and Company Workers.

### **3.9 Data Analysis Techniques**

To start with, common themes were identified. Secondly, the relevant information was broken into phrases or sentences, which reflected a single, specific thought. The responses to the close-ended items were assigned codes and labels. In order to come up with vital information as pertains the respondents frequency counts were generated. This helped in giving out the trend of findings on the variables being investigated.

Qualitative data were analyzed thematically along the study objectives and presented in narrative forms. Quantitative data were analyzed using frequencies and percentages descriptively and inferentially using linear regression analysis with the help of Statistical Packages for Social Science (SPSS Version 21) and presented using tables.

### **3.10 Ethical Considerations**

The researcher sought permission from the departmental heads in every institution involved. To start with an introductory letter was obtained from The School of Postgraduate Studies of Mount Kenya University. Secondly, an authorization letter and research permit from National Commission for Science, Technology and Innovation were sought and obtained from NACOSTI. Moreover, an authorization letter from the County Commissioner and County Director of Education, Murang'a, was also secured. These letters introduced the research team to the respondents in Maragua and in Kenol towns. After obtaining the pre-perquisites permits, appointments were booked with the respondents to conduct interviews to collect prerequisite data for the study.

Ethical considerations were observed throughout the study by getting voluntary informed consent from all the participants. Privacy and confidentiality were ensured by maintaining anonymity of the participants. No individual identity was disclosed to anybody. The assistants and the researcher ensured that human dignity was maintained

at all times. The questionnaires were accompanied by a cover letter requesting respondents' cooperation, confidentiality statement and a copy of a letter from the University showing that the study was only for scholarly purpose and all ethical issues were honored. The researcher ensured that privacy of any information given touching on their people or their private life was maintained. No private information was divulged to a third party. In this study, the anonymity of questionnaire was observed. The names of the respondents were not written anywhere in the questionnaire.

## CHAPTER FOUR

### RESEARCH FINDINGS AND DISCUSSIONS

#### 4.1 Introduction

The findings were given based on the four objectives.

#### 4.2 Settlement Patterns and Provision of Sewerage Services

The study sought to establish how settlement patterns influence provision of sewerage services. Descriptive data collected from consumers of sewerage services were given in Table 3.

**Table 3: Views of consumer of sewerage services on the influence of settlement on provision of sewerage services**

Summary of Test Items	SA	A	U	D	SD
	%	%	%	%	%
There is no easy access to sewerage services.	71.4	12.1	1.5	10.1	5.3
Buildings are not well planned.	66.9	13.2	2.4	12.7	4.8
Sewerage services are hindered by unplanned settlements.	80.5	12.4	1.6	3.3	2.2
Unplanned settlements outnumber the staff providing the sewerage service.	67.4	19.7	3.5	5.3	4.1
The company is serving a high number of settlements.	69.6	13.8	1.6	10.6	4.4

Source: Field Data (2019)

Table 3 reveals that majority (71.4%) of the consumers of sewerage services strongly agreed with the view that there is no easy access to sewerage services. At the same time, (12.1%) of the consumers of sewerage services agreed with the statement. However,

only (1.5%) of the consumers of sewerage services were undecided, (10.1%) disagreed whereas (5.3%) strongly disagreed.

(66.9%) of the consumers of sewerage services strongly agreed with the view that buildings are not well planned as did (13.2%) of the consumers of sewerage services who agreed. At the same time, (2.4%) of the consumers of sewerage services were undecided, (12.7%) disagreed whereas (4.8%) strongly disagreed. According to KNBS (2016) urban areas in Kenya have been growing at an average rate of (4.3%). According to KNBS (2016), the settlements grew without proper physical development plans and so in Kenol town in Murang'a county.

Moreover, most urban developmental plans when done have been reactionary and only (30%) of urban centres in Kenya are actually planned for hugely due to fast population growth and planning capacity which is not adequate. In summary, inability of the residents to efficient and easy access to sewerage services is due to fast population growth poor planning of the buildings and settlement patterns.

(80.5%) consumers of sewerage services strongly agreed with the view that sewerage services are hindered by unplanned settlements as did (12.4%) of the consumers of sewerage services who agreed. However, (1.6%) of the consumers of sewerage services were undecided, (3.3%) disagreed whereas (2.2%) strongly disagreed.

KNBS (2016) also noted that inadequate potential combined with economic difficulties has hindered the design of solutions to the challenges brought about rapid urbanization. Unprecedented growth of urban areas has led to poor living standards which are caused by degradation of the environment and inefficiencies in economy. They grow without proper physical development plans. These findings imply that planning of settlements is

a major determinant of the extent to which residents access easy and efficient sewerage services in any urban area.

Majority of the consumers of sewerage services (67.4%) strongly agreed with the view that unplanned settlements outnumber the staff providing the sewerage service.(19.7%) agreed. However, (3.5%) of the consumers of sewerage services were undecided, (5.3%) disagreed whereas (4.1%) strongly disagreed. Buller (2006) noted that provision of sewerage services has become a difficult endeavour to most county governments due unavailable resources, inadequate staff and the high degrees of corruption.

According to Water Impact Report (2015), to mitigate on this shortage of workers, communities have organized themselves to form CBOs and youth groups with an aim of managing the waste and get some income.

This has led to creation of employment opportunities. This indicates that the success of any sewerage company to offer services depends largely on the adequate number of workers it has to meet the needs of consumers of sewerage services. From Table 3, majority (69.6%) of the consumers of sewerage services strongly agreed with the view that the company is serving a high number of settlements as did (13.8%) of the consumers of sewerage services who agreed. (1.6%) of the consumers of sewerage services were undecided, (10.6%) disagreed whereas (4.4%) strongly disagreed. Republic of Kenya (2012) report pointed that county governments have planning units and that 4 out of 175 have been struggling and dealing with mushrooming settlements that are not planned, all kinds of pollution, traffic menace, very expensive and inefficient transport system. According to RoK (2012), provision of sewerage services is overwhelmed by many households that need service since informal settlements house is projected to accommodate to over (60%) of urban population. These findings point

that efficient provision of sewerage services depends on the number of households. This indicates that, in designing sewerage system, the planners need to factor in the number of households to be served.

#### **4.2.1 Inferential Findings on the Influence of Settlement Patterns on Provision of Sewerage Services**

H<sub>01</sub>: There is no statistically significant relationship between unplanned settlements and provision of sewerage services in Kenol town of Murang'a County.

To verify the possibility of relationship between settlement patterns and provision of sewerage services, data were collected on the number of unplanned settlements in the four sections of Kenol Town and the number of consumers accessing sewerage services in those sections and results are shown in Table 4.

