MANAGEMENT OF WATER RESOURCES IN THE PERI-URBAN AREAS OF RUIRU DISTRICT, KENYA

BY

EUNICE WAMBUI MUGERA
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DECLARATION

This Thesis is my original work and has not been presented for a degree in any other University or any other award.

Signature_____ Date 17/8/2011

Eunice Wambui Mugera, Bsc Nairobi,

We confirm that the work reported in this thesis was carried out by the candidate under our supervision.

Signed_____ Date 18/8/2011

Dr. Jones F. Agwata

Department of Environmental Sciences

Kenyatta University

Signed_____ Date 19/10/11

Dr. Stephen O. Anyango

Department of Environmental Sciences

Kenyatta University

DEDICATION

This work is dedicated to my parents, husband and children for the moral support and understanding they accorded me during the course of my studies.

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ACRONYMS AND ABBREVIATIONS

ASALs	Arid and Semi Arid Lands
CBO	Community Based Organization
CBS	Central Bureau of Statistics
DANIDA	Danish Development Agency
GOK	Government of Kenya
ILRI	International Livestock Research Institute
IWRMS	Integrated Water Resources Management Strategy
L/C	Local Community
MPND	Ministry of Planning and National Development
NEMA	National Environment Management Agency
NGO	Non Governmental Organization
TARDA	Tana and Athi River Development Authority
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environment Programme
USAID	United States Aid International Development
WHO	World Health Organization
WRMA	Water Resources Management Authority
WRI	World Resources Institute

ABSTRACT

In peri-urban areas of the country, there are numerous and complex problems that confront the residents. Water scarcity is one of the critical problems that deserves most attention. It is a major challenge hindering socio-economic development in these areas. This therefore calls for research to find out how water is managed in these areas. Ruiru District was chosen for the study to fill this gap due to its high population density as significant population working in Nairobi city and Thika towns are shifting to the District looking for places to settle. The high population increases water demand leading to water scarcity in the area. Ruiru District has two Divisions, six locations and ten sub locations. A multistage design involving stratified and random sample surveys were used to come up with the required sample. A household survey approach with the aid of questionnaires and observation record sheets were used to collect data on the major sources of water, their accessibility, reliability and utilization in the area. The study examined the techniques used to conserve water and established the problems the people experience while practicing these techniques. The data collected was analyzed using Statistical Packages for Social Scientists programme and presented in frequencies, percentages and ranking. The study has confirmed that Ruiru Distrtict has rapid population growth without a corresponding increase in water sources. The study also established the main sources of water as Nairobi Water Company mains, Community Based Organization's mains, boreholes, wells and rivers. The major problems found were limited access to potable water, inadequate number of water sources and drying up of wells during the dry season. The study revealed that the mean household water consumption rate in the area was 18.3 liters per person per day. This rate is slightly below the recommended per capita consumption rate of 20 liters per person per day. Water conservation techniques practiced include roof rain water harvesting, repair of leaking taps/pipes, water reuse, use of efficient taps and installation of dual flush toilets, among others. The various limitations that affected water conservation techniques include lack of finances, lack of awareness, dry weather conditions, altitude and culture, among others. Based on the findings it is necessary to provide water at homes so that people involved in providing water can be engaged in other productive activities. Promotion of appropriate technologies such as use of dual toilets, use of efficient taps, drip irrigation and mulching need to be encouraged. There is also need to promote marketing and processing of farm and livestock products so as to increase the people's daily earnings and so alleviate poverty in the District which is directly affecting water conservation practices. There is need to increase public awareness regarding protection of water sources, their use and conservation in the District. Specific efforts should be made through the Ministry of Water and Irrigation and other related actors to increase water conservation awareness programmes to enable the people appreciate the importance of water management in the District.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

A third of the world's population live in water stressed countries and it is expected that this will rise to two-thirds by the year 2015 (UNEP, 2004). In the developing world about 25 percent of the population have access to improved water sources (Abu-Eid, 2007). Peter Gleick from the Pacific Institute for Studies in Development, Environment and Security recommends a minimum of 50 litres per capita per day (lcd) for domestic uses, (Gleick *et al* 2002). Because access to water is a basic human right, the UN as part of its Millenium Development Goals programme (MDGs) aims at, among others, to increase the proportion of population (urban and rural) with sustainable access to an improved water source by 2015.

