FACTORS INFLUENCING WASTEWATER MANAGEMENT AND RE-USE IN PERI-URBAN AREAS IN KENYA: A CASE OF ONGATA RONGAI

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DECLARATION

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

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DEDICATION

This study is dedicated to my wife Rose, Mother Ruth and Aunt Phanice for their unrelenting support.

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ABBREVIATIONS AND ACRONYMS

ASAL – Arid and Semi-Arid Lands

CBO – Community Based Organization

df – degrees of freedom

FAO – Food and Agriculture Organization

ISSUE – Integrated Support for Sustainable Urban Environment

JICA – Japan International Corporation Agency

MAWEREMA – Menengai Waste Recycling Management

MDG – Millennium Development Goals

NEMA – National Environmental Management Authority

NGO – Non Governmental organization

R – Pearson's Correlation Coefficient

R^2 – Coefficient of determination

TPB – Theory of Planned Behavior

UK – United Kingdom

UN – United Nations

UNDESA –United Nations Department of Economic and Social Affairs

UNEP – United Nations Environment Programme

UNESCO – United Nations Education Scientific and Cultural Organization

UNICEF – United Nations Children's Fund

USEPA – United States Environmental Protection Agency

WHO – World Health Organization

x^2 – Chi-square

ABSTRACT

Water related challenges are increasingly becoming recognized as a major environmental threat to mankind. Since 1950s, water use has more than tripled, according to WHO and UNICEF report of 2000, lack of access to safe drinking water affects the health of 1.2billion people annually. In order to address these challenges there is need to improve the efficiency of consumptions and seek sustainable alternative sources. Several approaches exist among them efficient and effective wastewater management and reuse to supplement fresh water and keep environment clean. This study was based in Ongata Rongai, Kajiado county Kenya. The purpose of the study was to investigate the factors that influence wastewater management and reuse in peri-urban areas in Kenya. It was guided by six objectives: to assess the influence of water availability on wastewater management and reuse in Ongata Rongai; to assess the influence of culture on wastewater management and reuse in Ongata Rongai; to examine the influence of institutional arrangements on wastewater management and reuse; to establish the influence of developmental planning on wastewater management and reuse in Ongata Rongai; to examine the influence of financial resources on wastewater management and reuse and to assess the influence of technology on wastewater management and reuse in Ongata Rongai. This was a fact finding study and therefore descriptive research design was employed under which survey and observation methods were used in data collection. Cluster sampling was used in which the study area was divided into six clusters (area - cluster sampling) and simple random selection of fifty sampling units were studied in each of the clusters totaling to three hundred units. The data was manually edited, coded and analyzed using mainly descriptive statistics and inferential statistics that were done with the help of Excel and SPSS. Pearson's Correlation Coefficient and Chi square analysis were used to establish the association and relationship between the independent and dependent variables. The study established that water availability has direct influence on wastewater management and reuse. The Pearson's Correlation Coefficient between the respective indicators and wastewater reuse were very close to one signifying a statistically significant correlation. Similar results were found between the following variables and wastewater management and reuse in Ongata Rongai: financial resources, developmental planning and technology. Chi square analysis between culture, institutional arrangement and wastewater management and reuse yielded results that showed insignificant association between them and wastewater management and reuse in Ongata Rongai. Among the recommendations made by the study are legislations of enforceable by-laws governing reuse of wastewater, educational awareness to equip people with the advantages of reusing wastewater to for example conserve the environment and reduce water stress on fresh water. Further research is required to establish the influence of education, political commitment, age, attitude, poverty, health and safety among others on wastewater management and reuse.

CHAPTER ONE
INTRODUCTION

1.1 Background of Study

Water is an essential component of life and concerted effort is required in its conservation. It is estimated that 97% of all water on earth is found in oceans (UNESCO, 2004) and only 1% of the remainder fresh water is accessible for use (Corcoran, 2010). A functioning and healthy aquatic life provides us with food, medicine, recreation, shoreline protection, waste processing among other benefits. The world currently is facing water crisis both in terms of quality and quantity caused by among others increase in population, industrialization, food production practices, increased living standards and poor water use strategies. Effective wastewater management or lack of has direct impact on the biological diversity of ecosystems, disrupting the fundamental integrity of life support system upon which a wide range of sectors from urban development, food production and industry depend. It is therefore essential that wastewater is considered as part of the integrated, ecosystem based management that operates across sectors and borders.

Freshwater is a scarce resource and its distribution does not match the human development pattern. Over half of the world population faces water scarcity since it plays a vital role in the sustenance of all life; water is a source of economic and political power (Narasimhan T.N, 2008) with water scarcity a limiting factor in economic and social development. Over 900 million people world over do not have access to safe drinking water (UNDESA, 2009) and some 2.6 billion do not have access to adequate sanitation (WHO/UNICEF, 2010).

Water scarcity in Kenya is a major hindrance to development activities and therefore there is a great need for water saving and water enhancement strategies. In 2006 it was estimated that water availability in Kenya was $650m^3$/year per capita and was likely to drop to $350m^3$/year by the year 2020 (Ngigi 2006). With diminishing per capita fresh water availability there is increasing dominance of wastewater balance. This makes wastewater an important source of irrigation water for urban agriculture (Githuku C, 2009), biogas generation, car washing, domestic applications like flashing toilets, kitchen garden irrigation among others.

Cities around the globe are faced with numerous challenges ranging from provision of decent and adequate housing, provision of safe drinking water, providing proper waste management among other amenities. Increased population in urban areas as a result of rural

urban migration has led to urban sprawl and development of the suburban areas. Urbanization is one the most demographic trends in the developing world. According to 2009 Kenya Population and housing census, Kenya has a population of 38,610,097 out of which 32.3% live in urban centers (Kenya National Bureau of Statistics, 2009).Currently the rate of urbanization in Kenya is at 4% (French Institute for Research in Africa, 2008). This by far exceeds the capacity of the local authorities that manage these urban and peri-urban centers and poses a big challenge to provision of basic amenities.

The rate of urbanization in Kenya is quite high and is fueled by rural-urban migration among other factors. The increasing number of people in the urban areas with limited housing, poor/inadequate housing policies, expensive land in central area, restrictive urban zoning, need by middle class to develop their own residence has played a major role in growth of peri-urban centers (Tayler, 2003). Most suburban areas are unplanned and developers take advantage of the weak regulatory framework and the poor regulatory capacity of the local authorities. Suburban areas are characterized by mixed land uses and the inhabitants are of different economic status. The middle income earners tend to buy land to set up their residential homes while the poor and low income earners settle in the more informal settlements within the suburban areas. Light industries tend to set up base in these areas since the price of land in these regions is lower and the restrictions are less stringent. These restrictions are in relation to waste disposal, emissions, as well as the cost of casual labor is lower. Peri-urban areas are generally in rapid development, as a result there is constant social and environmental tension.

The responsibility of providing infrastructure in the peri-urban areas is bestowed in local authorities. Most of these local authorities have limited resources and therefore unable to provide the basic amenities. As a result management of solid waste, wastewater etc is a big challenge and results in environmental deterioration and subsequently health hazard. Increased population in these peri-urban areas leads to increased consumption of safe water which in turn leads to greater production of the wastewater that needs management (Bartones 1997). Most peri-urban centers lack the basic infrastructure such as drainage/sewerage system, road network (see appendix 1), health facilities, educational facilities etc. The capacity of local soil to absorb the water generated is not sufficient to allow infiltration of all the water generated. This calls for establishment of a good and sufficient sewerage system. The amount generated can be massive and hazardous to health. Faced with numerous challenges above, there is need to develop ways of effectively using available water resources and management and re-use the wastewater. There exist numerous

approaches for efficient and effective use of wastewater. These approaches include the use of wastewater in agricultural irrigation, industrial applications, domestic household etc.

In Ongata Rongai for instance most developers build septic tanks for collection of wastewater and excreta due to lack of a sewerage system. These tanks often overflow due to the large volumes of wastewater produced from domestic and commercial institutions. The situation is worsened during rainy season since storm waters often mix with the wastewater in the tanks. Some landlords pump the excess water into open fields and roadside channels. This results in foul smell for the residents downstream. Quite often residents provide piece meal infrastructure to cater for their immediate needs. The infrastructure includes roads, the sewerage system, piped water, solid waste collection, electricity as well as educational institutions, medical institutions among others. These amenities are inadequate, poor or not available at all see appendix 1A, 1B & 1C that show poor state of roads and drainage respectively in Ongata Rongai.

1.2 Statement of problem

In the preceding section it was highlighted that water is an essential resource for all kinds of development of any given nation. With over half of the world's population faced with water scarcity (Narasimhan, 2008), there is need for concerted efforts in effective water consumption and management across the world as well as seek alternative sources to supplement the diminishing sources. According to the ministry of state for planning national development and vision 2030, Kenya's population growth rate is 3% (Sambili, 2011) while economic growth rate is 4.3% (Fengler, 2013) with poverty level of 46 according to the strategy paper and indicative program for period 2008-2013.

The high population has put pressure on existing resources and people in search for better living standards there has been an upsurge in rural urban migration. This in turn has exerted strain on the existing urban infrastructure and resources such as water, sewerage, food, houses etc. The increased demand for houses has led to increase in their cost beyond the abilities of many which has resulted in mushrooming of informal settlement and growth of peri-urban areas. Ongata Rongai is one such peri-urban area on the outskirts of Nairobi that has grown as a result of inadequate and expensive houses in Nairobi. The area is under the jurisdiction the county government of Kajiado. Like many towns around the country is facing numerous challenges including providing safe drinking water for the residents, sewerage system among others. Currently the town has neither steady supply of municipal piped water nor public sewerage

system and developers have opted to sink boreholes and wells to provide water and have septic tanks for collection of the wastewater. The septic tanks often overflow due to the high population that consumes high volumes of water and discharge it. The situation is worse in rainy season since the domestic/institutional wastewater mix with storm water and exceed the capacity of the septic tanks thus overflow. Some landlords are forced to pump the water into open fields and roadside channels or use exhauster to drain the tanks (see appendix 1D). The overflowing wastewater poses health risks and calls for an urgent, enhanced and effective wastewater management system.

In the preceding paragraph it was mentioned that developers and locals of Ongata Rongai have sunk boreholes and wells to provide potable water. The cost of this water is quite high with 20litre jerrican costing an average of Ksh 5 for those who buy from vendors while Ksh 150 per unit for those who pay monthly. This calls for the government to put in place measures to provide potable water for the residents. Increased population does not only consume high volumes of water but also produce large quantities of wastewater that needs to be managed at lowest cost. Currently some landlords use exhausters to drain septic tanks at cost of Ksh 15,000 per trip depending on the size of the exhauster.

The above discussions bring out several challenges that are supposed to be handled by the government as well as individuals in relation to water. In general there is a serious shortage of water in Ongata Rongai that the government needs to address. There is to a problem of wastewater disposal since there is no public sewerage system. In order to address the above residents have come up with different approaches as discussed earlier but others are reusing the wastewater as a resource. This study seeks to investigate the factors influencing management and reuse of wastewater in peri-urban areas in Kenya with particular case of Ongata Rongai.

1.3 Purpose of Study

In this study "wastewater management and reuse in peri-urban areas in Kenya, a case of Ongata Rongai" researcher seeks to establish factors that influence wastewater management and reuse, ways through which residents in this area manage their wastewater. Among the factors the researcher intends to explore are: influence of water availability on wastewater reuse, cultural influence, developmental planning and institutional arrangements among others as outlined in objectives. The study also will seek to establish various uses of wastewater in the area under study.

1.4 Objectives of Study

The objectives of this study included:

1. To assess the influence of water availability on wastewater management and reuse in Ongata Rongai.
2. To assess the influence of culture on wastewater management and reuse in Ongata Rongai.
3. To examine the influence of institutional arrangements on wastewater management and reuse in Ongata Rongai.
4. To establish the influence of the financial resources on wastewater management and reuse in Ongata Rongai.
5. To examine the influence of developmental planning on wastewater management and reuse in Ongata Rongai.
6. To assess the influence of technology on wastewater management and reuse in Ongata Rongai.

1.5 Research Questions

The following are research questions to be studied in this project.

i. What is the influence of water availability on wastewater management and reuse in Ongata Rongai?
ii. How does a people's culture influence wastewater management and reuse in Ongata Rongai?
iii. What influence does institutional arrangement have on wastewater management and reuse in Ongata Rongai?
iv. How does developmental planning influence wastewater management and reuse in Ongata Rongai?
v. What influence do financial resources have on wastewater management and reuse in Ongata Rongai?
vi. What is the influence of technology on wastewater management and reuse in Ongata Rongai?

1.6 Rationale of the Study

Effective waste management is a big challenge to most cities around the world. This calls for an all inclusive planning and implementing an elaborate waste management system.

Water is a scarce resource and Kenya being a water scarce nation (Onjala, 2002) all efforts are supposed to be directed towards effective utilization of available water and ways of supplementing the potable water so as to reduce the pressure occasioned by high demand for water for industrialization, agriculture among others. This study seeks to bring out factors that influence management and reuse of wastewater. Several countries around the world including Bolivia, Tunisia, Ghana among others have embraced the wastewater reuse (Frans P Huibers, 2006). Kenya should do the same to ensure food security among other benefits.

Ongata Rongai is fast growing and generation of wastewater is on the rise and should be tapped to ensure the resource is not wasted. A random check around the town realized a number of people reuse the wastewater for timber treatment, agriculture and tree nursery irrigation. This study seeks to establish the reasons behind this.

1.7 Significance of the study

This study is beneficial to all stakeholders in the area of study including developers, landlords, locals, government, financial institutions and other residents of Ongata Ronga. Developers and land lords stand to benefit by reducing their water bills through reusing of water in their toilets for example, irrigating their lawns, irrigating gardens and therefore generating extra income through sales of the produce etc. This will reduce the existing pressure on water resources in the area since there will be an alternative source of water. Improved wastewater management is beneficial to all stakeholders since it reduces the risk of exposure to the health hazards. The environment will be well maintained and water pollution will be something of the past through development of sewerage system.

Development of the infrastructure is capital intensive, these calls for a financier. Financial institutions will cash in from the developers seeking finance to develop their water reuse systems. Employments will be created since there will be need for attendants to maintain the reuse systems. The government is a major player in water industry and it with policy makers will have to embrace the concept of water reuse and establish the relevant legislations that will govern the reuse and assure good working environment both for re-users as well as attendants.

1.8 Basic Assumption

In order to achieve the objectives of this study the following assumptions were made:

i. The cost of potable water in Ongata Rongai remains high as long as it remains unsubsidized by the government
ii. All the participants were residents of Ongata Rongai.
iii. The cost of effective management of wastewater is lower than the cost of the consequences of poor management of the same.
iv. The respondent will be willing to give concise, correct and true answers and that the sample selected represents the population.

1.10 Limitations of the Study

Ongata Rongai is area covering an average of 16.5km^2 without an elaborate road network (Infotrack East Africa Limited). This poses a challenge in accessing people who stay far away from the town center. The population distribution is not even and most residents stay close or around the town centre leaving the outskirts to the pastoralist communities who are the original owner of the place. There is very limited information on Ongata Rongai which makes is hard to trace the history on its development.

1.11 Delimitation of the Study

The study was confined to Ongata Rongai area composed of the following areas Rongai, Twala, Nkoroi, Ole Kesasi, Rimpa and Kandisi. The study will involve management and reuse of wastewater without separating black from grey. The study will also involve undertaking interviews with the residents in search factors that encourage or otherwise discourage wastewater management and reuse in Ongata Rongai.

1.12 Definition of the Significant Terms used in the study

Wastewater: In this study, the term is used to mean a combination of one or more of: domestic effluent consisting of black water and grey water; water from commercial establishments and institutions like schools and college, hospitals, industrial effluent, storm water and other runoff.

Black water: refers to wastewater that contains fecal sludge, excreta and urine that basically originates from toilets. The term is used interchangeably with other terms like brown water, foul water or sewage.

Grey water: refers to wastewater that originates from bathrooms, kitchen or laundry that does not contain excreta and/or urine.

Wastewater treatment: refers to the process of removing toxic and other contents of wastewater to makes it suitable for use by human activities.