**Table 4: Results of the number of unplanned settlements and the number of Consumers Accessing Sewerage Services**

<b>No. of Unplanned Settlements</b>	<b>No. of Consumers Accessing Sewerage Services</b>
7	91
17	47
23	39
32	22

Source: Field Data (2019)

Table 4 indicates that, from the four sections of Kenol Town, the higher the number of unplanned settlements, the lower the number of consumers accessing sewerage services. The ability of sewerage companies to offer sewerage services to consumers largely depends on the manner in which different settlements within the town are planned. According to KNBS (2016) that planning of settlements is a major determinant of the

extent to which residents access easy and efficient sewerage services in any urban area. These results were subjected to linear regression analysis and results are shown in Table 5.

**Table 5: Linear Regression Analysis Showing Relationship between Number of Unplanned Settlements and Number of Consumers Accessing Sewerage Services**

Model	Unstandardized		Standardized	t	Sig.
	Coefficients				
	B	Std. Error	Beta		
1 (Constant)	103.088	11.416		9.030	.012
Number of Unplanned Settlements	-2.701	.525	-.964	-5.144	.036

a. Dependent Variable: Number of Consumers Accessing Sewerage Services

**Source: SPSS Generated (2019)**

Table 5 shows linear regression analysis which generated a linear regression model of the form; **Number of Consumers Accessing Sewerage Services = 103.088 – 2.701 Number of Unplanned Settlements**. These results from the linear regression equation indicate that the coefficient for the number of consumers who access sewerage services attributed to the number of unplanned settlements is -2.701. This implies that with increased number of unplanned settlements, the number of consumers who access sewerage services is expected to decrease by a factor of 2.701 (though negative coefficient). The value 103.088 indicates that number of consumers accessing sewerage services not only depends on planning of settlements, but a multiplicity of other factors such as socio-economic status of consumers to afford the services and attitude towards the service delivery.

From the results in Table 5, the p-value, 0.036 is less than 0.05, that is, a low p-value ( $0.036 < 0.05$ ) which indicates that the null hypothesis,  $H_{01}$ , is rejected. Thus, there is statistically significant relationship between planning of settlements and provision of sewerage services. Hence, proper planning of settlements should be carefully thought out as key determinant of consumers' easy access to efficient sewerage services in any urban area.

#### **4.2.2 Thematic Analysis of Qualitative Findings on the Influence of Settlement**

##### **Patterns on Provision of Sewerage Services**

MUSWASCo Management Officers and company workers were also interviewed. They also responded in favor of the view that there is no easy access to sewerage services to residents. According to the interviewees, unplanned settlements within the urban and sub-urban areas make it difficult to provide sewerage services. On further probing, MUSWASCo Management Officers, MMO1, noted;

*It is not easy to provide sewerage services to many consumers due to unplanned settlements. Many settlements in urban and sub-urban sections of Kenol Town are poorly designed and buildings are haphazardly set up in a manner that makes it difficult to provide sewerage services*

KNBS (2016) noted that the inadequate potential combined with economic difficulties has hindered the design of solutions to the challenges brought about rapid urbanization. According to KNBS (2016) urban areas grow without proper physical development plans and so in Kenol town in Murang'a county. These views further indicate that poor planning of settlements make it difficult for consumers to have easy access to sewerage services. On availability of staff, MUSWASCO Management Officers and company workers concurred with the consumers that company staff are not enough. On further probing, company worker, CW1, observed:

*Sometimes, it is very difficult to respond and address immediate needs and complaints from consumers due to too much workload attributed to inadequate number of sewerage staff in the company*

These views further support the views expressed by Buller (2006) that provision of sewerage services has become a difficult endeavor to most county governments due to unavailable resources, inadequate staff and the high degrees of corruption.

According to Water Impact Report (2015), to mitigate on this shortage of workers, communities have organized themselves to form CBOs and youth groups with an aim of managing the waste and get some income. This has led to creation of employment opportunities. Further, this implies that the success of any sewerage company to offer services depends largely on the adequate number of workers it has to meet the needs of consumers of sewerage services. MUSWASCO Management Officer, MMO2, further noted:

*The inability to respond to consumers' urgent need for sewerage services is attributed to a high number of households is served by the company compared to the number of staff available.*

According to Republic of Kenya (2012) the county governments have planning units and 4 out of 175 have been struggling. They are dealing with mushrooming settlements. They are not planned, they have all kinds of pollution, traffic menace and they are very expensive and have inefficient transport system. According to RoK (2012), provision of sewerage services is overwhelmed by many households that need service since informal settlements house is projected to accommodate to over (60%) of urban population. Hence, these views, as did the quantitative findings, point to the fact that provision of sewerage services depends on the number of households.

### 4.3 Financial Constraints and Provision of Sewerage Services

The study intended to find out the extent to which financial constraints influence provision of sewerage services. Descriptive data were collected from consumers of sewerage services and results are shown in Table 6.

**Table 6: Views of Consumer of Sewerage Services on the Influence of Financial Constraints on Provision of Sewerage Services**

Summary of Test Items	SA	A	U	D	SD
	%	%	%	%	%
The charges are too high to pay the sewerage services offered	55.9	15.1	2.8	16.8	9.4
The cost of providing sewerage services is too high	59.1	23.5	2.7	5.9	8.8
The sewerage company does not have enough resources to provide sewerage services	58.9	17.2	2.0	19.3	2.6
There is inadequate machinery to offer sewerage services	78.4	11.1	2.1	3.9	4.5

Source: Field Data (2019)

Table 6 reveals that (55.9%) strongly agreed with the view that the charges are too high to pay the sewerage services offered. (5.1%) agreed with the statement. (2.8%) of the consumers of sewerage services were undecided, (16.8%) disagreed whereas (9.4%) strongly disagreed. This study also revealed that (59.1%) consumers of sewerage services strongly agreed with the view that the cost of providing sewerage services is too high as did (23.5%) of the consumers of sewerage services who agreed. However, (2.7%) of the consumers of sewerage services were undecided, (5.9%) disagreed whereas (8.8%) strongly disagreed.

Kaluli (2011) pointed that financial resources hinder provision of sewerage services since the cost of discharge of effluents would be out of reach, whereas in other areas, the cost of collection and treatment of sewage could determine the extent to which sewage is reused. In order to effectively harvest the sewages for reuse it is necessary to have an elaborate infrastructure as well as systems to treat the water before reuse. This implies that the high cost of setting up this infrastructure and maintenance is a hindrance to the reuse, especially so for small to medium size communities and the urban poor who lack the resources but have the willingness to reuse the water for economic development. Similarly, slightly more than half of the consumers of sewerage services (58.9%) strongly agreed with the view that the sewerage company does not have enough resources to provide sewerage services as did (17.2%) of the consumers of sewerage services who agreed. However, (2.0%) of the consumers of sewerage services were undecided, (19.3%) disagreed whereas (2.6%) strongly disagreed.