In Kenya about 57% of the population has access to improved water sources (GOK, 2009). In an effort to solve this problem, Kenya's Poverty Reduction Strategy Paper (PRSP) 2000-2003 prescribes steps to achieve the UN millennium development goal on water. The steps include among others introduction of private sector participation in water delivery and management, and rehabilitation of smaller water supply systems.

Despite the efforts, access to potable water in peri-urban areas in Kenya still remains a problem because of the uncontrolled increases in population. UNEP, 2003

confirms that "the carrying capacity of the peri urban areas is deteriorating due to growing populations that do not correspond with the rate at which resources are provided. In short, water demand exceeds supply due to the non- corresponding increase in per capita investment. In 2002, the Government of Kenya adopted the National Water Policy to address the problems of water supply.

The shortage of water in various parts of the world has affected the well being of ecosystems due to its uneven distribution in space and time, poor management of the available water and variations in its use for different socio economic activities (Abu-Eid, 2007). It is therefore important that water must be properly planned, utilized, conserved and be made accessible for continued social and economic development.

The number of African countries facing water stress, scarcity and land degradation is increasing. This is a major concern in the world. This is mainly caused by increasing demand for water due to increase in population, expansion of urbanization, agriculture, industry and livestock especially in the marginal areas leading to the clearance of natural habitats such as forests and wetlands. These land-use changes have affected Africa's water conservation efforts (Kundell, 2007).

The scarcity of water and unreliability of its supply is a major constraint for agriculture, domestic and livestock development in most African countries. This leads to reduction

of land productivity as a result prolonged dry spells and inappropriate agricultural production systems. Indeed, insufficient quantity of water is slowing social and economic development and is leading to increasing levels of poverty due to declining food availability and employment opportunities for the people in the world.

Kenya is regarded as a water scarce country whose water resources are declining as a result of catchments degradation, population growth and urbanization (UNESCO, 2003). This scarcity and unreliability of water poses a serious challenge to agriculture, domestic and livestock development in the peri-urban lands in various parts of the country. Estimate indicate that Kenya needs approximately 3.4 billion m^3 of storage for water by the year 2010 to reliably supply water for domestic, urban-rural agriculture and livestock development (UNESCO, 2003). For this demand to be met, the available water should be utilized in a sustainable manner by promoting water conservation in all sectors of development in the country.

The present urban population in Kenya has about 3.7 million people, representing about 18.5% of the total population (Shivoga, 2002). Due to the congestion in the urban areas, people are shifting to the nearby peri-urban areas in search of employment and for places to settle. Biswas *et al* (2005) established that such areas are typically poorly served with permanent water supply systems and also lack in infrastructure services. Frequently, such areas are not officially recognized by the local administration which deprives them of basic services even though they are centers of rapid population growth

due to both natural and population migration. Because of the high population density, generally low incomes and sociological features of communities' provision of water supply facilities is not a simple technological and economic issue. Solutions need to relate to the overall circumstances of the community in question.

Farming activities are also affected by the changes in land use practices in the peri-urban areas. The lands formerly used for farming and rearing of livestock are subdivided in to smaller plots for residential purposes living the farmers with limited farming lands, grazing lands and limited water sources for their activities. Ghettuba, (2004) in her study established that available water is given first priority to domestic water use while other uses come after. This suggests that in areas with limited water supplies farming and livestock are likely to suffer for lack of water unless more water sources are made available. Due to worsening of poverty levels in peri-urban areas, many low-income households suffer from extremely limited livelihood security. They engage in peri-urban farming and livestock keeping as a response to limited alternative livelihood options and food insecurity. This category of livestock keepers, lacking the control over access to water supplies (Waters-Bayer, 2005).

The peri-urban parts of the country require significantly more water and enhanced conservation measures to ensure availability of reliable supply of water to meet the increased demand in the domestic, irrigation and livestock sectors. This requires that the

sources of water for various uses and the amount of water used in the various sectors be known in order to plan for and manage the available water properly. In this study, water availability and use in the peri-urban areas of Ruiru District was examined with a view to optimizing its utilization in the District.