Wastewater reuse: refers to a series of uses that occur due to human activities in which some of the water originating from the first use is used a number of times without changing state (i.e. to gaseous state) and without treatment or with only primary treatment. In this study other terms closely related to wastewater reuse include:

- Unplanned reuse: this is a case in which the water after use is discharged to a collection point and subsequently used by other users in uncoordinated/unplanned manner between first and subsequent users.
- Planned reuse: refers to a deliberate repetitive use of water by same or different users that involve planning to coordinate the transfer of water between the first and subsequent users.
- Portable reuse: refers to reuse of wastewater after specialized treatment for domestic purpose including human consumption.

Wastewater recycling: Wastewater recycling refers to the use of wastewater after special treatment through processes like reverse osmosis and advanced filtration to remove toxic substances including pathogens and chemicals.

Peri-urban: In this study it refers to satellite towns around major cities like Ongata Rongai, Kiambu, Athi River, Ruiru around Nairobi..

Urbanization: Urbanization is a process by which an increasing proportion of the population in a given location lives in urban settlements. Urbanization increases the number as well as size of towns; it can take different forms such as population increase naturally, the outward spread of population and resources to the periphery of towns. Nairobi's population has been on steady increase leading to increase in demand for housing and space; this has led to the outward growth of the city.

Suburbanization: Suburbanization refers to the physical expansion of the urban area towards the periphery like Nairobi is expanding outwards and joining adjacent small towns like Ruirul. As cities and towns grow in population, the urban built-up area also expands.

1.13 Organization of the study

Chapter one of this study gives an overview of the water related challenges facing mankind in the world with emphasis on Kenya. The chapter outlines research questions as well as objectives that guide this study. The following areas have been highlighted by the chapter: research problem, purpose of the study, objectives of the study, research questions, significance of the study, study assumptions, limitations, de-limitations and definition of significant terms.

Chapter two reviews existing literature on wastewater reuse, theories related to water reuse that forms the theoretical framework for the study. The theories reviewed in this chapter are the Ajzen's theory and the input output principles. The chapter further describes the conceptual framework that forms the foundation of the study.

Chapter three gives the research methodology and highlights the design that was used, data collection, processing and analysis. The chapter briefly describes the target population as well as the sampling methods that the researcher employed. A sample of 300 units was used and cluster sampling method used for data collection while descriptive statistics was used for analysis and presentation of the data.

Chapter four presents the study's findings in which demographic characteristics of all the participants are described. The chapter presents the study findings according to the six study objectives starting with the influence of water availability, culture, institutional arrangement, developmental planning, financial resources and technology on wastewater management and reuse.

Chapter five presents the study findings in summary, discussion of the same and conclusion. The chapter also gives contribution of the study to the body of knowledge and recommendations both to policy makers as well as researchers.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter covers an outline of literature from previous writings and documents that were reviewed. It also covers theories that are closely related to planning and water as a resource and its contribution to well being of mankind. The chapter commences by giving a synopsis of wastewater reuse in various countries around the world and the previous studies in Kenya and the variables that can influence wastewater management and reuse. This is then followed by the critical assessment of the theoretical framework whereby Ajzen's theory of planned behavior in relation to water reuse and input output principles are appraised. Literature on wastewater management and reuse and its role on economic empowerment and health improvement in peri-urban areas is incorporated in various sections of this chapter. The chapter is concluded by giving a comprehensive conceptual framework that is based on the literature review, problem statement and background of the study.

2.2 Studies on waste management

Different cultures perceive wastewater differently. Human wastewater is seen as a valuable resource in some cultures like Chinese unlike African cultures. Chinese use human manure as fertilizer with villages recycling their own sewage and cities supplying sewage to the country around them (O'toole, 1995). This section looks at various wastewater management issues around the world and in particular Kenya.

2.2.1 Waste management

Human activities generate waste, the way this waste is managed may pose an environmental risk or otherwise. In places where human activities are concentrated like cities and their environs, appropriate and safe waste management are paramount. This will ensure healthy living conditions for man and his environment. This fact has been realized by many governments but implementation of appropriates measure to ensure it is realized has remained a challenge.

According to World Resource Institute, between one and two thirds of solid waste generated is not collected (World Resources Institute, 2013) as a result, uncollected waste which is often also mixed with human, animal excreta and even e-waste are indiscriminately dumped in the streets and drains. This cause flooding during rainy season due to blocked drainage system

which in turn becomes breeding grounds for mosquitoes, rodents and other vectors. Most of the collected solid waste is usually dumped in lands in uncontrolled manner like the Dandora dump site Nairobi Kenya. This poor ways of managing waste creates serious environmental and health problems.

2.2.2 Waste management in Kenya

Waste management in Kenya is a preserve of local authorities (county governments), for example Nairobi city council is mandated to ensure the city is clean at all times. This provision has proved to be a challenge to most local authorities due to limited resources and corruption. In some areas communities have teamed up to form CBOs and youth group to manage the waste and generate revenue thus creating employment. Practical action and integrated support for sustainable urban environment (ISSUE) consortium in Nakuru in conjunction with Community Based organizations have established a large composting plant. Some of the CBOs that are involved in this are Menengai Waste Recycling Management (MEWAREMA), Nakuru Waste Collectors and Recycles Management. They feed their plant with biodegradable waste from the dump site. In Kikuyu town there is a company, Green loop international that deals with recycling of plastic wastes. The company collects plastic wastes and recycles then thus creating a clean environment as well as creating jobs (Injemela, 2006).

2.2.3 Wastewater production

Currently in Kenya, the actual amount of wastewater production is not estimated due to little or no data on domestic, commercial and industrial wastewater production. Increasing population in suburban areas put more demand on water consumption and proliferation of waterborne sanitation, create widespread wastewater disposal problems. Wastewater originates from the kitchen, bathrooms, toilets and industrial activities among other activities. In Ongata Rongai this water is discharged into septic tanks, open fields and roadside channels (see appendix 1 for photograph). The water that is discharged into open fields and channels or even open ponds, produce foul smell, is breeding grounds for mosquitoes, a risk to children as well as a likely source of outbreak of waterborne diseases such as typhoid, cholera, diarrhea among others.

Inadequate infrastructure, service provision and wastewater management system in peri-urban areas has led to widespread pollution of surface water, groundwater and deterioration of

the environmental health conditions. The health risks posed by the poor management of wastes at large in peri-urban areas impact most on the poor who often inhibit low lying and marginal land for example the wetland along the polluted drainage channels. See appendix 1 for photographs of wastewater discharged to open tanks and open roadside channels.

2.2.4 Wastewater Reuse

Whether wastewater reuse or recycling will be appropriate in a given area depends on a number of factors including availability of additional water resources, a desire to conserve rather than develop water resources, economic considerations, potential use of recycled water, quality of the water, public policies and the strategy of wastewater discharge (Mantovani, 2001). In Africa and Asia wastewater reuse is a common practice while wastewater recycling is common in developed world: water scarce countries like Australia and regions with severe restrictions on disposal of treated wastewater effluents such as Italy and densely populated countries like Germany (Marsaleck, 2002). After reviewing many recycling projects, Radcliffe (2004) inferred that worldwide, water reuse is becoming an increasingly common component of water resource planning, as the cost of wastewater disposal rise and opportunities for conventional water supply development dwindle (Devi, 2009)

Wastewater is a resource that can be of value to urban and peri-urban agriculture. The increased volumes of wastewater can reduce pressure on freshwater used in irrigation. Hussain et al (2001:31) suggested that at least 20 million hectares in 50 countries are irrigated with raw or partially treated wastewater. Assessments have been done on the use of wastewater in Pakistan, India, Vietnam, China, Mexico and Jordan. These assessments indicate that in Pakistan 32,500 ha are irrigated directly with wastewater, 73,000ha in India are irrigated, at least 9000 ha are irrigated in Vietnam (Gayathi D.M, 2008). Although there are several benefits of wastewater reuse, there equally challenges associated with wastewater reuse. These include groundwater pollution, soil contamination, reduction of quality and quantity of yield and the adverse effects on the health of the both the farmers as well as the consumers. People world over reuse wastewater to support their livelihoods and generate considerable value in urban agriculture, these enable them reduce the level of poverty.

Kenya is a water scarcity country for example in Nairobi, most people use shallow wells as a major source of domestic water and less than 10% have access to tap water (Ngindu, 2007). The urban poor in Kenya use wastewater for irrigation although it is illegal. A study undertaken

in 2006 and 2007, indicated that only 50% of the wastewater generated in Nairobi is used in treatment plants while the rest is used for cultivation of over 720 hectares using raw sewage (Githuku, 2009). In the study it was established that over 100,000 households in Kahawa, Soweto, Kibera, Mailisaba, Maringo and Kariobangi South use raw sewage for cultivation. Over 75% of the produce grown in these areas especially vegetables is sold; marketing is usually done on the farm while the rest is consumed at home. Farmers use wastewater because it is provides nutrients, moisture necessary for plant growth. They usually dig canals that transport water to the farms and even block sewage lines carrying sewage from the residential estates (Kaluli, 2011). Kenyan towns having more than 100,000 residents such as Nairobi and its environs (JICA, 1998), have the possibility of producing enough wastewater for industrial use. However most of these towns do not have sewerage systems. NEMA does not recognize the re-use of wastewater as a possibility (Kaluli., 2011)

In some parts of the world wastewater has been used in irrigation of parks, play grounds, school yards, cemeteries, residential, green belts, snow melting, fire protection, construction, artificial wetlands recreation, cooling systems, process water, boiler feed water, air conditioning, toilets, among others.

2.3 Water availability and wastewater management and reuse

One would expect that regardless of the state of economic development of an area, the motivation for handling wastewater is water scarcity. In a developing country context like Kenya, an absolute or relative shortage of water would influence wastewater management and reuse. It is estimated that 70% of global water withdrawals are for agricultural use (FAO, 2013). This shows a close relationship between water resources and food production. Water scarcity has emerged as one of the biggest challenge facing many countries with the increasing population pressure and climatic change. The water scarcity is expected to have a big influence on how local governments manage their wastewater resources. Although in Kenya, the government through vision 2030 has provided for conservation of water sources and enhancement of ways of harvesting and using rain and ground water it has not included the reuse of wastewater instead has captured the need for provision of sanitation (Government of Kenya, 2007).

Economists look at water scarcity as a case where demand exceeds supply; this is depicted by the price. Thus if the demand greatly exceed supply its price will be very high. Since water is such an essential commodity, governments usually fix prices at lower level thus

stopping the rational adjustment. When this occurs the demand grows more greatly than supply and physical difference between the two grow. This difference between the two (the physical supply and demand) is the usual measure of water scarcity (Devi 2009). Although supply and demand can be used to define water scarcity; this is a very dynamic concept. The supply of water can be affected by changes in rainfall, groundwater among other hydrological factors

Over the years, different scholars have developed indices for quantitative evaluation of water resource vulnerability for example water scarcity or water stress. These indices are based on human water requirement e.g. Falkenmark indicator, social water stress index; Water resource Vulnerability indices e.g. the index of local relative water use & reuse; indices incorporating environmental water requirements e.g. population growth impacts on water resource availability, assessing water resource supplies using the water stress indicator. The finer details on these indicators are beyond the scope of this paper. In general the methodology used to measure water scarcity has evolved over time. In 1989, Falkenmark developed the initial water scarcity index formed basis of water demand analysis. By incorporating specific water requirements for basic human needs, Gleick & Falkenmark developed water scarcity index. In 2003 Asheesh suggested the link between population growth and water resources as a measure of water availability. Hoekstra et al (2003) proposed a method of measuring water stress using water footprints by calculating the respective blue, green and grey water footprints of an area. Ridoutt et al (2009) suggested that the water foot printing method need to be improved in order to create standardized model allowing for the comparison of footprints between areas, products etc and proposed an alternative approach to water footprint by combining the water footprint with the water stress index developed by Pfister et al (2009) (Amber, 2011)

Kenya's land mass is 592,000 km^2, out of this 2/3 is permanently pasture and 1/5 wilderness. Generally Kenya is an agricultural country and its development is greatly dependent on water. According to research by Joseph Oginga 2002, it is estimated that the annual quantity of renewable fresh water is 20.2 billion m^3 (19.59 billion m^3 surface water and 0.6billion m^3 ground water. In this research the per capita supply was estimated to be 696 m^3 per person per year. This is below the global benchmark of 1000 m^3 and therefore Kenya is a water scarce country (Onjala, 2002). In Ongata Rongai the main source of fresh water are the boreholes managed by communities as well as individuals who supply the water to their neighbors at a fee. The other source is the streams, most of which are seasonal e.g. Mbagathi river which is usually full of water during the rainy season and dry in dry spell. In this area some families travel a

considerable distance in search of water. The limited availability of water has made people seek an alternative source of water for their activities like car washing, timber treatment usually done besides the roads using water ferried from the wastewater running through the gutter. Communities faced with severe restrictions due to natural water scarcity, population growth or resource overuse often adopt laws requiring the use of recycled water while others take this initiatives on their own (Mckenzie, 2008).

2.4 Culture and wastewater management and reuse

The acceptance of the reuse of wastewater is greatly influenced by a people's socio-cultural and religious factors. In Africa for example the use of black water/excreta as fertilizer is objected seriously while in china and Japan the excreta is regarded as economical and ecologically sound for use as fertilizer (Hani, 2009).

The reuse of wastewater is gaining popularity as the source of fresh water diminishes. Treated wastewater reuse is gaining acceptance in several parts of the world. Generally wastewater reuse is accepted where other sources of water are not readily available or for economic reasons. Wastewater reuse is accepted in Islamic countries as long as the impurities (najassa) are removed. This is generally for economic reasons more than cultural preference. According to Koranic edicts, the practice of reuse is accepted religiously provided impure water is transformed to pure water (tahur) by the following methods (Farooq and Ansari 1983): self-purification, addition of pure water in sufficient quantity to dilute the impurities or removal of impurities by passage of time or by physical effects (Hespanhol, 1997).

In order to achieve general/public acceptance of wastewater reuse for any project active public involvement is paramount. There is need to involve the authorities and potential users for the public acceptance. The continuous exchange of information between the parties ensures that everyone embraces the wastewater reuse and that the users' needs are fulfilled and that the community's concerns of health, safety, ecological etc are attended (Crook, 1992)

A study undertaken by Mckay and Hurlimman predicted that the greatest opposition to water is people aged 50 and above. Surveys in California and Colorado indicated that older women tended to be less supportive of potable water reuse Hurlimann (2003).

2.5 The Institutional arrangements regulating wastewater management and reuse

In a developing country one might expect that the institutional arrangements for wastewater may not be well established and so clear guidelines would be missing. It is vital to establish realistic, achievable and enforceable standards and regulations in order to ensure sustainable management and reuse. Establishment of unrealistic standards and guidelines will lead to dislike among the stakeholders. For instance, "the cost of treating wastewater to high microbiological standards can be so prohibitive that use of untreated wastewater is allowed to occur unregulated" (Fatta D, 2005) to meet throughput goals.

Although establishing strict standards is paramount, they should be balanced between safeguarding the consumers as well as the farmers' livelihoods. In most countries the standards and regulations adopted are based on international practices like the world health organization (WHO), United States Environmental Protection Agency (USEPA) guidelines. While developing these standards and regulations it is vital that conditions of the country at hand are taken into account. According to the Kenya's National Policy on Environment 2012 on waste management, the government will develop an integrated waste management strategy, promote the use of economic instruments to manage waste and promote establishment of facilities and incentives for cleaner production, 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 wastewater reuse. Currently NEMA does not recognize wastewater reuse (Kaluli, 2011). According to Kenyan laws, no person is permitted to use wastewater for irrigation purposes unless it complies with the quality guidelines set out in schedule eight (appendix 2a) (NEMA, 2006) . Babin indicated that institutions like the Environmental Directorate (in Australia) ensures protection of the public health by ensuring safe onsite treatment of sewage and disposal/reuse of wastewater and provide advice on the intensification of land use on un-sewered land (Babin, 2005). This ensures controlled management and reuse of wastewater without adverse effects to both farmers and consumers of the products.

2.6 Financial resources and wastewater management and reuse

These could well be an impediment in both developed and developing regions. Sometimes, the cost of discharge of effluence would be out of reach, whereas in other areas, the cost of collection and treatment of wastewater could determine the extent to which wastewater is reused.