KSSF (2016) pointed out that lack of funds to set up sewerage collection services in urban and sub-urban areas has led to developers building septic tanks for collection of all the domestic and commercial/institutional sewage which quite often overflow. In some areas, there is totally no collection system for the sewage. The water therefore gets into open channels and fields. This makes it hard to effectively harvest the sewage for reuse.

Like in most towns, Kenol town Murang'a South sub-county for example the sewage that runs in the open channels along the roads is used by the youth to wash vehicles but most of it runs down to the streams or open field. This indicates that financial constraints are a major impediment to provision of sewerage services in towns. A record majority of the consumers of sewerage services (78.4%) strongly agreed with the view that there is inadequate machinery to offer sewerage services as did (11.1%) of the

consumers of sewerage services who agreed. However, (2.1%) of the consumers of sewerage services were undecided, (3.9%) disagreed whereas (4.5%) strongly disagreed. According to KSSF (2016), the costs of machinery and sewerage pumps is very high and are of special design to be able to handle the dirt in the sewage and are more expensive than the ordinary fresh water pumps. Moreover, the operation of this equipment also requires competent personnel, where maintenance requires finances KSSF (2016).

The high cost price of reclaiming the sewage to usable waters versus the price farmers and other people are willing to spend makes it prohibitive. In other words, lack of funding as the major constraint of water reuse.

#### **4.3.1 Inferential Findings on the Influence of Financial Constraints on Provision of Sewerage Services**

H<sub>02</sub>: There is no statistically significant relationship between financial constraints and provision of sewerage services in Kenol town of Murang'a County.

To verify the possibility of relationship between financial constraints and provision of sewerage services, data were collected on the annual financial allocations for sewerage services in the four sections of Kenol Town and the number of consumers accessing sewerage services in those sections and results are shown in Table 7.

**Table 7: Results of the Annual Financial For sewerage Services and the Number of Consumers Accessing Sewerage Services**

<b>Annual Financial Allocations for Sewerage Services</b>	<b>No. of Consumers Accessing Sewerage Services</b>
363, 000	91
273, 000	47
231, 000	39
146, 000	22

Source: Field Data (2019)

Table 7 indicates that, from the four sections of Kenol Town, the higher the annual financial allocations for sewerage services, the higher the number of consumers accessing sewerage services. The ability of sewerage companies to offer sewerage services to consumers largely depends on the available financial resources.

The findings of Kaluli (2011) indicate that financial resources hinder provision of sewerage services since the cost of discharge of effluents would be out of reach, whereas in other areas, the cost of collection and treatment of sewage could determine the extent to which sewage is reused. These results were subjected to linear regression analysis and results are shown in Table 8.

**Table 8: Linear Regression Analysis Showing Relationship Between Annual Financial Allocations for Sewerage Services and the Number of Consumers Accessing Sewerage Services**

Model	Coefficients <sup>a</sup>					
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	
	B	Std. Error	Beta			
	(Constant)	105840.640	31538.374		3.356	.078
1	VAR0000	2963.002	564.288	.966	5.251	.034

a. Dependent Variable: VAR00001

Model	Coefficients					
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	
	B	Std. Error	Beta			
	(Constant)	100848.540	33466.788		3.013	.095
1	Annual Financial Allocations for Sewerage Services	3048.271	598.792	.964	5.091	.036

a. Dependent Variable: Number of Consumers Accessing Sewerage Services

**Source: SPSS Generated (2019)**

Model	Unstandardized		Standardized	t	Sig.
	Coefficients		Coefficients		
	B	Std. Error	Beta		
1 (Constant)	-32.624	19.306		-1.690	.233
Annual Financial Allocations for Sewerage Services	.329	.074	.953	4.448	.047

b. Dependent Variable: Number of Consumers Accessing Sewerage Services

**Source: SPSS Generated (2019)**

Table 8 shows linear regression analysis which generated a linear model of the form; **Number of Consumers Accessing Sewerage Services = -32.624 + 0.329 Annual Financial Allocations for Sewerage Services**. These results from the linear regression equation indicate that the coefficient for the number of consumers who access sewerage services attributed to the annual financial allocations for sewerage services is 0.329. This implies that with increased annual financial allocations, the number of consumers who access sewerage services is expected to increase by a factor of 0.329. The value -32.624 shows that number of consumers accessing sewerage services only depends on financial resources. Table 11 further shows the p-value, 0.047 is less than 0.05, that is, a low p-value ( $0.047 < 0.05$ ) which indicates that the null hypothesis,  $H_0$ , is rejected. Thus, there is statistically significant relationship between financial constraints and provision of sewerage services. Thus, financial resources determine the extent to which companies provide sewerage services.

In other words, lack of funds to set up sewerage collection services in urban and sub-urban areas has led to developers building septic tanks for collection of all the domestic and commercial/institutional sewage which quite often overflow.

#### **4.3.2 Thematic Analysis of Qualitative Findings on the Influence of Financial Constraints on Provision of Sewerage Services**

During the interviews, the MUSWASCO Management Officers and the company workers, however, expressed contrary views. The interviewees indicated that provision of sewerage services is the mandate of the company and nobody is required to pay any extra fees. These views contradict the views expressed by Kaluli (2011) that financial resources hinder provision of sewerage services since the cost of discharge of effluents would be out of reach, whereas in other areas, the cost of collection and treatment of sewage could determine the extent to which sewage is reused.

The findings are indicative of the fact that cost of setting up this infrastructure and maintenance is a hindrance to the reuse, especially so for small to medium size communities and the urban poor who lack the resources but have the willingness to reuse the water for economic development. This further indicates that lack of funds to set up sewerage collection services in urban and sub-urban areas has led to developers building septic tanks for collection of all the domestic and commercial/institutional sewage which quite often overflow. In other words, financial constraints are a major impediment to provision of sewerage services in towns. On the question about machinery, MUSWASCO Management Officers and the company workers concurred with the consumers that machinery for providing sewerage services are inadequate. One company worker, CW2, admitted:

*The company does not have adequate machines to provide services promptly to consumers. In cases of emergencies, sometimes, we are forced to hire machineries from the neighboring companies*

The cost of machinery and sewerage pumps is very high and they are of special design to be able to handle the dirt in the sewage and are more expensive than the ordinary fresh water pumps KSSF (2016). Hence, resources and finance are the main determinants of successful provision of efficient sewerage services.

#### **4.4 Technological Knowledge and Provision of Sewerage Services**

The study intended to assess the influence of technological knowledge on provision of sewerage services. Descriptive data were collected from consumers of sewerage services and results are shown in Table 9.

**Table 9: Views on Sewerage Services on the Influence of Technological Knowledge on provision of Sewerage Services**

Summary of Test Items	SA	A	U	D	SD
	%	%	%	%	%
There is unavailable modern sewer equipment which assist in providing sewerage services	58.8	21.6	4.1	10.4	5.1
There is lack of trained staff to offer modern sewerage services	59.9	19.8	2.5	12.2	5.6
There is no new technology in the provision of sewerage services	65.9	13.4	3.7	10.3	6.7
There is adequate and competent staff	69.1	18.1	2.8	7.0	3.0
There are no technological sewerage systems to run sewerage system and provide sewerage services in Kenol town	70.1	11.9	1.9	8.3	7.8

Source: Field Data (2019)

Table 9 reveals that (58.8%) strongly agreed with the view that there is unavailable modern sewer equipment which assists in providing sewerage services. At the same time, (21.6%) agreed. On the contrary, (4.1%) of the consumers of sewerage services were undecided, (10.4%) of them disagreed whereas (5.1%) strongly disagreed. According to Davis *et al* (2001), sewerage supply facilities and networks adopted automation in the early fifties.

According to Davis *et al* (2001), in other parts of the world, sewerage companies are making use of technology through the use of regulated operated pumps, coordinating withdrawals from various origins and dams and lastly controlling of purification in

facilities that reclaim sewages. These findings pointed that there is need to infuse technology in the sewerage management system to improve performance in provision of sewerage services to consumers. Similarly, (59.9%) strongly agreed with the view that there is lack of trained staff to offer modern sewerage services as did (19.8%) of the consumers of sewerage services who agreed. However, (2.5%) of the consumers of sewerage services were undecided, (12.2%) disagreed whereas (5.6%) strongly disagreed.

Majority of the consumers of sewerage services (65.9%) strongly agreed with the view that there is no new technology in the provision of sewerage services as did 13.4% of the consumers of sewerage services who agreed. However, (3.7%) of the consumers of sewerage services were undecided, (10.3%) disagreed whereas (6.7%) strongly disagreed. Majority of the consumers of sewerage services (69.1%) strongly agreed with the view that there is adequate and competent staff. At the same time, (18.1%) also agreed. However, (2.8%) of the consumers of sewerage services were undecided, (7.0%) disagreed whereas (3.0%) strongly disagreed. An impressive majority of the consumers of sewerage services (70.1%) strongly agreed with the view that there are no technological sewerage systems to run sewerage system and provide sewerage services in Kenol town. In the same vein, (11.9%) also agreed. However, (7.8%) of the consumers of sewerage services were undecided, (8.3%) disagreed whereas (3.0%) strongly disagreed.

According to Karanja and Nyambura (2014) that, in government facilities, provision of sewerage services is lagging behind in managing their supply and consumption and thus, improved performance will always be as a result of system technology and support of its adoption by consumers and the management. Renzetti and Dupont (2004) pointed that, in countries like Israel, every consumer is served with a sewerage meter. These

findings point to the fact that technology has become vital thing in provision of sewerage services and sewerage companies must adopt despite the challenges.

#### **4.4.1 Inferential Findings on the Influence of Technological Knowledge on**

##### **Provision of Sewerage Services**

*H<sub>03</sub>: There is no statistically significant relationship technological knowledge on provision of sewerage services in Kenol town in Murang'a County.*

To verify the possibility of relationship between technological knowledge and provision of sewerage services, data were collected on the number of staff with technology skills and the number of consumers accessing sewerage services in those sections and results are shown in Table 10.

**Table 10. Results of the Number of Staff with Technology Skills and the Number of Consumers Accessing Sewerage Services**

<b>No. of Staff with Technology Skills</b>	<b>No. of Consumers Accessing Sewerage Services</b>
17	91
12	47
9	39
7	22

Source: Field Data (2019)

Table 10 indicates that, from the four sections of Kenol Town, the higher the number of staff with technological skills, the higher the number of consumers accessing sewerage services.

In other words, the ability of sewerage companies to offer sewerage services to consumers largely depends on the number of trained staff with technological skills to offer sewerage services to consumers. These results further lend credence to the

assertions of Karanja and Nyambura (2014) that provision of sewerage services is lagging behind in managing their supply and consumption and thus, improved performance will always be as a result of system technology and support of its adoption by consumers and the management. These results were subjected to linear regression analysis and results are shown in Table 11.

**Table 11. Linear Regression Analysis Showing Relationship Between Number of Staff with Technological Skills and the Number of Consumers Accessing Sewerage Services**

Model	Coefficients <sup>a</sup>				t	Sig.
	Unstandardized Coefficients		Standardized Coefficients			
	B	Std. Error	Beta			
1	(Constant)	4.017	1.070		3.754	.064
	VAR0000	.145	.019	.983	7.595	.017

a. Dependent Variable: Number of Consumers Accessing Sewerage Services

**Source: SPSS Generated (2019)**

Model	Coefficients <sup>a</sup>				t	Sig.
	Unstandardized Coefficients		Standardized Coefficients			
	B	Std. Error	Beta			
1	(Constant)	-16.073	15.880		-1.012	.418
	Number of Staff with Technological Skills	5.851	1.325	.952	4.417	.048

b. Dependent Variable: Number of Consumers Accessing Sewerage Services

**Source: SPSS Generated (2019)**

Table 11 shows linear regression analysis which generated a linear model of the form; **Number of Consumers Accessing Sewerage Services = -16.073 +5.851 Number of Staff with Technological Skills**. These results from the linear regression equation indicate that the coefficient for the number of consumers who access sewerage services attributed to the number of staff with technological skills is 5.851. This implies that with increased number of staff with technological training and skills, the number of consumers who access sewerage services is expected to increase by a factor of 5.851.

The value -16.073 indicates that number of consumers accessing sewerage services mostly depend on the availability of staff with technological skills to offer sewerage services. From Table 14, the p-value, 0.048 is less than 0.05, that is, a low p-value (0.048 < 0.05) which indicates that the null hypothesis, **H<sub>03</sub>**, is rejected. Thus, there is statistically significant relationship between availability of trained staff with technological skills and provision of sewerage services.

Trained staffs with skills in use of technology play an important role in efficient provision of sewerage services.