In order to effectively harvest/collect wastewater for reuse it is necessary to have an elaborate infrastructure as well as systems to treat the water before reuse. 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 job creation. In most developing countries like Kenya, lack of funds to set up sewerage collection system in peri-urban areas has lead to developers building septic tanks for collection of all the domestic and commercial/institutional wastewater which quite often overflow. In some areas there is totally no collection system for this water. The water therefore gets into open channels and fields. This makes it hard to effectively harvest the wastewater for reuse. In Ongata Rongai for example the wastewater 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 and is not reused.
Other financial constraints include the cost of electricity to run the equipment like pumps to take the water to a place of application. These pumps are of special design to be able to handle the dirt in the water and are more expensive than ordinary fresh water pumps. The operation of this equipment to requires a competent person who will need to be paid. Furthermore according the WHO standards and guidelines, it is not recommended to reuse raw wastewater but have it treated to safe healthy standards. These factors raise the operations and maintenance costs of any wastewater management and reuse project.

The high price of reclaimed/wastewater versus the price farmers and other people are willing to spent makes it prohibitive. Survey of municipalities California indicated that the major constraint of water reuse is lack of funding. The survey indicated that although major municipalities have set up projects for water reuse, smaller ones have not due to lack of funds (Miller, 2004).

2.7 Developmental planning and wastewater management and reuse

Wastewater reuse constitutes a very important element of water resources policy, strategy and environmental management. Several countries world over especially in arid areas like the Middle East have embraced the use of treated wastewater as a resource. A well and clearly thought out wastewater reuse strategy transforms wastewater from an environmental and health liability to an economic and environmentally sound resource (Kandiah, 1994)

The governments are expected to develop, establish and control wastewater reuse policy within national effluent use policy that is supposed to be part of national plan on water resources.

The governments and local authorities that are responsible for treatment and disposal of wastewater must allocate the costs among other factors in establishing the relevant infrastructure for the effective system for wastewater reuse such as irrigation.

Kenyan urban areas have been growing at an average rate of 3.9% annually (2005 -2010 period). The inadequate capacity combined with economic difficulty has hindered the design of solutions to the challenges brought about rapid urbanization. Urban areas have been growing haphazardly most without physical development plans which have caused economic inefficiency and environmental degradation and led to poor living conditions. Most urban developmental plans when done have been reactionary and only 30% of Kenya's urban centers are planned, partly due to inadequate planning capacity and rapid population growth. Out of the 175 local authorities only 4 viz Nairobi, Mombasa, Kisumu and Eldoret have planning units within their establishment. This has resulted in most towns grappling with unplanned settlements, traffic congestion, pollution and inefficient and costly transport systems. At present the Kenyan urban housing sector is characterized by large urban slums without proper sanitation. Informal settlements house over 60% of urban population (Republic of Kenya, 2007). A well and clearly thought out strategy transforms wastewater from an environmental and health liability to an economic and environmentally sound resource (Kandia 1994). It is therefore the role of the government and its institutions to ensure an elaborate plan for harvesting and or disposal of wastewater.

2.8 Technology and wastewater management and reuse

Before reusing wastewater, it is essential to subject it to treatment to meet public safety and the given needs. According to UNEP, the wastewater can be subjected to basic treatment such as physical processes, biological processes or chemical processes (UNEP, 2005) before reuse.

2.8.1 Physical processes

These are basically physical processes that are used to improve or treat wastewater with no gross chemical or physical changes. The process occur in stages including clarification (sedimentation), aeration, screening, filtration floatation, degasification and equalization

2.8.2 Biological processes

This method involves the use of microorganisms like bacteria in biochemical decomposition of wastewater to stable end products. More microorganisms are formed and portion of waste is converted to carbon dioxide, water and other products.

2.8.3 Chemical processes

This process involves the use of chemical reactions to improve the water quality. The processes involved here include chlorination, ozonation, neutralization, coagulation, iron exchange and adsorption.

In most cases, conventional methods are used. This method involves preliminary, primary, secondary and disinfection. Preliminary and primary stages are physical processes that involve removal of debris, large solids and sedimentation using screens for example. While secondary involves the use of biological methods that involve use of stabilization ponds, trickling filters, activated sludge and sedimentation of the sludge. Tertiary and advanced treatments involve removal of more pollutants like phosphorus using more advances technologies. Appendix 2 (fig 2) shows a sample the process of wastewater treatment.

The above discussed processes play a major role in ensuring that the wastewater being used is safe. This however comes with a cost; each method or a combination of two or three methods has associated cost, both in terms of the structure and running. People however generally expect to pay less for using recycled water since they consider it to be of lower quality (Marks, 2002). This is a big challenge in encouraging them to embrace wastewater reuse as a means of conserving water as well as environment. Gagliardo asserts that there is need to show the potential users economic advantages in recycled water (Murni, 2003).

2.9 Environmental considerations and wastewater management and reuse

These become more important as regions and countries develop. Often times, the environment is not high on the agenda of countries struggling to alleviate poverty and water scarcity in cities.

2.10 Theoretical framework

2.10.1 Ajzen's Theory of Planned Behavior

Ajizen's theory is one of the theoretical frameworks that have been used in explaining the constructs of attitude, subjective norms and perceived behavioral control on water reuse. The theory is modeled as shown in fig 1

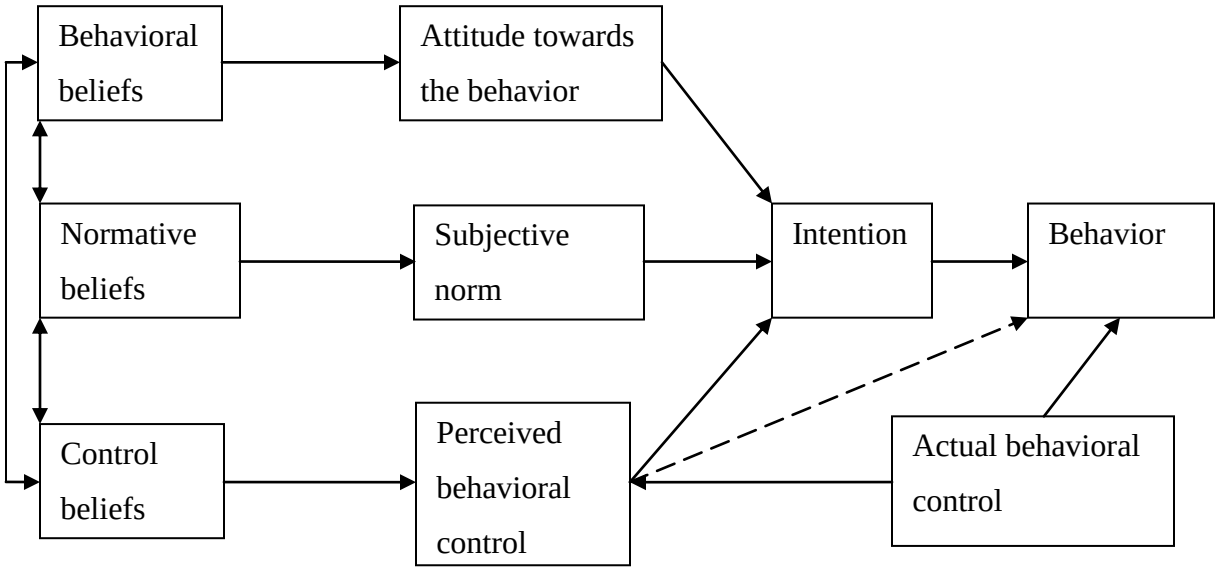

Fig 1 Ajzen's theory (University of Twente)

The various constructs identified in the theory are discussed herein below:

Behavioral beliefs link the behavior of interest to expected outcomes and suggest the possibility that a given behavior will produce a certain outcome. The theory stipulates that although a person exhibits many behavioral beliefs, only a relatively small number are accessible at a given moment. The accessible beliefs in combination with the subjective values of the expected outcome determine the prevailing attitude toward the behavior.

Attitude toward the behavior refers to the degree to which performance of the behavior is positively or negatively valued. According to expectance value model attitude towards a behavior is determined by the total set of accessible behavioral beliefs linking the behavior to various outcomes and other attributes. Expressed mathematically $A \propto \sum b_i e_i$ i.e. the strength of each belief (b) is weighted by the evaluation (e) of the outcome or attribute, and the products are aggregated.

Normative beliefs refer to the perceived behavioral expectations of such important referent individuals or groups as the person's spouse, family, friends, and -- depending on the population and behavior studied - - teacher, doctor, supervisor, and coworkers. It is assumed that these normative beliefs -- in combination with the person's motivation to comply with the different referents -- determine the prevailing subjective norm. $SN \propto \sum n_i m_i$ i.e. the strength of each normative belief (n) is weighted by motivation to comply (m) with the referent in question, and the products are aggregated

Subjective norm is the perceived social pressure to engage or not to engage in a behavior. It is assumed that subjective norm is determined by the total set of accessible normative beliefs.

Control beliefs have to do with the perceived presence of factors that may facilitate or impede performance of a behavior. It is assumed that these control beliefs -- in combination with the perceived power of each control factor -- determine the prevailing perceived behavioral control.

Perceived behavioral control refers to people's perceptions of their ability to perform a given behavior. It is assumed that perceived behavioral control is determined by the total set of accessible control beliefs. The equation $PBC \propto \sum c_i p_i$ shows the strength of each control belief (c) is weighted by the perceived power (p) of the control factor, and the products are aggregated.

Intention is an indication of a person's readiness to perform a given behavior, and it is considered to be the immediate antecedent of behavior. The intention is based on attitude towards the behavior, subjective norm and perceived behavioral control, with each predictor weighted for its importance in relation to the behavior and population of interest.

Behavior is the manifest, observable response in a given situation with respect to a given target. Single behavioral observations can be aggregated across contexts and times to produce a more broadly representative measure of behavior. In the TPB, behavior is a function of compatible intentions and perceptions of behavioral control. Conceptually, perceived behavioral control is expected to moderate the effect of intention on behavior, such that a favorable intention produces the behavior only when perceived behavioral control is strong. In practice, intentions and perceptions of behavioral control are often found to have main effects on behavior, but no significant interaction.

Actual behavioral control refers to the extent to which a person has the skills, resources, and other prerequisites needed to perform a given behavior. Successful performance of the behavior depends not only on a favorable intention but also on a sufficient level of behavioral control. To the extent that perceived behavioral control is accurate, it can serve as a proxy of actual control and can be used for the prediction of behavior. (Ajzen, 1991)

In general the intention to perform a behavior is strong when performance of a particular behavior elicits favorable attitude from individual, the surrounding social environment is conducive to the behavior, and the individual feels confident of their ability to perform the behavior (Ajzen I. , 1988)

Syme and Nancarrow attempted to use Ajzen's theory of planned behavior to model the different factors that influence people's willingness to use recycled water for horticultural purposes. Fig 2 illustrates details of Ajzen's model the used. According to the research conducted by Murni Po, Juliane D. Kaercher and Blair E. Nancarrow application of Ajzen's theory to water reuse proposes that people's willingness to use recycled water (i.e. behavioral intention) depend on their attitude towards using the water, their perception of what their significant others think about using recycled water (i.e. subjective norm) and their perceived ease or difficulty in using recycled water (i.e. perceived control). This study concludes that people's attitude towards water reuse is determined by their beliefs about the outcomes of using recycled water (Murni Po, 2003).

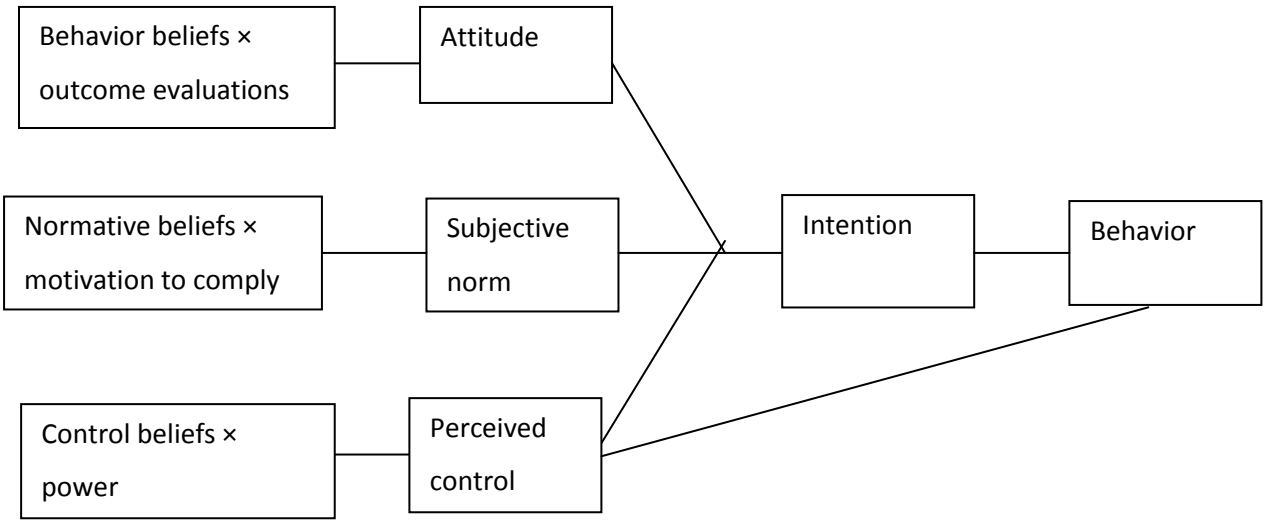

Fig 2 Ajzen (2001) model (Murni Po, 2003)

2.10.2 Input output principle

Wassily Leontief (1905-1999) introduced the input-output model in 1930's which depicts inter-industry relations of an economy and shows how the output of one industry is an input to the other and vice versa. Leontief presented this information in the form of a matrix in which an input is enumerated in the column of an industry and its outputs are enumerated on the corresponding row. This shows interdependence of industries to each other both as customers of their outputs as well as suppliers of their inputs. Each columns of the input-output matrix reports the monetary value of the industry's inputs and each row represents the value of an industry's outputs. (Steins, 2012)

The input-output theory has been adopted by a number of scholars including De Haan (1976), Hedricks et al (1977), Raitano (1978), Bengoechea (1979) among others. Their works majorly focused on the water transfer between individual system components i.e. physical pathways of distributing water to various users. When applying the input-output principles to water resource systems, internal components take over the roles of various industries in Leontief's model. These components represent selected water resource system features whose relationships and interactions that various scholars have investigated. The features can be water conveying facilities such as rivers, canals, ditches, water storage facilities such as lakes, groundwater reservoirs, surface reservoirs; and water use systems such as municipal water supplies, industries and agriculture. In addition to the mentioned internal components, the set of system components is completed by entry and exit components. Through the entry components, water enters the water resource system under consideration; and through the exit components, the water leaves it. Considering a system components as origins and destinations then the entry components are just but origins as long as they do not receive water from the system while the internal components can be considered as both origins and destinations because water enters and leaves them. Exit components are the destinations of water which leaves the system (Hendricks, 1980).

2.11 Conceptual Framework

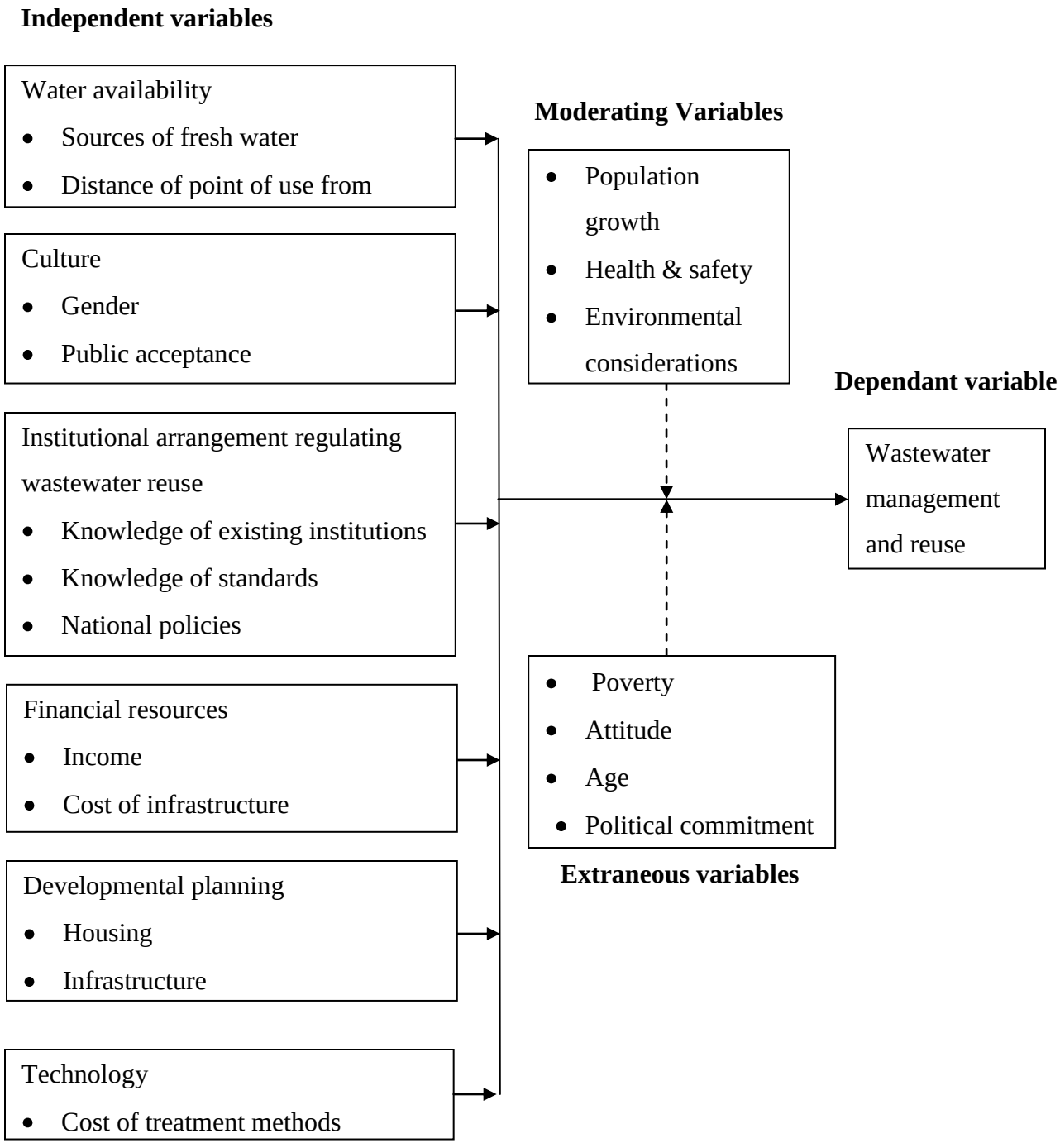

Fig 3: Conceptual framework

The above variables were chosen because they provide an all encompassing perspective of the wastewater problem facing policy makers and city planners. The physical problems of fresh water supply and wastewater generation are encompassed in the water availability

dimension of the framework. The processes involved in managing a public utility with external ramifications are captured in the institutional arrangements. The purely financial aspects of running wastewater systems either at household or institutional levels are captured when financial resources are investigated. Also, the ultimate problems of dealing with a wastewater are accounted for in the developmental planning and these to a degree are related to the financial resources and infrastructure.

If policy makers are to come to terms with wastewater management and reuse practices over a lengthy period of time, they will require tools that can help them assess the nature and the scope of the problem. There is no reason to believe that the tools that are required at one stage would be those required at another stage in the developmental cycle of an estate/county. These tools could be (and are) based on the rational economic principles that trade off the benefits against the costs, over a long period of time. There is also a need to illustrate and apply these tools in different settings for which the case study of Ongata Rongai, Kenya is being undertaken.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter is dedicated to the description of the methods, procedures and instruments that were used to obtain data, how the data was analysed, interpreted, and how the conclusion was drawn. This chapter also shows how validity and reliability of the instruments was tested and ethical considerations taken care of. All these helped in the processing of the data and the formulation of the conclusions. Specifically, this chapter covers: the research design and methodology, the respondents, the data collection instrument, validity and reliability of the instruments, ethical consideration and the data analysis.

3.2 Research Design

A research design is a program that guides the investigator in the process of collecting analyzing and interpreting observation (Chava, 2005).This study utilized descriptive method of research. Descriptive method of research is a fact-finding study that involves adequate and accurate interpretation of findings that describes a certain present condition/situation. This method was appropriate to the study since it aims at describing the present condition of wastewater management and reuse in Ongata Rongai. The technique that was used under descriptive method is the survey approach and evaluation, which is commonly used to explore opinions according to respondents that can represent a whole population. Survey was appropriate in this study because it enabled the researcher in formulation of generalizations. Specifically, the types of direct-data survey were included in this study. These involved a combination of questionnaire survey, observation and interviews. Interviews with respondents were conducted to provide further insight about the results of the survey. The direct-data type of survey is a reliable source of first-hand information because the researcher directly interacts with the participants. The questionnaire survey was undertaken hand in hand with interviews in order to save on time but those not ready with feedback were given ample time to review the questionnaire and give reasons that made them reuse wastewater or otherwise in Ongata Rongai Kenya. Their own experience with water management was necessary in identifying the factors that influence wastewater management and reuse.

The purpose of employing the descriptive method is to describe the nature of a condition, as it takes place during the time of the study and to explore the cause(s) of a particular condition. The researcher used this kind of research due to the desire to acquire first hand data from the respondents so as to formulate rational and sound conclusions and recommendations for the study. According to Creswell (1994), the descriptive method of research is to gather information about the present existing condition. Since this study is focused on the factors that encourage or otherwise influence wastewater management and reuse in peri-urban areas in Kenya, the descriptive method was the most appropriate method.

3.3 Target population

Out of several peri-urban areas around Nairobi the researcher targeted resident of Ongata Rongai in Kajiado County Kenya. The population of the study area is fast growing, according to the population and housing census of 2009 the area has human population of 40,178 (Commission on Revenue Allocation, 2011).

3.4 Sampling design

A sample is defined as a subset of a population which refers to the total population about which information is required (Hani, 2009). It comprises of some members of the population. Sampling is the process of selecting sufficient elements from the population so that the study of the sample and an understanding of its properties would enable us generalizes such properties to the population elements. The sample unit of the study was one household for residential community or one institution for other entities. The study area was quite vast with high population that could not be studied within the time and resources allocated but still were able to study a sample large enough to represent the population. In this study cluster sampling was employed in order to achieve the study objectives.

3.5 Sampling technique

In order to achieve the above and ensure adequate representation of the population, the researcher employed both non probability technique and probability on need basis. The study aimed at capturing information from all diverse groups of people; those who use wastewater, those who do not, different income groups, gender and levels of education. The study's aim was to relate the different factors/variables and establish their influence on the water management and reuse. To achieve this, the study area was divided into six clusters (area sampling) and a

simple random sampling was used to carry out the study. Appendix 3 is a sample of an interview schedule and questionnaire that was used in this study.

3.6 Sample Size

The sample size that was used in this study was representative to ensure minimal errors. The sample size was determined mathematically: $ss = \frac{z^2(p) \times (1-p)}{c^2}$ where ss is sample size; Z is the Z value (for 95% confidence level is 1.96); p is percentage picking choice expressed as decimal (usually 0.5 for sample size needed) and c is the confidence interval expressed as decimal for this case 0.0564 (Creative Research Systems). Ongata Rongai (study area) has a population of 40,178. Taking a confidence level of 95% with a confidence interval of 5.64, the sample size for this study worked out to 300 (rounded off to the nearest hundred). Cluster sampling technique was used in the study under which the study area was divided into six geographic regions and a random sample of 50 sampling units was studied in each of the clusters as indicated in the table below.

Table 3.1 Sample size schedule

Samples to be studied		
	Geographic area (area cluster)	Sample units
1	Kandisi	50
2	Nkoroi	50
3	Rimpa	50
4	Twala	50
5	Rongai	50
6	Ole Kasasi	50
Total sample units		300

3.7 Data collection methods and procedures

This section explains various ways through which data was collected, processed, analyzed and presented. Data was obtained from two sources, primary or secondary. Primary data refers to information collected originally and directly by the researcher on the variables of interest for the specific purpose of the study. Examples of primary sources are from individual residents, institutional managers, etc. Data gathered through existing sources such as statistical bulletins, government publications, data available from previous research etc are called

secondary data. That is, they are data that already exist and do not have to be collected originally by the researcher. The following methods were used for data collection.

3.7.1 Primary data collection methods

These are the instruments that were used to collect data required for the study. Questionnaires that were complemented by interviews and observation were used in collection of the primary data from the respondents. Both open ended and closed ended questions were used. Letter of transmittal (appendix 3a) and reference letter from the university accompany the questionnaire to make the respondents aware of the research in order to cooperate and be assured of confidentiality. The letter described the purpose, the importance, significance of the study as well as assuring them of confidentiality. Some of the methods and instruments that were used to collect data include:

i. Interview schedule method

Appendix 3b and 3c shows the questionnaires and observation checklist that were used to collect data. Both structured and unstructured face to face interviews as well as in depth interviews were employed in the study. Questionnaire bore predetermined questions grouped together to address specific objectives of the study; they also contained unstructured questions in order to obtain as much information as possible from the participants with regard to the reuse, the challenges, benefits etc. In order to ensure clear understanding of the questions, interview method was used; this also helped illiterate participants, and minimized the risk of collecting incomplete or wrong information. This method is quite flexible and allowed for supplementary questions as well as omission as the situation demanded. In order to guarantee accuracy and authentic results, the following were undertaken:

i. Carefully selected and trained the research assistants
ii. Organized field visits to check & ensure consistency and adherence to the research objectives
iii. Researcher participated in the research with the research assistant

ii. Questionnaires

As discussed in the preceding section, questionnaires were used in conjunction with the interview in order to obtain as much information as possible that guided in answering the research questions. Appendix 3b contains the questions that were pilot tested to ascertain that they were agreeable to most participants sampled randomly across Ongata Rongai.

iii. Observation

Observation was used to collect data through watching and documenting the various uses, technology used/treatment methods and the infrastructure. Through observation the researcher was able to analyze the situation and determine issues like living standards, safety standards, conservation practices among others. This method assisted the researcher to make various recommendations and areas of further research. A check list (see appendix 3c) and hand held camera were used in this process. Hand held camera was used to record data like the state of drainage system (infrastructure). This kept the record obtained in observation other than the written information.

3.7.2 Primary data collection procedures

Both structured and unstructured interview procedures were used as mentioned above. Upon successful establishment of the schedule, the researcher will pilot tested the questionnaire to establish if the questions are properly set and solicited feedback from the respondents. This was followed by reviewing the questions to meet the objectives and make them agreeable to the participants. The researcher trained research assistants on the procedures, objectives and ethical issues of the study. This minimized the challenges that were faced both by research assistants and the respondents encountered while answering the questions. The general data collection procedure involved introducing themselves, showing letter of intent, not rushing respondents and thanking the participants.

3.7.3 Secondary data collection methods and procedures

The study involved reviewing of existing literature on wastewater management and reuse by identifying the location and analyzing the documents. This included reviewing both published and unpublished information documents. The reviewing of the information from existing literature was aimed at establishing the uses, challenges and success stories of wastewater management and reuse around the world. The sources of the secondary data include government session papers, journals, MDGs, Vision 2030, publication by the UN and its bodies among others.

The areas of interest were analyzed through literature review, browsing and field surveys with the objective of capturing a general understanding of the subject of the study. This formed

the basis of developing research tools, research scope as well as drawing recommendation and conclusion.

3.7.4 Validity of Instruments

Validity of an instrument determines the degree to which the instrument used in research is truly measuring what is intended to measure. Validity of qualitative data is measured by trustworthiness, dependability and credibility. In this study the instruments used were pilot tested to help check for face, content and criterion validity. This process assisted in estimating the time required to administer questionnaires. During piloting questionnaires were administered to 30 sampling units in Ongata Rongai. This process helped in identifying ambiguous questions and adjusting or removing them. After adjustments a similar number of questionnaires were administered to other sample units to establish if the questions are agreeable to participants.

The study controlled validity by triangulation, submitting questionnaires to University of Nairobi panelists, pre-testing the tools, assuring the participants of their anonymity and using both English and Kiswahili languages as the situation demanded as well as using locals in conducting the interviews.

3.7.5 Reliability of the instruments

In research, reliability is the ability of an instrument to yield same results on other occasions even when used by other researchers (Easterby-Smith, 2002). In this study reliability was assured by test-retest method whereby a simple random sampling were undertaken to re-administer the questionnaires to the participants and the feedback compared to ascertain consistency.

3.8 Data Analysis

In the preceding sections of this chapter, it was mentioned that descriptive research design will be employed. Different data analysis and presentations were engaged to facilitate interpretation of the data. The preliminary data processing involved cleaning, coding and reduction of data to enable the researcher use statistical package for social scientists (SPSS). Descriptive statistics, cartographic presentations such as pie charts and tables were used to analyse quantitative data in order to achieve the research objectives as well afford the data greater meaning. The data was further subjected to statistical tests in order to make relevant inferences on the relationship between the variables. A regression function describes how means of dependent variables change according to the values of the independent variables. Linear

regression uses ordinary least squares (OLS) that gives an approximate relationship between the variables based on the observations from a random sample. In a regression equation $E(y)=\alpha+\beta x$ for a population in which alpha (α), beta (β) and standard deviation (δ) are not known for a given population, they must be estimated in order to estimate the given regression equation. The estimated regression equation can be used to make predictions about the dependent variable x. some of the assumptions made in this regression model include the specific error i.e. The relationship between x and y is linear and the dependent variables are clearly identified, he measurement of the error are accurately measured at interval scale and that for the error tern: the mean is zero, error component is constant and there is no auto-corrections for the error term.

Pearson's Correlation Coefficient (R) was used in determination of the association between the x and y i.e. the independent and dependent variables. In the equation $y = a+bx$, b indicates the slope which is either a positive or negative association depending on its value. The value of b is usually not conclusive since it does not accurately measure the strength of the association and hence the need to calculate correlation coefficient (R) which is a standard slope whose value is independent of units on measurement. In general the properties of R include falling between negative one and one ($-1 \leq R \geq 1$); only appropriate for use when a straight line is a reasonable model and the larger the absolute value of R, the stronger is the degree of linear relationship. For nominal data, Chi-squared test of association was used to establish the influence of the respective variable on wastewater management and reuse in Ongata Rongai.

3.9 Ethical considerations

This study like many others could have raised some ethical issues that required to be looked into. These issues included respondents' unwillingness to participate citing reasons like many studies have been undertaken and they have not benefited from the outcomes, some were not be willing to give information touching their income especially in the presence of spouses. In order to achieve objectives of the study and overcome the above issues the researcher was flexible and visited the participant when s/he is ready and comfortable to give information. The option of compensating time of the participant so that s/he feels that his/her time is not wasted employed in few cases.

3.10 Operationalization of variables

An operational definition is one that gives the exact manner in which a variable is to be measured. Table 3.2 below indicates the types of variables and how they will be measured.