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.	
	B	Std. Error	Beta		
(Constant)	2.997	1.769		1.694	.232
1					
Number of Staff with Technological Skills	.171	.032	.967	5.402	.033

a. Dependent Variable: Number of Consumers Accessing Sewerage Services

**Source: SPSS Generated (2019)**

#### **4.4.2 Thematic Analysis of Qualitative Findings on the Influence of Technology**

##### **Knowledge on Provision of Sewerage Services**

Qualitative data was also collected using interviews. During the interviews, MUSWASCo Management Officers and company workers noted that modern sewer equipment is unavailable to assist in the provision of sewerage services. They also concurred with the consumers that the Sewerage Company has few trained staff to offer modern sewerage services. According to Davis *et al* (2001), sewerage supply facilities and networks adopted automation in the early fifties. These views further indicate that technology is critical in improving provision of sewerage services. In other words, provision of sewerage services is lagging behind in managing their supply and consumption and thus, improved performance will always be as a result of system technology and support of its adoption by consumers and the management. Hence, technology has become the in thing in provision of sewerage services and sewerage companies must adopt despite the challenges.

#### **4.5 Physical Environment and Provision of Sewerage Services**

The study intended to find out how physical environment influences provision of sewerage services. Descriptive data were collected from consumers of sewerage services and results are shown in Table 12.

**Table 12: Views on Consumer of Sewerage Services on the Influence of Physical Environment on provision of Sewerage Services**

<b>Summary of Test Items</b>	<b>SA</b>	<b>A</b>	<b>U</b>	<b>D</b>	<b>SD</b>
	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>
Weather condition is reliable to enhance provision of sewerage services	69.1	19.4	1.1	6.9	3.5
There is provision of pathways where sewer lines are constructed	71.4	17.9	2.3	5.2	3.2

Source: Field Data (2019)

Table 12 reveals that (69.1%) strongly agreed with the view that weather condition is reliable to enhance provision of sewerage services. At the same time, (19.4%) agreed. (1.1%) of the consumers of sewerage services was undecided, (6.9%) disagreed whereas (3.5%) strongly disagreed. According to Fatta (2005) that the cost of treating sewage to high microbiological standards could be so exorbitant that use of raw sewage is allowed to occur unregulated so as to meet throughput goals. This implies that physical environment is a major determinant of the extent to which consumers access sewerage services.

The study also revealed (71.4%) strongly agreed with the view that there is provision of pathways where sewer lines are constructed as did (17.9%) of the consumers of sewerage services. However, (2.3%) of the consumers of sewerage services were undecided, (5.2%) disagreed whereas (3.2%) strongly disagreed.

According to Urban Areas and Cities Act (2011), the biggest challenge experienced in developing countries is that there is very small scale of institutional arrangements for sewage reuse policies and in some cases, the policies may not be well established and lack of clear guidelines. According to Urban Areas and Cities Act (2011), it is vital to establish realistic, achievable and enforceable policies in order to ensure sustainable

management and reuse of the sewage. Moreover, establishment of unrealistic standards and regulations will lead to aversion among the stakeholders. This indicates that every urban center has got well-designed pathways where sewer lines ought to be constructed despite the challenges.

#### **4.5.1 Levels of Satisfaction with Physical Environment**

The study also collected data on the levels of satisfaction with the physical environment. Descriptive data were collected from consumers of sewerage services and results are shown in Table 13.

**Table 13: Level of Satisfaction with Physical Environment**

<b>Levels of Satisfaction</b>	<b>Number of Consumers of Sewerage Services</b>	
	<b>f</b>	<b>%</b>
<b>Highly satisfied</b>	57	28.6
<b>Satisfied</b>	17	8.5
<b>Not satisfied</b>	113	56.8
<b>Not sure</b>	12	6.1

Source: Field Data (2019)

Table 13 shows (56.8%) of the consumers of sewerage services were not satisfied with physical environment as a determinant to access to sewerage services, (28.6%) were highly satisfied, (8.5%) were satisfied whereas (6.1%) were not sure of the levels of satisfaction.

According to Kenya's National Policy on Environment (2012) that on waste management; the government would come up with a combined waste management strategy which is aimed at promoting the use of instruments of economy. This strategy helps to encourage the establishment of facilities and guidelines for cleaner production,

manage waste recovery, recycling and reuse and thus, boost consumers' levels of satisfaction.

#### **4.5.2 Inferential Findings on the Influence of Physical Environment on Provision of Sewerage Services**

*H<sub>04</sub>: There is no statistically significant relationship between physical environment and the provision of sewerage services in Kenol town in Murang'a County.*

To verify the possibility of relationship between physical environment and provision of sewerage services, data were collected on the levels of satisfaction with the physical environment and the number of consumers accessing sewerage services in those sections and results are shown in Table 14.

**Table 14: Results of the levels of Satisfaction with Physical Environment and the Number of Consumers Accessing sewerage Services**

<b>Levels of satisfaction with Physical Environment</b>	<b>No. of Consumers Accessing Sewerage Services</b>
4	91
2	47
1	39
1	22

Source: Field Data (2019)

Table 17 indicates that, from the four sections of Kenol Town, the higher the levels of satisfaction with the conditions of the physical environment, the higher the number of consumers accessing sewerage services. These results were subjected to linear regression analysis and results are shown in Table 15.

**Table 15: Linear Regression Analysis Showing Relationship Between levels of Satisfaction with Physical Environment and the Number of Consumers Accessing Sewerage Services**

Model	Unstandardized		Standardized	t	Sig.
	Coefficients		Coefficients		
	B	Std. Error	Beta		
1 (Constant)	9.417	8.417		1.119	.380
Levels of Satisfaction with Physical Environment	20.167	3.589	.970	5.619	.030

a. Dependent Variable: Number of Consumers Accessing Sewerage Services

**Source: SPSS Generated (2019)**

Table 15 shows linear regression analysis which generated a linear model of the form; **Number of Consumers Accessing Sewerage Services = 9.417 + 20.167Levels of Satisfaction with Physical Environment.** These results from the linear regression equation indicate that the coefficient for the number of consumers who access sewerage services attributed to the levels of satisfaction is 20.167. This implies that with increased levels of satisfaction, the number of consumers who access sewerage services is expected to increase by a factor of 20.167. The value 9.417 indicates that number of consumers accessing sewerage services depend on the levels of satisfaction with conditions within the physical environment where sewer lines are to be constructed. From Table 15, the p-value, 0.030 is less than 0.05, that is, a low p-value (0.030 < 0.05) which indicates that the null hypothesis, **H<sub>04</sub>**, is rejected. Thus, there is statistically significant relationship between physical environment and provision of sewerage

services. This affirms the fact that physical environment where sewer lines are to be constructed is critical since it determines the number of consumers to be tapped.