Table 3.2 Operational definition of variables

Objective	Variable	Indicator	Scale	Question
1. Water availability	Independent	Sources of water	Ordinal	1.1, 1.2, 1.4
		Distance of the source from point of use	Ordinal	1.3, 1.4, 1.5
2. Culture	Independent	Gender (M/F)	Nominal	2.1, 2.2
		Public acceptance	Nominal	2.2, 2.4,2.5, 2.6
3. Institutional arrangement regarding reuse	Independent	Knowledge of existing regulatory institutions	Nominal	3.1, 3.2
		Knowledge of standards	Nominal	3.3
		Awareness of the national policies	Nominal	3.4, 3.5
4. Financial resources	Independent	Income	Ordinal	4.1, 4.2
		Cost of infrastructure	Ordinal	4.3, 4.4
5. Developmental planning	Independent	Housing/dwelling	Ordinal	5.1, 5.2
		Infrastructure	Ordinal	5.3, 5.4, 5.5
6. Technology	Independent	Cost of treatment method	Ordinal	6.1, 6.2, 6.3, 6.4

CHAPTER FOUR
DATA ANALYSIS, PRESENTATION AND INTERPRETATION

4.1 Introduction

This chapter presents the study findings that have been discussed under various thematic sections according to the study objectives and questions. The objectives that guided the study included: ascertaining the influence of water availability, culture, institutional arrangement, developmental planning, financial resources and technology on wastewater management and reuse in Ongata Rongai. In order to achieve these objectives, the research had to answer study questions that included: what is the influence of water availability on wastewater management and reuse in ongata Rongai? How does a people's culture influence wastewater management and reuse in Ongata Rongai? What influence does institutional arrangement have on wastewater management and reuse in Ongata Rongai? How does developmental planning influence wastewater management and reuse in Ongata Rongai? What influence do financial resources have on wastewater management and reuse in Ongata Rongai? What is the influence of technology on wastewater management and reuse in Ongata Rongai? Various indicators were identified as key to finding out the influence of the variables identified in the objectives. The analysis which is subdivided into sections according to the study objectives is preceded by a demographic section that describes the attributes of the sample surveyed. The study used chi-square and correlation analysis to investigate the influence of various variables under study including water availability, culture, institutional arrangement, financial resources, developmental planning and technology.

4.2 Demographic characteristics of the respondents

Respondents of both gender and varied age groups above 18 years participated in the study from various areas of Ongata Rongai including Nkoroi, Rongai, Ole Kasasi, Twala, Kandisi and Rimpa. A total of 300 respondents participated in the study out of which165 were women and 135 were men of different age groups and marital status as shown in Table 4.7 and Table 4.1. The study obtained background information in order to understand the participants and their environment. The participant's age, education level, dwellings, occupation among other parameters were also obtained.

From the study findings, it was established that the majority of the participants were aged between 40 and 50 followed by 29-39 as shown in Table 4.1. This implies that the study area has

energetic people who can be put to very productive activities. It was further established that most of the participants were married.

Table 4.1 Age distribution and marital status

			Marital status			
Age range	Response	Percentage	Married	Single	Widow	Separated
18-28	38	13%	26	8	3	1
29-39	106	35%	73	21	10	2
40-50	110	37%	76	22	10	2
51-above	46	15%	32	7	4	1
Total	300		207	58	27	6
Percentage			69%	19%	9%	2%

Table 4.2 shows that education level in the study area is quite low with majority of the participants having achieved some secondary school education. Out of the 300 participants 83 (28%) of the have achieved some secondary education while 64 (21%) completed secondary education, 46 (15%) college education and 22 (7%) university education. The low level of education shows limited exposure to available application options for wastewater such as biogas generation from black wastewater, irrigation, timber treatment, car wash among others.

Table 4.2 Education level in the study area

Education level	**Respondents**	**Percentage**	**Cumulative**
Some primary	44	15%	44
Primary	41	14%	85
Some secondary	83	28%	168
Secondary	64	21%	232
College	46	15%	278
University	22	7%	300
Total	300	100%	

The study established that most participants are self employed either in the informal sector or are land lord. This group constituted 160 (53%) of the participants followed by those who do not have definite occupation 66 (22%) and depend on casual jobs as shown in Table 4.3.

Table 4.3 Occupation of participants

Occupation	Frequency	Percentage	Cumulative
Civil servant	21	7%	21
Employed in private	53	18%	74
Self employed	160	53%	234
Other (casual jobs/house wives)	66	22%	300
Total	300	100%	

4.3 Influence of water availability on wastewater management and reuse in Ongata Rongai

This was the first objective of the study that sought to establish how availability of water influences management and reuse of wastewater. The participants stated their sources of water and how far they are. Co-relational analysis was undertaken between the cost of the different sources of water and wastewater management and reuse and between the distances and wastewater management and reuse.

4.3.1 Sources of fresh water

The main source of water within the study area is borehole for almost all applications including domestic, commercial and even agricultural. As indicated in Table 4.4 below, out of 300 participants, 183 (61%) depend on boreholes followed by shallow wells 57 (19%), vendors 45 (15%), municipal water 12 (4%) and lastly other sources 3 (1%); this included river and rain water. The results were analyzed by determining Pearson's Correlation Coefficient as shown herein below.

Table 4.4 Sources of water

Source	Respondents	Percentage	Unit cost	Reusers
Borehole	183	61%	150	12
Shallow Well	57	19%	150	18
Vendors	45	15%	250	30
Municipal	12	4%	100	4
Other	3	1%	0	0
Total	300			64

Correlations between sources of water and re-users

		Cost	Re-users
Cost	Pearson Correlation	1	.945*
	Sig. (2-tailed)		.015
	N	5	5
Re-users	Pearson Correlation	.945*	1
	Sig. (2-tailed)	.015	
	N	5	5

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

The above correlation analysis between unit cost of sources of water and re-users shows that there exist a significant correlation between the two with Pearson's Correlation Coefficient of 0.945 close to 1 and sig.(2-tailed) of 0.015 being less than 0.05. The correlation is a strong direct relation i.e. the unit cost of water has a direct influence on the wastewater management and reuse.

From the study 64 participants indicated that they reuse wastewater in one way or the other as shown in Table 4.21. The main reason for reusing wastewater was water scarcity. From Table 4.5, 35 (55%) of the participants of those who reuse wastewater indicated that water scarcity is the main cause. Other reasons included availability of wastewater and environmental conservation. These reasons make the wastewater re-users to manage it effectively to ensure harvesting and reusing of the water easier.

Table 4.5 Reason for wastewater reuse

Reason for management and reuse	Respondents	Percentage
Water scarcity	35	55%
Wastewater is readily available	20	31%
Conserve environment	9	14%
Total	64	100%

4.3.2 Distance of the source from point of use

One of the challenges faced by the residents of Ongata Rongai is the distance they have to travel in search of water. This has led to the growth of water vending business that has seen a number of locals keep donkeys for transporting water from the source to the residents at a fee. There are also a number of water kiosks that sell water both to vendors and end users. As indicated in Table 4.4, 15% of study participants depend on this service. The study sought to establish the relationship between the distance of water sources and the wastewater management and reuse. Correlation analysis was undertaken and findings were as follows where Pearson's Correlation Coefficient (R) was calculated.

Table 4.6 Distance of the source from point of use

Distance (km)	Average distance	Re-users	Cumulative
0.00 -0.5	0.25	11	11
0.51-1.01	0.76	15	26
1.02-1.52	1.27	16	42
1.53-2.03	1.78	22	64

Correlations between distance & re-users

		Distance	Re-users
Distance	Pearson Correlation	1	.966*
	Sig. (2-tailed)		.034
	N	4	4
Re-users	Pearson Correlation	.966*	1
	Sig. (2-tailed)	.034	
	N	4	4

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

In order to establish the relationship between distance and wastewater management and reuse Pearson's Correlation Coefficient was determined from data in Table 4.6 as 0.966. This value is close to 1 indicating a strong direct relationship between distance and wastewater management and reuse. There is therefore a statistically significant correlation between the two indicators since the sig (2-tailed) value is less than 0.05.

The correlation analysis between the indicators for water availability and wastewater management and reuse above can be summarized as follows. Pearson's Correlation Coefficient between unit cost of different sources water was found to be 0.945 at sig (2-tailed) of 0.015. This value shows a strong positive correlation between the two indicators. The sig (2-tailed) value is less than 0.05 is an indication of a statistically significant correlation. The R value between distance and wastewater reuse was found to be 0.966 at sig (2-tailed) value of 0.034. The R value is close to 1 and sig (2-tailed) value is less than 0.05 showing that there exist a statistically strong correlation between the distance and wastewater management and reuse in Ongata Rongai.

The above discussion shows that water availability has a direct influence on wastewater management and reuse in Ongata Rongai. The two indicators has used for the analysis of this variable yielded similar results.

4.4 Influence of culture on wastewater management and reuse in Ongata Rongai

The second objective of the study was to ascertain the influence of culture on wastewater management and reuse in Ongata Rongai. The study sought to establish this through gender and public acceptance as the key indicators. The study investigated whether one's gender can influence his/her decision on reusing wastewater; and whether the population accepts wastewater as a resource. The study used Chi-square to analyze the results of the mentioned indicators and the level of significance was 0.05.

4.4.1 Gender

In order to establish the influence of gender on wastewater management and reuse, participants were required to state their gender. The results were as tabulated in Table 4.7. Out of 300 participants 135 (45%) were men and 165 (55%) were women.

Table 4.7 Gender distribution

Gender	Number of respondents	Percentage
Male	135	45%
Female	165	55%
Total	300	100%

To investigate the influence of gender on wastewater management and reuse, the study employed Chi-square analysis as shown in Table 4.8.

Table 4.8 Chi-square analysis of the influence of gender on wastewater management and reuse

Observed frequencies	Reusing	Not Reusing	Row Total	
Male	25	110	135	
Female	39	126	165	
Column Total	64	236	300	
Expected frequencies	**Reuse**	**Not Reusing**	**Row Total**	
Male	28.8	106.2	135	
Female	35.2	129.8	165	
Column Total	64	236	300	
Chi-squared statistic (x^2)	**Observed (O)**	**Expected (E)**	**|O-E|**	**x^2**
Male reusing	25	28.8	3.8	0.38
Male Not reusing	110	106.2	3.8	0.10
Female reusing	39	35.2	3.8	0.31
Female Not reusing	126	129.8	3.8	0.08
Total				0.87

The following formulae were employed in determination of the figures in Table 4.8 above

$$overall\ total = \frac{row\ total \times column\ total}{expected\ frequency}$$

$$Chi - squared\ statistic(x^2) = \frac{\Sigma\left(\left|O - E\right| - 1/2\right)^2}{E}$$

$$Degrees\ of\ freedom\ (df) = (no.of\ rows - 1) \times (no.of\ columns - 1)$$

NB: correction factor of (-1/2) was used since there are only two rows and two columns

The calculated value of x^2 is 0.87 against the table value of 3.841 at df of 1 and α of 0.05 therefore the calculated value is less than the critical table value. This implies there is insignificant influence of gender on wastewater management and reuse.

4.4.2 Public acceptance

This is one of the key indicators used to investigate the influence of culture on wastewater management and reuse in Ongata Rongai. In this respect the study sought the views of the participants. They were required to state if they recognize wastewater as a resource or otherwise and whether they reuse water or consider reusing it at one point in the future. Their responses were analyzed using chi-square as shown in Table 4.9.

Table 4.9 Acceptance of wastewater reuse

Observed frequency	Reuse	Do not reuse	Row total	
Resource	30	80	110	
Not a Resource	34	156	190	
Column total	64	236	300	
Expected frequency	Reuse	Do not reuse	Row total	
Resource	23.4667	86.5333	110	
Not a Resource	40.5333	149.4667	190	
Column total	64	236	300	
Chi-squared statistic (x^2)	Observed (O)	Expected (E)	|O-E|	x^2
Resource, reusing	30	23.4667	6.5333	1.5512
Resource, Not reusing	80	86.5333	6.5333	0.4207
Not a Resource, reusing	34	40.5333	6.5333	0.8980
Not a Resource, not reusing	156	149.4667	6.5333	0.2435
Total	300	300		3.1134

The calculated Chi-square (x^2) is 3.1134 while tabulated value at df of 1 and α of 0.05 is 3.841, this show that there is insignificant level of acceptance since the calculated value is less than the table value.

Asked to state some of the applications they (participants) would wish to use the wastewater for, their response was: over 152 (52%) of the respondents indicated they would use the wastewater for irrigation, 81 (27%) for flushing toilets, 63 (21%) for commercial activities

like treatment of timber in readiness for sale while only 4 (1%) would use it for watering livestock.

The chi-square analysis of the two indictors discussed above yielded x^2 values that are less than the critical table values. This shows an insignificant influence of culture on wastewater management and reuse in Ongata Rongai. During data collection it was observed that a number of people are yet to embrace wastewater as a resource. The water is usually disposed into septic tanks and open fields instead of harvesting it for reuse. Although participants indicated they cannot use wastewater for watering their livestock, some livestock were seen drinking water in open field and roadsides. From the above analysis it can be concluded that culture does not have influence on wastewater management and reuse.

4.5 Influence of institutional arrangement on wastewater management and reuse

The study sought to determine the level of awareness on existing regulatory and standardization institutions and whether they influence wastewater management and reuse. In this connection the study further established the level of awareness national policies a particular case of case vision 2030. The participants were asked to identify some of the institutions as well as if they have an idea on vision 2030.

4.5.1 Knowledge of existing regulatory institutions

In order to gain an understanding of participants' awareness of the regulatory institutions in Kenya, they were asked to identify institutions that regulate and/or set standards for water resources. The response and analysis was as shown in Table 4.10 below.

Table 4.10 Knowledge of regulatory and standardization institutions in Kenya

Knowledge of institutions	Reusing	Do not reuse	Row total	
Have Knowledge	31	81	112	
No Knowledge	33	155	188	
Column Total	64	236	300	
Expected frequency	Reusing	Do not reuse	Row total	
Have Knowledge	23.8933	88.1067	112	
No Knowledge	40.1067	147.8933	188	
Column Total	64	236	300	
Chi-squared	Observed (O)	Expected (E)	| O-E |	x^2
Have Knowledge, reuse	31	23.8933	7.1067	1.8268
have knowledge, do reuse	81	88.1067	7.1067	0.4954
No Knowledge, reuse	33	40.1067	7.1067	1.0883
No Knowledge, do not reuse	155	147.8933	7.1067	0.2951
Total				3.7057

The analysis above show the calculated x^2 value is 3.7057 against critical table value of 3.841 at df of 1 and α of 0.05. The calculated value is less than the table value indicating there is little statistical significance of the indicator to wastewater management and reuse i.e. the knowledge of the existing regulatory institutions is insignificant to wastewater management and reuse.

From Table 4.10 above, only 112 of the respondents are aware of existence of regulatory and standardization institutions in the country. This explains why a good number of the participants who reuse wastewater do not expose the water to any form of treatment prior to reuse as shown in section 4.8. The participants identified some of the regulatory and standardization institutions they know and the feedback was as shown in the Figure 4 below.

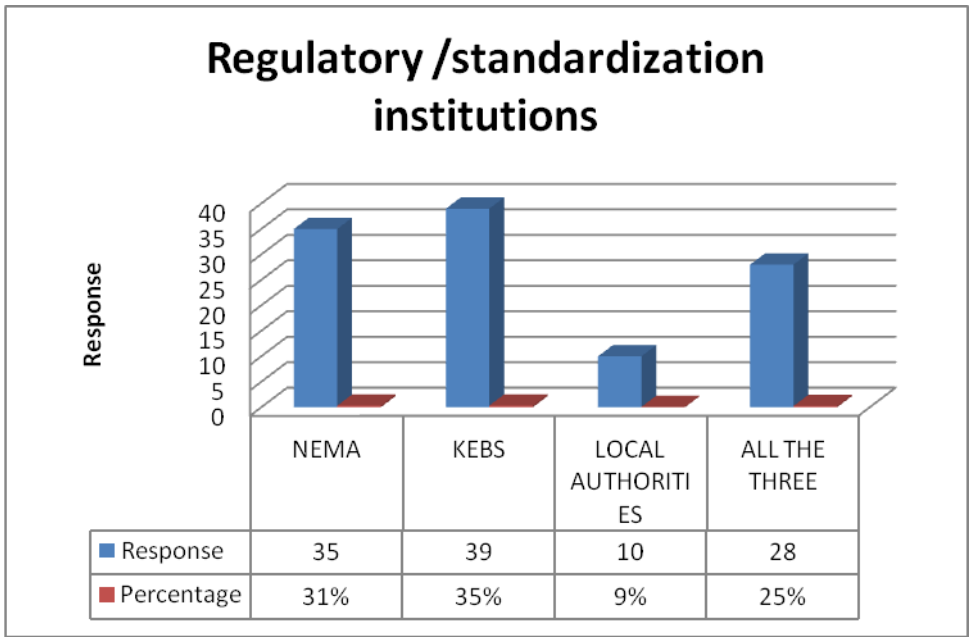

Fig 4 Knowledge of regulatory & standardization institutions in Kenya

The above chart shows 35 (31%) of the respondents who know about regulatory institutions are aware of NEMA while 39 (35%) know KEBS, 10 (9%) are aware of local authorities as a regulatory institution and 28 (25%) know that all the above institutions play a role in regulatory and standardization with regard to water.

4.5.2 Knowledge of standards

Asked if they are aware of existing standards on wastewater reuse, no one had any idea about existence of such standards of the study participants. The participants were asked if they had been visited by an official from NEMA, KEBS or local authorities. The response was as shown in Table 4.11.

Table 4.11Knowledge of standards

	Respondents	Percentage	Visited	Not visited
Knowledge of standards	0	0%	0	300
No Knowledge of standards	300	100%	0	0
Total	300	100%	0	300

From Table 4.11 clearly shows that the participants have no knowledge on the existing wastewater reuse standards. This shows that there is no influence of the standards on wastewater management and reuse in Ongata Rongai.

4.5.3 National policies

The respondents were asked whether they are aware of the national policies and strategies for water conservation and the response was no. Asked if they understand the contents of Kenya's vision 2030, the response and analysis of the same were as shown in Table 4.12.

Table 4.12 knowledge on Kenya's vision 2030

Observed frequency	Reuse	Not reuse	Row total	
Have idea	32	87	119	
No idea	32	149	181	
Column total	64	236	300	
Expected frequencies	**Reuse**	**Not reuse**	**Row total**	
Have idea	25.3867	93.6133	119	
No idea	38.6133	142.3867	181	
Column total	64	236	300	
Chi-square	**Observed (O)**	**Expected (E)**	**|O-E|**	**x^2**
Have idea, reuse	32	25.3867	6.6133	1.4721
Have idea, not reuse	87	93.6133	6.6133	0.3992
No idea, reuse	32	38.6133	6.6133	0.9679
No idea, not reuse	149	142.3867	6.6133	0.2625
Total				3.1017

The above analysis shows that the calculated x^2 is less than the tabulated critical value of 3.841. This shows that the knowledge of the policies like vision 2030 is insignificant to wastewater management and reuse.

Analysis of the three indicators under this variable shows that institutional arrangement has no influence on wastewater management and reuse. The chi square value establishing the relation between regulatory institutions was less than the table value same for national policies and no one of the participants knows the set standards for water reuse. It can therefore be concluded that institutional arrangements have no influence on wastewater management and reuse in Ongata Rongai.

4.6 Influence of financial resources on wastewater management and reuse

Like any other investment, one would expect financial resources to be a necessity for effective conversion of wastewater into a useful resource. In the study the respondents were asked to state their gross monthly income. This was in effort to establish the relationship between ones income and wastewater management and reuse. The study also established the relationship between the cost of infrastructure and wastewater management and reuse.

4.6.1 Income

The study sought to establish the gross monthly income of the participants and the results were as shown in Table 4.13. From the table it can be observed that most residents of Ongata Rongai get a monthly income ranging between Ksh 20,000 – Ksh 30,000 (30%), followed by Ksh 10,000 – 20,000 (26%) while the lowest is above Ksh 60,000.00 with only 10 (3%) of the respondents. These results were analyzed as shown below.

Table 4.13 Monthly gross incomes

IncomeKsh'000'	Respondents	Percentage	Average income	Re-users	Cumulative
00 – 10	61	20%	5000	15	15
10 – 20	69	23%	15000	13	28
20 – 30	59	20%	25000	8	36
30 – 40	43	14%	35000	11	47
40-50	31	10%	45000	6	53
50-60	19	6%	55000	4	57
Above 60	18	6%	65000	7	64

Correlations between income & reuse

		Income	Re-users
Income	Pearson Correlation	1	-.854*
	Sig. (2-tailed)		.014
	N	7	7
Re-users	Pearson Correlation	-.854*	1
	Sig. (2-tailed)	.014	
	N	7	7

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

The above correlations between ones income and wastewater reuse show a significant correlation between the two with R value of -0.854 and sig. (2-tailed) of 0.014 that is less than 0.05. The correlation is strong since the R value is close to 1.

4.6.2 Cost of infrastructure

After establishing whether a participant reuses wastewater or not, s/he was required to give some financial requirement to set up mechanism of reuse that s/he has (if any). 18 (28%) out of the 64 respondents have set up system for harvesting and reusing the wastewater as shown Table 4.14.

Table 4.14 participants with infrastructure for harvesting and reusing wastewater

Infrastructure	Respondents	Percentage
With infrastructure	18	28%
No infrastructure	46	72%
Total	64	100%

The study sought to establish the effects of cost of infrastructure on wastewater management and reuse. Pearson's Correlation Coefficient was calculated between the cost and wastewater management and reuse as shown in Table 4.15.

Table 4.15 Cost of infrastructure for wastewater harvesting and reuse

Range	Cost	Re-users	Cumulative
0,000 - 20,000	10,000	3	3
20,000 - 40,000	30,000	5	8
40,000 - 60,000	50,000	3	11
60,000 - 80,000	70,000	3	14
80,000 - 100,000	90,000	2	16
100,000 - 120,000	110,000	1	17
120,000 - 140,000	130,000	1	18
Above 140,000	150,000	0	18

Correlations between cost of infrastructure & reuse

		Cost	Re-users
Cost	Pearson Correlation	1	-.885**
	Sig. (2-tailed)		.003
	N	8	8
Re-users	Pearson Correlation	-.885**	1
	Sig. (2-tailed)	.003	
	N	8	8

**. Correlation is significant at the 0.01 level (2-tailed).

The calculated value for Pearson's Correlation Coefficient was found to be -0.885, this is close to 1 therefore a strong inverse correlation between the indicators. There is a statistically significant correlation between the two cost of infrastructure and wastewater management and reuse in Ongata Rongai since the sig (2-tailed) is less than 0.01.

During the visit it was observed that those participants with better financial resources had set up more elaborate systems to harvest and reuse the water. For example some had biogas generators that were converting black water into biogas. This was beyond ability of many of the participants.

The above analysis on the respective indicators under financial resources variable shows a strong correlation between the variables. The analysis in each case yielded Pearson's Correlation Coefficient of 0.854 and 0.885 respectively that are close to 1 showing a strong correlation between the respective indicators with sig (2-tailed) value of 0.014 and 0.03

respectively which are less than 0.05 and 0.01 showing a statistically significant correlation. It can therefore be inferred that financial resources influence wastewater management and reuse.

4.7 Influence of developmental planning on wastewater management and reuse

In this study developmental planning was a key variable that would influence wastewater management and reuse. The study sought to get to know the dwellings of the participants and existing public infrastructure on managing wastewater and whether they influence wastewater management and reuse. The study investigated the influence of the type of house and the infrastructure influence on wastewater management and reuse.

4.7.1 Housing

Out of 300 responses obtained, 215(72%) stay in free standing stone house/flat, 40 (13%) free standing farm house, 29 (10%) informal houses, 13 (4%) in a prefabricated, 2 (1%) in detached maisonate and 1 (0%) in traditional house as shown in Fig 5. Table 4.17 shows house/dwelling ownership status of the respondents; 135 (45%) own the dwelling, 61 (20%) own the dwelling without title deeds, 12 (4%) inherited the dwelling while 92 (31%) rent their dwelling places.

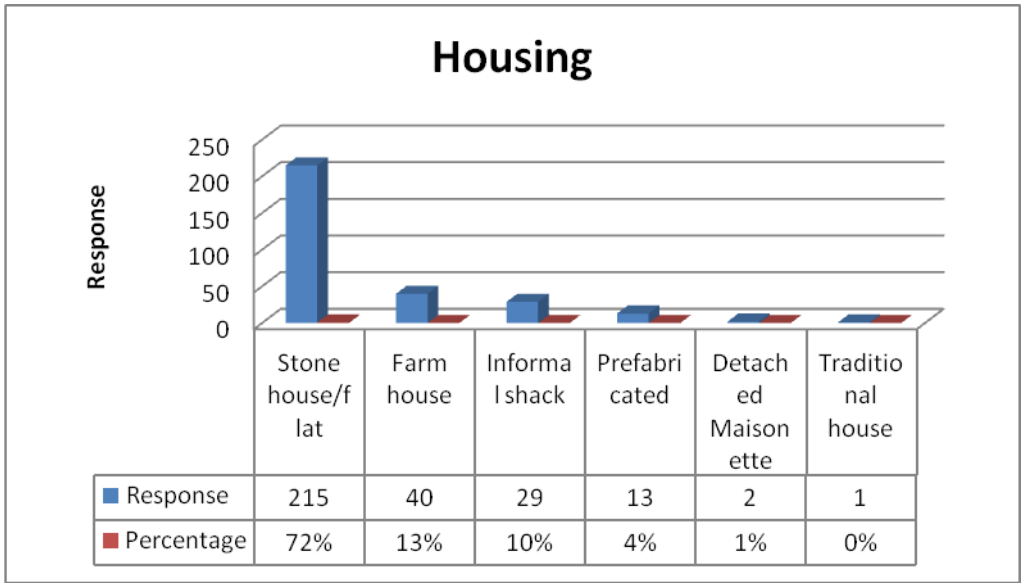

Fig 5 Dwellings/Housing

The above results were analyzed using Pearson's Correlation Coefficient as follows:

Table 4.16 Housing & wastewater management and reuse

Housing	Response	Cumulative	Reusing
Stone house/flat	215	215	37
Farm house	40	255	16
Informal shack	29	284	11
Prefabricated house	13	297	0
Detached Maisonette	2	299	0
Traditional house	1	300	0

Correlations between Housing & Reuse

		Response	Re-users
Response	Pearson Correlation	1	.953**
	Sig. (2-tailed)		.003
	N	6	6
Re-users	Pearson Correlation	.953**	1
	Sig. (2-tailed)	.003	
	N	6	6

**. Correlation is significant at the 0.01 level (2-tailed).

The above correlation analysis show a strong direct correlation between housing and wastewater management and reuse with the value of 0.953 close to 1 and sig (2-tailed) value of 0.003 that is less than 0.01 indicating a statistically significant correlation.

Table 4.17 House ownership status

Status	Respondents	Percentage
Owner of dwelling	135	45%
Owner of dwelling no title	61	20%
Inherited	12	4%
Rent	92	31%
Total	300	100%

4.7.2 Infrastructure

The study investigated the role of public infrastructure in wastewater management and reuse in Ongata Rongai. The participants were asked whether they have access to public

sewerage system and the response was unanimously no as shown in Table 4.18. There being no public infrastructure basically no sewerage line it therefore implied it cannot be investigated as an indicator since it played no role. However the study investigated the relationship between the toilet facility and wastewater disposal method and wastewater reuse.

Table 4.18 Access to public sewerage system

Access to sewerage system	Response	Percentage
Yes	0	0%
No	300	100%
Total	300	100%

Table 4.19 Wastewater disposal methods

Toilet & Wastewater disposal facility	Response	Percentage	Re-users
Flush & Septic tank	101	34%	22
Latrine & Septic tank	113	38%	28
Latrine & open field	86	28%	14
Total	300	100%	64

Correlations between wastewater disposal facility & reuse

		Respondents	Re-users
Respondents	Pearson Correlation	1	1.000*
	Sig. (2-tailed)		.012
	N	3	3
Re-users	Pearson Correlation	1.000*	1
	Sig. (2-tailed)	.012	
	N	3	3

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

The results were analyzed as shown above and yielded Pearson's Correction Coefficient of 1 with a sig (2tailed) value less than 0.05 indicates a very strong correlation between the facility and wastewater management and reuse.

During data collection it was observed that the biggest challenge for those who willing and/or reuse the wastewater is inadequate infrastructure to harvest the wastewater and the exorbitant cost of setting up one's own system. The above analysis leads to a conclusion that

developmental planning has great influence on wastewater management and reuse in Ongata Rongai

4.8 Influence of technology on wastewater management and reuse in Ongata Rongai

Assessing influence of technology on wastewater management and reuse was the last objective of the study. The participants who indicated that they reuse wastewater were asked to identify some of the techniques they employ in treating the wastewater to ensure their safety as well as those of consumers of the products.

4.8.1 Cost of treatment methods

After establishing that a respondent reuses water, it was necessary to know if s/he treats the water before reusing and if at all s/he has the necessary knowledge on wastewater treatment. Table 4.20 shows the results of those who reuse wastewater. Out of 64 participants who reuse wastewater only 18 treat the water before reusing it as indicated in Table 4.21. The rest use raw wastewater for various applications in spite of the health risks involved. There exist numerous methods of treating wastewater before reusing, in this study it was established that physical method is the most commonly used technique, out of 18 participants who treat the water before reuse, 9 treat the water using physical methods, 5 treat the water using a combination of physical and chemical methods, 3 treat the water using combination of physical and biological methods while only 1 treat the wastewater using a combination of physical, biological and chemical methods as shown in Table 4.21. Asked whether s/he knows about other methods, majority of participants indicated they have no knowledge on how to use them or they only apply the method they know and is affordable to them. In order to establish the influence of treatment methods on wastewater management and reuse, the study sought to know the cost implication of the different methods. The results were as shown in Table 4.21 and a correlation analysis was undertaken as shown herein below.

Table 4.20 Wastewater reuse

	No of respondents	Percentage
Reuse wastewater	64	21%
Do not reuse wastewater	236	79%
Total	300	100%

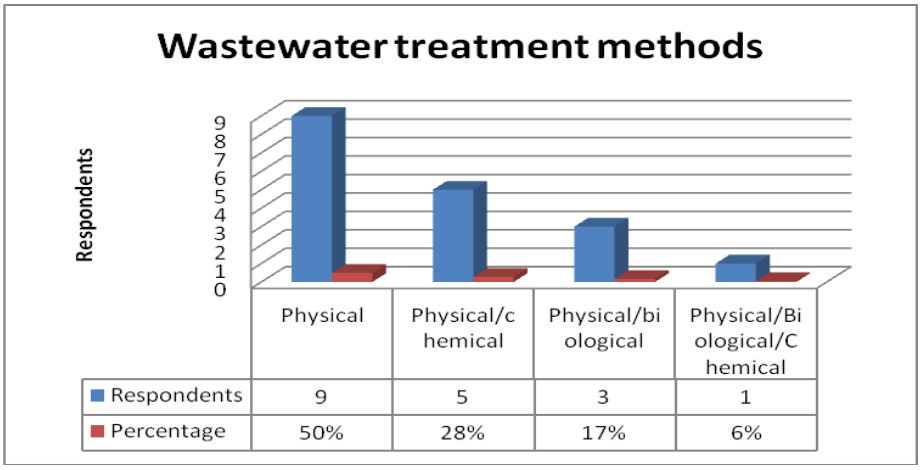

Fig 6 Wastewater treatment methods

Table 4.21 Cost of treatment method

Method	Cost range '000'	Average cost	Re-users	Cumulative
Physical	0-20	10,000	9	9
Physical/Chemical	20-40	30,000	5	14
Physical/biological	40-60	50,000	3	17
Physical/Chemical/ Biological	60-80	70,000	1	18

Correlations between cost of technology & reuse

		Cost	Re-user
Cost	Pearson Correlation	1	-.983*
	Sig. (2-tailed)		.017
	N	4	4
Re-user	Pearson Correlation	-.983*	1
	Sig. (2-tailed)	.017	
	N	4	4

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

The correlation analysis above shows a significant correlation between technology and wastewater management and reuse in Ongata Rongai. The Sig. (2-tailed) value is less than 0.05 and R value is close to one indicating a strong inverse correlation between the indicators. During

data collection it was observed that participants with better understanding of treatment methods and financial independence tended to put in place better systems. They ensured those interacting wastewater have protective gear and the environmental conservation is taken into consideration.

From the above analysis it can be concluded that technology has influence on wastewater management and reuse in terms of cost, skills safety among other factors.

CHAPTER FIVE
SUMMARY OF FINDINGS, DISCUSSIONS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of study findings based on the six research questions, discussion of the findings, conclusions and sums up with recommendations and suggestions of areas for further research. The study aimed at investigating the factors that influence wastewater management and reuse in peri-urban areas in Kenya a particular case of Ongata Rongai. The study was guided by six objectives whose findings were as summarized in the next section. The study employed descriptive research design like any other fact finding research. A sample size of three hundred was used to conduct the study using cluster sampling. The results were analyzed using both descriptive and inferential statistics using excel and SPSS.