#### **4.5.3 Thematic Analysis of Qualitative Findings on the Influence of Physical**

##### **Environment on Provision of Sewerage Services**

During the interviews, the MUSWASCo Management Officers and company workers also responded in favor of the view that weather condition is reliable to enhance provision of sewerage services. According to the views expressed by Fatta (2005) that the cost of treating sewage to high microbiological standards could be so exorbitant that use of raw sewage is allowed to occur unregulated so as to meet throughput goals. On the question of pathways for sewer lines, the interviewees concurred:

*There are designs and plans showing pathways where sewer lines are constructed despite the unplanned settlements in some instances*

According to Urban Areas and Cities Act (2011), the biggest challenge experienced in developing countries is that there is very small scale of institutional arrangements for sewage reuse policies and in some cases, the policies may not be well established and lack of clear guidelines. However, the interviewees concurred with the provision of Urban Areas and Cities Act (2011) that it is vital to establish realistic, achievable and enforceable policies in order to ensure sustainable management and reuse of the sewage.

These findings are indicative of the fact that every urban center has got well-designed pathways where sewer lines ought to be constructed despite the challenges. In other words, physical environment is a major determinant of the extent to which consumers access sewerage services.

## **CHAPTER FIVE**

### **SUMMARY, CONCLUSION AND RECOMMENDATIONS**

#### **5.1 Introduction**

Summary, conclusion and recommendation have been covered in this chapter. The content is in line with study objectives.

#### **5.2 Summary of Research findings**

This section gives a summary based on the objectives. They were; effect of unplanned settlements, financial constraints, technology knowledge and physical environment on provision of sewerage services.

##### **5.2.1 Settlement Patterns and Provision of Sewerage Services**

More than two thirds of the consumers of sewerage services strongly agreed with the view that there is no easy access to sewerage services. At the same time slightly more than a tenth of the consumers of sewerage services agreed with the statement. However, only a few of the consumers of sewerage services were undecided, about a tenth disagreed whereas a fraction strongly disagreed. Two thirds of the consumers of sewerage services strongly agreed with the view that buildings are not well planned as did slightly more than a tenth of the consumers of sewerage services who agreed. At the same time, less than a fifth of the consumers of sewerage services were undecided, disagreed and strongly disagreed.

Moreover, most urban developmental plans when done have been reactionary and only a third of urban centres in Kenya are actually planned for hugely due to fast population growth and planning capacity which is not adequate. In summary, inability of the residents to efficient and easy access to sewerage services is due to fast population growth poor planning of the buildings and settlement patterns. More than three quarters

consumers of sewerage services strongly agreed with the view that sewerage services are hindered by unplanned settlements as did a tenth of the consumers of sewerage services who agreed. However, a percentile of the consumers of sewerage services were undecided, a mere fraction disagreed and strongly disagreed.

The study established that there is no easy access to sewerage services to residents. Unplanned settlements within the urban and sub-urban areas make it difficult to provide sewerage services. This indicates that inadequate potential combined with economic difficulties has hindered the design of solutions to the challenges brought about rapid urbanization. Urban areas grow without proper physical development plans and so in Kenol town in Murang'a county. These views further indicate that poor planning of settlements make it difficult for consumers to have easy access to sewerage services. The study also established that company staff is not enough to cater for the needs of all consumers of sewerage services. Thus, provision of sewerage services depends on the number of households to be served.

### **5.2.2 Financial Constraints and Provision of Sewerage Services**

The study also established that financial resources allocated for sewerage services are often inadequate. In other words, inadequate financial resources hinder provision of sewerage services since the cost of discharge of effluents would be out of reach, whereas in other areas, the cost of collection and treatment of sewage could determine the extent to which sewage is reused. The cost of setting up this infrastructure and maintenance is a hindrance to the reuse, especially from small to medium size communities and the urban poor who lack the resources but have the willingness to reuse the water for economic development. Lack of funds to set up sewerage collection services in urban and sub-urban areas has led to developers building septic tanks for collection of all the domestic and commercial/institutional sewage which quite often

overflow. Besides, the costs of machinery and sewerage pumps is very high and are of special design to be able to handle the dirt in the sewage and are more expensive than the ordinary fresh water pumps.

### **5.2.3 Technological Knowledge and Provision of Sewerage Services**

The sewerage company lacks modern sewer equipment to assist in the provision of sewerage services characterized by few trained staff to offer such modern sewerage services. This indicates that, that sewerage supply facilities and networks adopted automation in the early fifties. As noted earlier, provision of sewerage services is lagging behind in managing their supply and consumption and thus, improved performance will always be as a result of system technology and support of its adoption by consumers and the management. Hence, technology has become the in thing in provision of sewerage services and sewerage companies must adopt despite the challenges.

### **5.2.4 Physical Environment and Provision of Sewerage Services**

The study also established that weather condition is reliable to enhance provision of sewerage services. The study also revealed that there is provision of pathways where sewer lines are constructed. The cost of treating sewage to high microbiological standards could be so exorbitant that use of raw sewage is allowed to occur unregulated so as to meet throughput goals. This implies that physical environment is a major determinant of the extent to which consumers access sewerage services.

From the study findings, the biggest challenge experienced in developing countries is that there is very small scale of institutional arrangements for sewage reuse policies and in some cases, the policies may not be well established and lack of clear guidelines.

Thus, every urban center has got well-designed pathways where sewer lines ought to be constructed despite the challenges.

### **5.3 Conclusions**

From the findings, there is no easy access to sewerage services to residents. Unplanned settlements within the urban and sub-urban areas make it difficult to provide sewerage services. In other words, poor planning of settlements and inadequate number of trained company staff make it difficult for consumers to have easy access to sewerage services. It is also evident that financial resources allocated for sewerage services are often inadequate which hinder provision of sewerage services.

Besides, lack of funds to set up sewerage collection services in urban and sub-urban areas has led to developers building septic tanks for collection of all the domestic and commercial/institutional sewage which quite often overflow. From the study findings, it is also evident that the sewerage company lacks modern sewer equipment to assist in the provision of sewerage services characterized by few trained staff to offer such modern sewerage services. Hence, technology has become the in thing in provision of sewerage services and sewerage companies must adopt despite the challenges. From the study findings, physical environment is also important in the provision of sewerage services. That is, weather condition is reliable and pathways for construction of sewer lines to enhance provision of sewerage services.

### **5.4 Recommendations**

- i. On settlement patterns, the County Government should ensure that all buildings and any other form of settlement are planned and designed in a manner not to interfere with the pathways for construction of sewer lines.

- ii. On financial constraints, the County Government should allocate more financial resources towards provision sewerage services.
- iii. On technology knowledge, the County Government should offer training opportunities for its staff in sewerage departments to advance their skills in modern sewerage system using technology.
- iv. On physical environment, the County Government should ensure physical planning is adhered to and that any construction must conform to weather conditions such as the physical location of rivers and other natural resources.
- v. The County Government should formulate a policy which puts strict and punitive measures to any individual which does not adhere to physical planning and sewerage designs while setting up any structure.

#### **5.4.1 Suggestions for Further Research**

- i. A study should be carried out to assess the extent to which staff influences provision of sewerage services.
- ii. A study should be conducted to examine the extent to which awareness strategies influence provision of sewerage services.