5.2 Summary of findings

The study sought to gain an understand the background of the participants prior to completing the questionnaire, the information gathered included age, gender, marital status, levels of education and even occupation. From the study, it was established that 37% of the participants are aged between 40 -50. This was the highest number of the participants followed by those aged between 29 –39, who constituted 35%. This shows the area has high proportion of energetic population that can greatly be productive if empowered. Majority of those who participated in the study are married, with 207 (69%) being married out of the 300 participants. Education levels in this area are low with 43% of the participants having achieved secondary school and above. 53% of the participants are self employed.

One of the variables used to measure objectives of the study was water availability; this was measured using two indicators: source water and distance from the point of use. It was established that the main source of potable water is boreholes with 61% of the respondents using it. Among the respondents who reuse wastewater, 55% indicated that they are encouraged by water scarcity. The distance of water sources from point of use range between 0 - 2km. in ascertaining the influence of water availability on wastewater management and reuse, Pearson's Correlation coefficient between unit cost of the different sources of water and wastewater management and reuse was found to be 0.945 while that between distance and wastewater

management and reuse was calculated and found to be 0.966. Both values of R are close to 1 indicating a strong correlation between the indicators.

Influence of Culture on wastewater management and reuse was investigated using gender and public acceptance as key indicators. Chi-square analysis was used in determining the relationship between the indicators. From the findings, the chi-square value between gender and wastewater management and reuse was found to be 0.87 against a critical table value of 3.841 while that between public acceptance and wastewater management and reuse was 3.1134 against a critical table value of 3.841. The calculated values of Chi-square are less than the value table values, an indication of lack of influence of culture on wastewater management and reuse. 52% of the participants indicated they can reuse wastewater for irrigation while 27% of them can reuse wastewater for toilet flushing, and 21% on commercial activities like timer treatment.

The respondents of this study showed limited knowledge and understanding of institutions regulating and setting standards in the water sector. A chi-square analysis between the knowledge on regulatory/standardization institutions and wastewater management and reuse yielded a calculated value of 3.7057 against a table value of 3.841 showing an insignificant influence. None of the participants knows the existence of standards for the wastewater. This implies the standards have no influence on the management and reuse of wastewater. Chi-square analysis between vision 2030 and reuse yielded a calculated value of 3.1017 less than a critical table value of 3.841, this also shows insignificant influence. On the specific institutions, 35 (31%) know NEMA, 39 (35%) KEBS, 10 (9%) local authorities and 28 (25%) know that the NEMA, Local authorities and are regulatory & standardization institutions.

The study sought to establish the relationship between financial resources and wastewater management and reuse. The indicators measured here were income and cost of infrastructure in relation to wastewater management and reuse. R was calculated between income and wastewater management and reuse found to be -0.854 while that between cost of infrastructure and wastewater management and reuse determination as -0.885. Both values have sig (2-tailed) value less than 0.05 and 0.01 respectively an indication of statistically significant correlation.

To assess the influence of developmental planning on the wastewater management and reuse, this study worked out Pearson's Correlation Coefficient between the type of house and wastewater management and reuse and found to be 0.953 and that between toilet facility and wastewater disposal method and wastewater management and reuse and found to be 1. Both values of R show a strong correlation between the indicators and wastewater management and

reuse. This shows significant influence of developmental planning on wastewater management and reuse.

The study sought to determine the influence of technology on wastewater management and reusing by determining Pearson's Correlation coefficient between the cost of treatment method and wastewater management and reuse. This was found to be -0.983 indicating a strong correlation between technology and wastewater management and reuse. The study found out that 50% of the participants reusing wastewater use physical methods and the reminder use a combination of physical and other methods including biological and chemical.

5.3 Discussion

The study established a number of factors that influence wastewater management and reuse in peri-urban areas in Kenya; a case of Ongata Rongai. Several factors were investigated and results tabulated as shown in chapter four and discussed herein below.

Water availability was found to be a significant factor influencing wastewater management and reuse. The study established that water scarcity is a major factor that drives most people to reuse the water. Most people interviewed indicated that potable water is limited and they supplement it with wastewater to meet their non potable application needs. Distance of water source from point of use to is a key driver to reusing of wastewater. The two indicators i.e. sourced of water and distance yielded a Pearson's Correlation Coefficient (R) of 0.945 and 0.966 that are very close to 1 showing a strong correlation between water availability and wastewater management and reuse leading to a conclusion that in Ongata Rongai water availability has influence on wastewater and reuse. Communities faced with severe restrictions due to natural water scarcity, population growth or resource overuse often adopt laws requiring the use of recycled water while others take this initiatives on their own (Mckenzie, 2008). These findings tend to agree with the findings of the study that water availability influences wastewater management and reuse.

Investigation into the influence of culture on wastewater management and reuse showed that it is not a major factor. Under this objective, it was established that gender plays a negligible role in determining whether one will reuse wastewater or not. Chi-square analysis undertaken on the indicators resulted in both values i.e. gender 0.87 and acceptance 3.114this values are less than the critical table values of 3.841and 3.841 respectively. This led to the conclusion that

culture does not have influence on wastewater management and reuse in Ongata Rongai. These findings tends to agree by Jeffrey (2002) that there is no significant variations in public support for grey water reuse across gender age or socioeconomic groups (Jeffrey, 2002). The findings however differs predictions Mckay and Hurlimman (2003) predictions that the greatest opposition to water is people aged 50 and above. Surveys in California and Colorado indicated that older women tended to be less supportive of potable water reuse (Hurlimann, 2002).

It was established that institutional arrangement plays no role in wastewater management and reuse in Ongata Rongai. Both users and nonusers of wastewater portrait high level of ignorance on the institutions regulating water sector in the country. According to the indicators used, the calculated values of chi-square were less than the table values. This showed how limited the institutions are in terms of both knowledge dissemination and enforcement of the existing laws thus have negligible influence on the wastewater management and reuse. The above results are in contrast to the findings by Babin which indicated that institutions like the Environmental Directorate (in Australia) ensures protection of the public health by ensuring safe onsite treatment of sewage and disposal/reuse of wastewater and provide advice on the intensification of land use on un-sewered land (Babin, 2005).

One's financial resources play a major role in safe management and reuse of wastewater. From the study findings, Pearson's Correlation Coefficient for income and reuse was -0.854 and that between the costs of infrastructure was -0.885 both values were close to 1 with sig (2-tailed) values less than 0.05 and 0.01 respectively. These values show that there exist a statistically significant correlation between financial resources and wastewater management and reuse. This led to the conclusion that financial resources have influence on wastewater management and reuse in Ongata Rongai. These results coincide with surveys of municipalities done in California which indicated that the major constraint of water reuse is lack of funding. The survey indicated that although major municipalities have set up projects for water reuse, smaller ones have not due to lack of funds (Miller, 2004).

The study established that Ongata Rongai does not have a public sewerage system and majority of the residents use septic tanks for disposal of their wastewater. Dry pit latrines are widely used source of toilet facility. Developmental planning for the town does not exist and poor or total lack of has posed a challenge in managing wastewater. During the study analysis the nature of one's housing played a role in reusing wastewater as this dictated the type of infrastructure available for wastewater harvesting and reuse. A well and clearly thought out

strategy transforms wastewater from an environmental and health liability to an economic and environmentally sound resource (Kandia 1994).

The ignorance level on wastewater treatment technology is quite high with majority of those who reuse wastewater majorly using physical methods of treatment and exhibiting lack of knowledge on other methods. The cost of the different methods of wastewater treatment determined the number of respondents who use it. From the correlation analysis undertaken, it was established that the technology has influence on wastewater management and reuse in Ongata Rongai. The findings of this study coincide with suggestions that people generally expect to pay less for using recycled water since they consider it to be lower quality (Marks, 2002). Gagliardo asserts that there is need to show the potential users economic advantages in recycled water (Murni, 2003)

5.4 Conclusion

The study investigated various factors that influence wastewater management and reuse in peri-urban areas in Kenya a particular case of Ongata Ronga. The study area has varied sources of water for domestic and other uses including boreholes, wells, and vendors among others. From the correlation analysis undertaken in this study, it was established that water availability, developmental planning, financial resources and technology have influence on wastewater management and reuse. Similarly chi squares analysis undertaken on culture and institutional arrangement established that they have insignificant influence on wastewater management and reuse.

Assessing the influence through the respective indicators resulted in positive Pearson's Correlation Coefficients that were very close to 1 showing a strong direct correlation. It therefore be concluded that water availability has influence on wastewater management and reuse. The analysis of the influence of financial resources on wastewater yielded similar results that indicated that they have great influence. Site visits during data collection it was observed that people with stable financial income had established infrastructure that is efficient and safe for use. The analysis showed that people with low to average income of the participants had more interest in reusing the wastewater. The cost of technology has inverse relation with the wastewater management and reuse and as the cost increased the number of participants reusing

the water reduced. Conversely an investigation into the influence of culture and institutions arrangement on showed that they do not have significant influence.

Finally the government and its institutions should set up mechanisms, legal framework and policies that will ensure wastewater is transformed from a liability into a resource. Developers in these areas should develop wastewater harvesting systems to conserve the environment and reduce demand on potable water.

5.5 Recommendations of the study

Based on the findings of this study, the following recommendations were made to the policy makers and researchers.

i. Recommendations to policy makers

1. As indicated in background and literature review of this study, water sources around the world are diminishing and concerted efforts are required to harvest wastewater and convert it from being a problem to a resource and therefore reduce strain on available sources. Policy makers should ensure a well integrated and coordinated management of wastewater by ensuring appropriate developmental plans are in place and that they are adhered to during implementation of the projects.
2. A review and enactment of by-laws governing wastewater management and reuse should be done to make them enforceable in the harvesting and reuse of wastewater for whatever application. Public awareness should be encouraged and public education on the laws should be undertaken by both local and central government.
3. The government and its agents should participate in dissemination of information regarding the importance on water and environmental conservation and educate people on the safety and standards required of them when they engage in wastewater reuse.
4. The government should subsidize the equipment and chemicals used for wastewater treatment to ensure all the stakeholders in the industry can afford and therefore effectively reuse wastewater without fear of the negative impacts of the same.

ii. Recommendations for practitioners

From the foregoing discussion a number of recommendations can be made for both the end users as well as the developers that will ensure effective wastewater harvesting and reuse. These recommendations include the following:

1. Developers especially in real estate should ensure an elaborate design and construction of wastewater harvesting system that will ensure safe and sound reuse for production of among others biogas. This will reduce the dependence on petro-fuels and firewood/charcoal and therefore conserve our forests.
2. Farmers in peri-urban areas should embrace wastewater reuse and reuse dependence on rain fed agriculture. This will ensure food security and create employment to those working in the farms. Institutions and business entities in these areas should also embrace wastewater reuse for irrigation of the flower gardens and other launches and reduce water stress.
3. Municipal and town planers should develop a system that will encourage wastewater management and reuse. Such system will involve sewerage systems and good drainage lines that will make it easier for those interested in reusing the water to harvest for treatment and subsequent reuse.

5.6 Recommendations for further research

This study has shown how various variables including water availability, institutional arrangement, financial resources, developmental planning among others can influence waste water management and reuse. Based on this results furthers studies are needed to access the extent to which education, poverty, attitude, population, environmental considerations and lack of political commitment influences wastewater management and reuse. The role played by local governments in ensuring planning and management of water resources need to be investigated in addition to information dissemination on safety, health and standards.

REFERENCES

Ajzen, I. (1988). Attitude, Personality & Behavior. Chicago: The Dorsey Press.

Ajzen, I. (1991). Theory of Planned Behavior. Organizational Behavior & Human Decision Processes , 180-198.

Amber, B. M. (2011, 4). A Review of Water Scarcity Indices and Methodologies. Sustainability Consortium . Arkansas, USA.

Babin, R. E. (2005). ASSESSMENT OF FACTORS INFLUENCING . Queensland, Australia: University of Southern Queensland.

Bartones, C. R. (1997). FINANCING WASTEWATER MANAGEMENT. In WHO/UNEP, Water Pollution Control-A Guide to the Use of Water Quality Management Principle. E&F SPON.

Chava, D. N. (2005). Research Methods in the social Science 5th Edition. Milwaukie: University of Wisconsity.

Commission on Revenue Allocation. (2011). Kenya: County Facts Sheets. Kajiado County . nairobi, Kenya.

Corcoran, E. C. (2010). Sick water? the central role of wastewater management in sustainable development. Norway: UNEP UN-HABITAT.

Corcoran, E. C. (2010). Sick water? The central role of wastewater management in sustainable development. Arendal: UNEP UN-HABIT.

Creative Research Systems. (n.d.). Creative Research Systems. Retrieved 4 5, 2013, from Creative Research Systems Website: www.surveysystem.com

Crook, J. A. (1992). Guidelines for Water Reuse. Cambridge, Massechusetts: Camp Dresser & McKee Inc.

Devi, G. M. (2009). A Framework for detarmining and establishing the factors that affect Wastewater Treatment and Recycling. Melbourne.

Devi, M. G. (2009). A Framework for Determining and Establishing the factors that affect Wastewater Treatment and Recycling. Melbourne Parkville: not published - PhD Thesis University of Melbourne.

Easterby-Smith, M. T. (2002). Management Research: An introduction 2nd edition . London: Sage.

FAO. (2013). Food and Agriculture Organization. Retrieved 2 24, 2013, from Food and Agriculture Organization Web site: http://www.fao.org/nr/water/aquastat/water_use/index6.stm

Fatta D, M. M. (2005). wastewater reuse: Problems and Challenges in Cyprus, Turkey, Jordan and Morocco. European Water , 11-12;63-69.

Fengler, W. (2013, 1 9). World Bank. Retrieved 3 15, 2013, from World Bank Website: www.blogs.worldbank.org

Frans P. Huibers, L. S. (2006). Wastewater and Irigated agricultue lessons Learnt and Possible Applications in africa. Wastewater and Irigated agricultue . Nairobi, Nairobi, Kenya: African Technology Policy Studies Network.

Gayathi Devi Mekali, B. D.-M. (2008). Wastewater Reuse and Recycling Systems: A Perspective into india and Australia. Colombo, Sri Lanka: International Water Management Institute.

Githuku. (2009). Assessment of the Environmental Risks of Wastewater reuse in Urban and Peri-urban Agriculture. MSc Thesis JKUAT . Nairobi, Nairobi, Kenya.

Githuku C. (2009). Assessment of the Environmental Risks of Wastewater Reuse in Urban and Peri-urban Agriculture in Nairobi. MSC Thesis, JKUAK . Nairobi.

Githuku, C. (2009). Assessment of the Environmental Risks of Wastewater reuse in Urban and Peri-Urban Agriculture. MSc Thesis, JKUAK . Naironi.

Government of Kenya. (2007). Kenya Vision 2030. Nairobi: Government Press.

Government of Kenya. (2007). Kenya Vision 2030. Nairobi: Government Press.

Hani, D. (2009, 8 5). Explorable. Retrieved 3 10, 2013, from Explorable website: http://explorable.com/samplegroup

Hendricks, D. K. (1980). Planning Water Reuse: Development of Reuse Theory and Input-Output Model Vol. II: Application. Washington DC: Olorado Water Research Institude;Colorado State University.

Hespanhol, I. (1997). Wastewater as a Resource. E. & F. Spon.

Hurlimann, A. &. (2002). Community attitude to an innovative dual water supply system at mawson Lakes South Autralia. Environ 2002 Convention & Exhibition. Melbourne, Autralia.

Infotrack East Africa Limited. (n.d.). Infotrack East Africa Ltd. Retrieved 3 3, 2013, from Infotrack East Africa Ltd Web site: infotrackea.co.ke

Injemela, B. M. (2006). Public Education on Waste Management in Nairobi Central Business District. Nairobi: Not published - research project.

Irungu, G. (2012, 5 8). Business Daily. Retrieved 2 20, 2013, from Nation Media Group Website: http://www.businessdailyafrica.com/Kenya-poverty-level-constant-for-six-years/-/539546/1402060/-/cwlbe3/-/index.html

J. W Kaluli, C. G. (2011). Towards a National Policy on Wastewater Reuse in Kenya. Journal of Agriculture, Science and Technology , 116-125.