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## APPENDICES

### Appendix 1: Letter of Introduction

April, 2019

Dear Sir/Madam,

RE: PERMISSION TO CARRY OUT RESEARCH

I am a student undertaking a course in Master of Arts in Geography at Mount Kenya University. My research topic is: **Evaluation of the Provision of Sewerage Services among the residents of Kenol Town, Murang'a County, Kenya**. In order to succeed in this noble task, you are requested to be part of the study. Humbly, I request you to assist by participating in the study. The study's information will be used purely for academic purpose and your name will not be given anywhere in the report.

I will highly appreciate your participation and co-operation.  
Thank you.

Rufus Kinyanjui Ng'ang'a.

## Appendix II: Informed Consent Form

Dear respondent,

The researcher is taking a degree course in Master of Arts in Geography in Mount Kenya University carrying out a research on **Evaluation of the Provision of Sewerage Services among the residents of Kenol Town, Murang'a County, Kenya**. My request is to be granted some of your time to conduct some interview concerning this study. Your privacy and confidentiality will be maintained. Your identity will be withheld because your information and your participation will be voluntary and only researcher will have access to it, and you may decide not to participate prior or during the interview. No payment or facility will be provided by the researcher towards this participation. Please, if you are willing to be part of this study sign the form below. In case of complaint or any misunderstanding, please contact;

THE CHAIRMAN, ERC, MKU

P. O. Box 342-01000

THIKA

Participant:

-----	-----	-----
Code of Participant	Signature	Date

Researcher:

-----	-----	-----
Name of Researcher	Signature	Date



**Section C: Financial Constraints and Provision of Sewerage Services**

1. How much do you think sewerage companies allocate annually for sewerage services?

.....  
 .....

2. Key: **SA**-Strongly Agree **A**-Agree **U**-Undecided **D**-Disagree **SD**-Strongly Disagree

Test Items	SA	A	U	D	SD
	5	4	3	2	1
The charges are too high to pay the sewerage services offered					
The cost of providing sewerage services is too high					
The sewerage company does not have enough resources to provide sewerage services					
There is inadequate machinery to offer sewerage services					

**Section D: Technological Knowledge and Provision of Sewerage Services**

1. How many company staff has technology skills?

.....

2. Key: **SA**--Strongly Agree    **A**--Agree    **U**--Undecided    **D**--Disagree    **SD**--Strongly Disagree

<b>Test Items</b>	<b>SA</b>	<b>A</b>	<b>U</b>	<b>D</b>	<b>SD</b>
	<b>5</b>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>
There is unavailable modern sewer equipment which assist in providing sewerage services					
There is lack of trained staff to offer modern sewerage services					
There is no new technology in the provision of sewerage services					
There is adequate and competent staff					
There are no technological sewerage systems to run sewerage system and provide sewerage services in Kenol town					

**Section E: Physical Environment and Provision of Sewerage Services**

1. Please, rate your levels of satisfaction with the physical environment where sewer lines are to be constructed

Highly satisfied [ ]

Satisfied [ ]

Not satisfied [ ]

Not sure [ ]

2. Key: **SA**--Strongly Agree    **A**--Agree    **U**--Undecided    **D**--Disagree    **SD**--Strongly Disagree

Test Items	SA	A	U	D	SD
	5	4	3	2	1
Weather condition is reliable to enhance provision of sewerage services					
There is provision of pathways where sewer lines are constructed					

Thank you,

Rufus Kinyanjui Ng'ang'a

**Appendix IV: Interview Guides for MUSWASCo Management Officers and Company Workers**

Dear respondent,

The researcher is taking a degree course in Master of Arts in Geography in Mount Kenya University carrying out a research on **Evaluation of the Provision of Sewerage Services among the residents of Kenol Town, Murang'a County, Kenya**. No information will be disclosed to anyone.

**Section A: General Information**

1. Gender:.....
2. What is your highest level of education?.....

**Section B: Unplanned Settlements and Provision of Sewerage Services**

1. Kenol town is divided into how many sections?

.....  
.....

2. How many unplanned settlements do you have in every section in Kenol Town?

.....  
.....

3. To what extent do unplanned settlements influence provision of sewerage services?

.....  
.....  
.....

**Section C: Financial Constraints and Provision of Sewerage Services**

1. How much do you allocate annually for sewerage services?

.....

2. What is the influence of financial constraints on provision of sewerage services?

.....

**Section D: Technological Knowledge and Provision of Sewerage Services**

1. How many of your company staff have technology skills?

.....

2. How does technological knowledge among your staff influence provision of sewerage services?

.....

**Section E: Physical Environment and Provision of Sewerage Services**

1. How would you rate the levels of satisfaction with the physical environment where sewer lines are to be constructed among consumers of sewerage services?

.....

2. To what extent does physical environment influence provision of sewerage services?

.....

Thank you,

Rufus Kinyanjui Ng'ang'a

**Appendix V: Introduction Letter from The School of Postgraduate Studies of  
Mount Kenya University**



**SCHOOL OF POSTGRADUATE STUDIES**

MAGE/2017/71264

8<sup>th</sup> April, 2019

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

Dear Sir/Madan,

**RE: RUFUS KINYANJUI NG'ANG'A - REGISTRATION NO. MAGE/2017/21264**


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

The title of his research is *"Challenges in the Provision of Sewerage Services in Kenol Town, Murang'a County."*

He has been cleared by the University's Ethics Review Committee (Certificate attached) and now has to proceed to the field to collect data for his research between **April and June, 2019.**

Any assistance accorded to him will be highly appreciated.

Thank you.

*for* 

Mount Kenya University  
School of Postgraduate Studies  
P. O. Box 342 - 01000 Thika

**Dr. Samuel M. Karenga, Ph.D**  
**Dean, School of Postgraduate Studies**  
**Enc.**




# Mount Kenya University

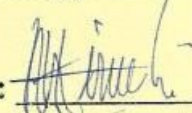
MARCH 28, 2019

Ref. No. MKU/ERC/1199

## CERTIFICATE OF ETHICAL CLEARANCE

This is to certify that the proposal titled “**CHALLENGES IN THE PROVISION OF SEWERAGE SERVICES IN KENOL TOWN, MURANG’A COUNTY**” whose Principal Investigator is Rufus Kinyanjui Ng’ang’a (MAGE/2017/71264) has been reviewed by Mount Kenya University Ethics Review Committee (ERC), and found to adequately address all ethical concerns.

 **Dr Francis W. Makokha**  
Secretary, Mount Kenya University ERC

Sign: 

Date: 28/3/2019

**Prof. Francis W. Muregi**  
Chairman, Mount Kenya University ERC

Sign: 

Date: 28.03.2019

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

**Appendix VII: Authorization Letter from National Commission for Science,  
Technology and Innovation, NACOSTI**



**NATIONAL COMMISSION FOR SCIENCE,  
TECHNOLOGY AND INNOVATION**

Telephone: +254-20-2213471,  
2241349, 3310571, 2219420  
Fax: +254-20-318245, 318249  
Email: dg@nacosti.go.ke  
Website: www.nacosti.go.ke  
When replying please quote

NACOSTI, Upper Kabete  
Off Waiyaki Way  
P.O. Box 30623-00100  
NAIROBI-KENYA

Ref: No. **NACOSTI/P/19/84802/29573**

Date: **12<sup>th</sup> April, 2019**

Rufus Kinyanjui Nganga  
Mount Kenya University  
P.O. Box 342-01000  
**THIKA**

**RE: RESEARCH AUTHORIZATION**

Following your application for authority to carry out research on "*Challenges in the provision of sewerage services in Kenol Town, Murang'a County, Kenya*" I am pleased to inform you that you have been authorized to undertake research in **Murang'a County** for the period ending **12<sup>th</sup> April, 2020**.

You are advised to report to **the County Commissioner and the County Director of Education, Murang'a County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit a **copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

**GODFREY P. KALERWA MSc., MBA, MKIM  
FOR: DIRECTOR-GENERAL/CEO**

Copy to:

The County Commissioner  
Murang'a County.

The County Director of Education  
Murang'a County.



## Appendix IX: Research Permit from NACOSTI, Back Page

### THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013

The Grant of Research Licenses is guided by the Science, Technology and Innovation (Research Licensing) Regulations, 2014.

#### CONDITIONS

1. The License is valid for the proposed research, location and specified period.
2. The License and any rights thereunder are non-transferable.
3. The Licensee shall inform the County Governor before commencement of the research.
4. Excavation, filming and collection of specimens are subject to further necessary clearance from relevant Government Agencies.
5. The License does not give authority to transfer research materials.
6. NACOSTI may monitor and evaluate the licensed research project.
7. The Licensee shall submit one hard copy and upload a soft copy of their final report within one year of completion of the research.
8. NACOSTI reserves the right to modify the conditions of the License including cancellation without prior notice.

National Commission for Science, Technology and innovation

P.O. Box 30623 - 00100, Nairobi, Kenya

TEL: 020 400 7000, 0713 788787, 0735 404245

Email: [dg@nacosti.go.ke](mailto:dg@nacosti.go.ke), [registry@nacosti.go.ke](mailto:registry@nacosti.go.ke)

Website: [www.nacosti.go.ke](http://www.nacosti.go.ke)



REPUBLIC OF KENYA



National Commission for Science,  
Technology and Innovation

RESEARCH LICENSE

Serial No.A 24047

CONDITIONS: see back page

**Appendix X: Research Authorization Letter from County Commissioner,  
Murang'a**

REPUBLIC OF KENYA



**THE PRESIDENCY**

MINISTRY OF INTERIOR AND CO-ORDINATION OF NATIONAL GOVERNMENT

Telephone: 060-2030467  
Email: cc.muranga@interior.go.ke

COUNTY COMMISSIONER  
MURANG'A COUNTY  
P. O. BOX 7-10200  
MURANG'A

*When replying please quote*

**REF.NO.PUB.24/11/VOL.1II/27**  
**RUFUS KINYANJUI NG`ANG`A**  
**MOUNT KENYA UNIVERSITY**  
**P.O BOX 342-01000**  
**THIKA.**

**26<sup>RD</sup> APRIL, 2019.**

**RE: RESEARCH AUTHORIZATION.**

In reference to a letter **NACOSTI/P/19/84802/29573** dated **12<sup>TH</sup> APRIL, 2019** from the National Commission for Science, Technology and Innovation regarding the above subject, you are hereby authorized to carry out research on ***“Challenges in the provision of sewerage services in Kenol town , Murang`a County`***  
*For the period ending 12<sup>TH</sup> April ,2020 .*

  
**DANIEL MWENDWA**  
FOR: COUNTY COMMISSIONER  
**MURANG'A COUNTY.**

**CC: Deputy County Commissioner**  
**Murang`a South Sub-County**

**Appendix XI: Research Authorization Letter from County Director of Education,  
Murang'a**



**MINISTRY OF EDUCATION  
STATE DEPARTMENT OF EARLY LEARNING AND BASIC EDUCATION**

**Email: [cdemuranga@gmail.com](mailto:cdemuranga@gmail.com)  
Telephone: 060 2030227  
When replying please quote**

**COUNTY DIRECTOR OF EDUCATION  
P.O BOX 118 - 10200  
MURANG'A**

**REF: MGA/CTY/GEN./64/VOL.III/258**

**26<sup>th</sup> April, 2019**

Rufus Kinyanjui Nganga  
Mount Kenya university  
P.O.Box 342-01000  
**THIKA**

**RE: RESEARCH AUTHORIZATION**

The County Education office is in receipt of your request and authority letter from the National Commission for Science, Technology and Innovation, reference No. NACOSTI/P/19/84802/29573 dated **12<sup>th</sup> April, 2019** to carry research on **"Challenges in the provision of sewerage services in Kenol Town, Murang'a County, Kenya"**

Permission is hereby granted to carry out Research in **Murang'a County** for a period ending **12<sup>th</sup> April, 2020**.

You are kindly advised to deposit a copy of the final research report to the County Director of Education office.

A handwritten signature in blue ink, appearing to read 'Anne Kilu'.

Anne Kilu  
County Director of Education  
**MURANG'A**

EVALUATION OF THE  
PROVISION OF SEWERAGE  
SERVICES AMONG THE  
RESIDENTS OF KENOL TOWN,  
MURANG'A COUNTY, KENYA

*by* Kinyanjui Rufus

---

**Submission date:** 12-Feb-2021 05:56PM (UTC+0300)  
**Submission ID:** 1507949953  
**File name:** Rufus\_Kinyanjui.pdf (2.03M)  
**Word count:** 24335  
**Character count:** 140932

  
Ann Mwangi  
13-02-2021

## EVALUATION OF THE PROVISION OF SEWERAGE SERVICES AMONG THE RESIDENTS OF KENOL TOWN, MURANG'A COUNTY, KENYA

### ORIGINALITY REPORT

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*[Handwritten signature]*  
11/11/2021

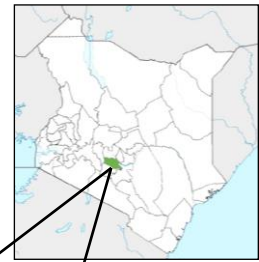
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13-02-2021

## Appendix XII: Map Showing Kenol Town



### Kenol Town