Jeffrey, P. &. (2002). Public receptivity regarding 'in-house' water recycling: results from a UK survey. Enviro 2002 Convention and Exhibition. Melbourne, Australia.

Kaluli, J. C. (2011). towards a National Policy on Wastewater Reuse in Kenya. Journal of Agriculture, Science & Technology , 117-121.

Kaluli., G. C. (2011). Towards a National Policy on Wastewater Reuse in Kenya. Journal of Agriculture, Science & Technology , 116-125.

Kandiah, A. (1994). The use of wastewater in the context of overall water resources planning and policy. Paper presented at WHO/FAO/UNCHS/UNEP Workshop. Harare Zimbabwe.

Kenya National Bureau of Statistics . (2010). Kenya 2009 Population Census Highlights. Nairobi: Government Press.

Kenya National Bureau of Statistics. (2009). Kenya Population and Housing Census. Nairobi: Government Printers.

Kenya National Bureau of Statistics. (2010). Ministry of Planning and vision 2030. Retrieved 2 5, 2013, from Ministry of Planning and Vision 2030 web site: www.planning.go.ke

Mantovani, P. T. (2001). Management for non potable water reuse. Alexandria: Project 97-IRM-6 Water Environment Research Foundation.

Marks, J. C. (2002). Community experience and perceptions of water reuse. Melbourne, Australis.

Marsaleck, J. K. (2002). Water Reuse and Recycling. Winnipeg: Canadian Council of Ministers.

Mckenzie, B. &. (2008). Addressing water scarcity through recycling & reuse: A menu for policymakers. Trevose, USA.

Miller, G. W. (2004). Integrated concepts in water reuse: managing global water needs. Alexandria, VA, USA: WateReuse Association.

Ministry of Environment and Mineral resources. (2012). National Environment Policy. Nairobi.

Murni Po, J. D. (2003). Factors influencing public perceptions of water reuse. Victoria Australia.

Murni, P. J. (2003). Literature review of factors influencing public perceptions of water reuse. Melbourne: Csiro.

Mwaura Kimani, C. M. (2012, 5 15). The East African. Retrieved 2 20, 2013, from The East African Web site: http://www.theeastafrican.co.ke/news/Kenya+slashes+2012+economic+prospects++cites+high+inflation/-/2558/1406302/-/x6o4lb/-/index.html

Narasimhan T.N. (2008). Water Law, Science. Journal of Hydrology , 125-138.

NEMA. (2006). National Environmental Management Authority. Retrieved 2 27, 2013, from National Environmental Management Authority Website: http://www.nema.go.ke/index.php?option=com_content&view=article&id=136&Itemid=489

Ngigi A. and Macharia.D. (2006). Kenya Water Sector policy overview paper. Intelligent Energy Europe.

Ngindu, K. A. (2007). Quality of Water Slum Dwellers Use: The case of Kenyan Slum. Jounal of urban Health 84(6) , 829-838.

Onjala, J. O. (2002, 1). Managing Water Scarcity in Kenya: Industrial response to tariffs and regulatory enforcement. Phd Thesis . Copenhagen, Copenhagen, Denmark: Roskilde University.

O'toole, M. (1995). Science and Our Future Water. Cambridge: Press Syndicate of University of Cambridge.

Republic of Kenya. (2007). Kenya Vision 2030 - a globally competitive and prosperous Kenya. Nairobi.

Sambili, D. E. (2011, 11 2). Ministry of State for Planning National Development and Vision 2030. Retrieved 2 20, 2013, from Ministry of State for Planning National Development and Vision 2030 Web site: http://www.planning.go.ke/index.php?option=com_content&view=article&id=329:kenya-to-address-rising-population-growth&catid=1:latest-news&Itemid=53

Steins, K. (2012, 4 26). Universitaten Babes-Bolyai. Retrieved 4 19, 2013, from Universitaten Babes-Bolyai Web site: http://www.cs.ubbcluj.ro/~per/C8%20Vs/C8_Ms.pdf

Tayler, J. P. (2003). Decentralized Wastewater Management in Peri-Urban Areas in Low Income Countries. Environment & Urbanization , 75-76.

UK Government. (2012). National Policy Statement for Wastewater. London.

UNDESA. (2009). Millennium development goals report 2009. New York: United Nations Department of Economic and Social Affairs.

UNEP. (2005). Water & Wastewater Reuse - an environmentally sound approach for sustainable urban water management.

UNESCO. (2004). Improving Municipal Wastewater Management in Coastal cities. Hague Netherlands: Train-Sea-Coast GPA.

University of Twente. (n.d.). University of Twente. Retrieved 2 19, 2013, from University of Twente Website: http://www.utwente.nl/cw/theorieenoverzicht/Theory%20Clusters/Health%20Communication/theory_planned_behavior.doc/

WHO/UNICEF. (2010). Report of WHO/UNICEF Joint Monitoring Programme on Water Supply and Sanitation. New York & Geneva: United Nations Children's Fund and World Health Organization.

World Resources Institute. (2013). World Resources Institute. Retrieved 2 17, 13, from World Resources Institute Website: http://www.wri.org/publication/content/8570

APPENDIX

Appendix 1 – Basic infrastructure

Fig 7 Appendix 1A section of a road in Ongata Rongai town

Fig 8 Appendix 1B A flooded road in Ongata Rongai town

Fig 9 Appendix 1C An open septic tank behind Rongai market

Fig 10 Appendix 1D: Exhauster emptying septic tank at Crystal Plaza in Ongata Rongai

Appendix 2

Appendix 2a: Eighth Schedule

Environmental Management and Co-ordination (water quality) regulation, 2006 arrangement of regulation

Microbiological quality guidelines for wastewater use in irrigation

Reuse conditions	Exposed group	Intestinal nematodes (MPNL)*	Coliforms (MPN/100 ml)
Unrestricted irrigation (crops likely to be eaten uncooked, sports fields, public parks)	Workers, consumers, public	<1	<1000**
Restricted irrigation (cereal crops, industrial crops, fodder crops, pasture and trees***	Workers	<1	No standard recommended

* Ascaris lumbricoides, trichuris trichiura and human hookworms

** A more stringent guideline (<200 coliform group of bacteria per 100 ml) is appropriate for public lawns, such as hotel lawns, with which the public may come into direct contact

*** In the case of fruit trees, irrigation should cease two weeks before fruit is picked and fruit should be picked off the ground, overhead irrigation should not be used.

Appendix 2b: Steps in wastewater treatment

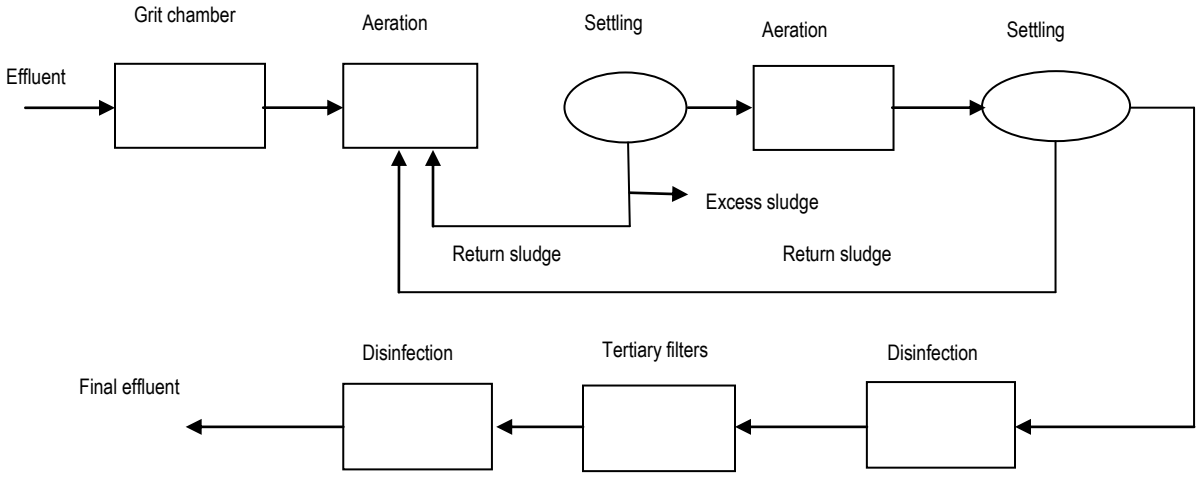

Fig 11: major treatment steps for traditional wastewater treatment in Kuwait. Adopted from international Business and economic research Journal Jan 2010 vol 9, number 1

Appendix 3

Appendix 3a: Letter of intent

Ashiembi Peter Angatia,
P.O. Box 51018-00100
NAIROBI.
May 6th 2013.

Dear Sir/Madam,

My name is Peter Angatia, a student at the University of Nairobi per suing a Master of Arts degree in Project Planning and Management. I am writing to invite you to participate in research in the form of a questionnaire.

My research project focuses on the factors influencing wastewater management and reuses in peri urban areas in Kenya a case of Ongata Rongai. An integral part of the project is to identify such factors as water availability, financial resources, awareness of the legal requirement and other socio-economic factors and how these factors determine wastewater management and reuse. The questionnaire should take about 30 minutes to complete and the findings will be submitted to the University of Nairobi in partial fulfillment of the degree of MA PPM.

I wish to assure you that the information you provide will be treated as confidential and it will be kept in the faculty at the University of Nairobi. Access to the information provided in this questionnaire will be restricted to my supervisor and myself.

I look forward to your assistance.

Yours sincerely

Peter Angatia

Appendix 3b: Questionnaire

General information

i. Age: 18-25 yrs ☐ 26-35yrs ☐ 36-50yrs ☐ 51yrs-above ☐

ii. Marital status: Single ☐ Married ☐ Widowed ☐ Separated ☐

iii. Residence: Kandisi ☐ Nkoroi ☐ Rimpa ☐ Twala ☐

Rongai ☐ Ole Kasasi ☐ Other (specify) _____

iv. What was your highest level of education? (Tick one)

a) Some primary ☐

b) Primary education ☐

c) Some secondary education ☐

d) Secondary education ☐

e) College education ☐

f) University education ☐

g) Others (specify)_____

v. What do you do for a living?

a) Civil servant ☐

b) Employed in private sector ☐

c) Self employed (jua kali/farmer/business person) ☐

d) Other (please specify) _____

1. Water availability

1.1 What is the source of water that you use? (tick as appropriate)

i. Municipal (piped) ☐

ii. Vendors ☐

iii. Borehole ☐

iv. Shallow well ☐

v. Other (specify…river/rain)_____

1.2 how much do you spent per unit of water (1unit=1000litres)

> Ksh 100

Ksh100>Ksh 200

Ksk100>Ksh300

1.3 How far is the source of water from your house/workplace?

i. 0km- 0.5km ☐

ii. 0.51km-1.01km ☐

iii. 1.02km -1.52km ☐

iv. 1.53km-2.03 km ☐

1.4 Wastewater is a combination of one or more of domestic effluent consisting of water from toilet, bathroom, laundry, industrial effluent, storm water and other run off. Would you consider reusing it?

i. Yes ☐

ii. No ☐

1.5 What challenges do you face in sourcing for water?

i. Distance ☐

ii. Cost of water ☐

iii. Availability of water ☐

iv. Other (please specify) _____

2. Culture

2.1 Gender: Male ☐ Female ☐

2.2 Do you think gender plays a role in wastewater reuse?

Yes ☐ No ☐

2.3 Would you using wastewater? Yes ☐ No ☐

2.4 If 'No' in 2.3 above, what are the reasons?

i. Cultural beliefs ☐

ii. Infrastructure for harvesting ☐

iii. Gender ☐

2.5 What opinion on wastewater as a resource?

i. it is a water resource ☐

ii. It is not a resource ☐

2.6 What are some of the uses you put used water to?

i. Irrigation ☐

ii. Watering livestock ☐

iii. Commercial activities like timber treatment ☐

iv. Toilet flushing ☐

v. Other (specify-e.g. Biogas)_____

_____

_____

2.7 What benefits do you think you will derive from reusing wastewater?

i. Availability ☐

ii. Low cost to access ☐

iii. Rich in nutrients for irrigation ☐

3. Institutional arrangement

3.1 Are you aware of any institutions regulating water reuse? Yes ☐ No ☐

3.2 Identify some of the institutions regulating and setting standards for water resources in Kenya

i. National Environmental Management Authority (NEMA) ☐

ii. Kenya Bureau of standards ☐

iii. Local Authorities ☐

iv. All the above_____

3.3 Do you know of any standards and regulations on water resource use? Yes ☐ No ☐

3.4 Do you know the contents of Kenya's Vision 2030? Yes ☐ No ☐

3.5 Have you ever been visited by NEMA/KEBS/Local environmental officials? Yes ☐ No ☐

4. Financial resources

4.1 What is your gross income per month (tick one)

i. Ksh 0 – KShs10,000 ☐

ii. KShs 10,000-20,000 ☐

iii. KShs 20,000-30,000 ☐

iv. KShs 30,000-40,000 ☐

v. Ksh 40,000-KShs 50,000 ☐

vi. Ksh 50,000- ksh 60,000 ☐

vii. Over Ksh 60,000 ☐

4.2 Do you reuse wastewater? Yes ☐ No ☐

4.3 Have you set up any plumbing system to harvest your wastewater? Yes ☐ No ☐

4.4 If 'Yes' how much did it cost you to set up systems for reusing the wastewater?

i. Ksh0 - KShs 20,000 ☐

ii. KShs 20,000-Ksh40,000 ☐

iii. Ksh40,000 - KShs 60,000 ☐

iv. Ksh60,000 - KShs 80,000 ☐

v. Ksh80,0000 - KShs 100,000 ☐

vi. Ksh100,000 - KShs 120,000 ☐

vii. Ksh120,000 - KShs 140,000 ☐

viii. KSh140,000 – above ☐

5. Developmental planning

5.1 What kind of dwelling/household do you occupy?

i. Free standing stone house/flat ☐

ii. Farm house ☐

iii. Prefabricated house ☐

iv. Detached Maisonettet ☐

v. Informal shack ☐

vi. Traditional home state (village) ☐

5.2 What is your tenure status on your housing unit?

i. No access to land ☐

ii. Owner of the dwelling and holder of the title deed to the plot ☐

iii. Owner of the house but no title to the plot ☐

iv. Inherited ☐

v. Rent/hired ☐

vi. Others (specify) _____

_____

_____

5.3 Do you have access to public sewage system? Yes ☐ No ☐

5.4 In your opinion, is the current developmental system for your area planned? Yes ☐ No ☐

5.5 What is your main source of toilet facility and wastewater disposal?

i. Flush & septic tank ☐

ii. Latrine & septic tank ☐

iii. Latrine & open field ☐

5.6 What challenges do you face in disposing your wastewater?

i. Lack of infrastructure ☐

ii. Lack of adequate plan for sewerage system ☐

i. High population ☐

ii. Other (specify) _____

_____

_____

6. Technology

6.1 Do you reuse wastewater? Yes ☐ No ☐

6.2 If 'Yes' in 6.1 above, do you treat wastewater before reusing? Yes ☐ No ☐

6.3 If 'Yes' (in 6.2 above) which method do you use?

i. Physical ☐

ii. Physical & chemical ☐

iii. Physical & biological ☐

iv. Physical/chemical & biological ☐

6.4 Have you ever considered potable reusing of wastewater? Yes ☐ No ☐

6.5 How much do spent on treatment of the wastewater?

i. Ksh0 – Ksh 20,000 ☐

ii. Ksh 20,000 – Ksh 40,000 ☐

iii. Ksh 40,000 –Ksh 60,000 ☐

iv. Ksh 60,000 – Ksh 80,000 ☐

Appendix 3c: Observation check list

1. Any health and safety precautions: Yes _____ No _____
2. Any form of water reuse: Yes _____ No _____
3. Source of water reused: Black ____ Grey _____ Storm _____
4. Any benefits of reuse: _____

   _____

   _____
5. Any mode of disposal: Septic tank_____ sewerage line ____ Open field _____
6. Any livestock on the compound: Yes _____ No _____
7. Mode of waste disposal in the compound:

   Municipal collection ____

   Private collector _____

   In open field _____