1.2 Statement of the Problem

Lack of water threatens progress towards sustainable development in the peri-urban areas of the country. The unregulated use of water in these areas has caused over-exploitation and degradation of water sources leading to drying of rivers and shallow boreholes (Turton and Waner, 2002). This leads to increased water scarcity which in turn leads to competition for access to available water sources for domestic, livestock and irrigation activities. These competition leads to low levels of agricultural production leading to starvation of the people and livestock. This therefore suggests the need to understand the water situation and establish the solutions to peri-urban water problems.

The problem of access to water sources is one of the major problems that currently confront many communities in the world. According to the Kenya's Poverty Reduction Strategy Paper (PRSP) 2000-2003, access to improved water sources (piped water) by both rural and urban populations is limited (30% and 70% respectively) and is declining due to non-performance of existing schemes. Moreover, 73% of the urban community with pipe network have experienced irregular or no water. Households without access to

piped water tend to rely on a variety of less reliable sources, including mobile water tankers, water vendors and shallow wells.

The peri-urban areas of Ruiru District are faced with a lot of water shortages and land use changes leading to transformations in the hydrological, ecological, geomorphological and socio economic systems. The District is also characterized by a high population from different ethnic communities of the country. The high concentration of people have placed enormous pressure on the available water resources. This has increased demand on the available water supplies. At the same time, under decentralization of policies, the responsibility for delivering such services face a lot of facilitation challenges in terms of financial and human resources. As a result these areas have suffered slow progress towards sustainable water development (GOK, 2009).

The majority of research projects reviewed have focused on highlighting the current water shortage and management in the urban and rural areas. Research in water management in cities has been restricted to the capital and not in other cities especially small and medium size ones and in particular the peri-urban areas. Most of the information about water use and management is reported within figures for total annual water consumption or is contained in information about existing problems. There appears to be no specific information about water use and management in domestic, livestock and irrigation in peri-urban areas. This study seeks to fill this gap by addressing the management of water resources in the peri-urban areas of Ruiru District.

The study will establish the various sources from where water is drawn, determine how much water is used in the various sectors and examine the methods used to conserve water and assess their limitations and propose ways of improving water supply in the District.

1.3 Research Questions

The following research questions are addressed in the study.

(a) Which sources of water are available for use in Ruiru District and how accessible and reliable are they?

(b) How much water is used in the domestic, livestock and crop irrigation activities in the District?

(c) Which techniques are used to conserve water in the District and what are the limitations associated with these techniques?

1.4 Objectives of the Study

The objectives of this study are to:

(a) Establish the major sources of water, their accessibility and reliability in Ruiru District.

(b) Determine the amount of water used for domestic, livestock and irrigation activities in the District.

(c) Examine the various methods used to conserve water and establish the limitations associated with these techniques.

1.5 Justification, Significance and Limitations of the Study

The problem related to water scarcity can be resolved through water resource management activities that optimize on sustainable use of the available water. This change in emphasis is particularly important for Ruiru District due to continued water scarcity and increased water demand in the area as a result of increase in human population, livestock and irrigation activities. There was need, therefore, to establish the water resource availability and determine the amount of water used in domestic, irrigation and livestock sector. Information on the way water is conserved and the limitations of various conservation efforts is also necessary in the District with a view to making recommendations on what can be done to improve the situation.

The study is important as its findings can be used to address water resources management issues in the area. The information obtained from the study can also be used by the Government and other relevant agencies involved in water management to improve water availability in related peri-urban areas and activities. The findings from the study can also be used as a basis for comparison with similar studies in other areas having similar climatic and hydrological conditions, settlement patterns and land use activities to ensure sustainable water management for enhanced socio- economic development of these areas.

Few limitations were experienced while carrying out this study. The farms have been sub-divided into smaller sizes of quarter acre plots for residential purposes as opposed to

the original sizes due to lack of benefit from farming activities. This affected the sample size because 20 more households were added to increase data validity and reliability.

1.6 Conceptual Framework for Water Management in Peri-Urban Areas

The research is based on a conceptual framework on water management (Figure 1.1) borrowed from Solei *et al* (2010) and modified to match with the study.

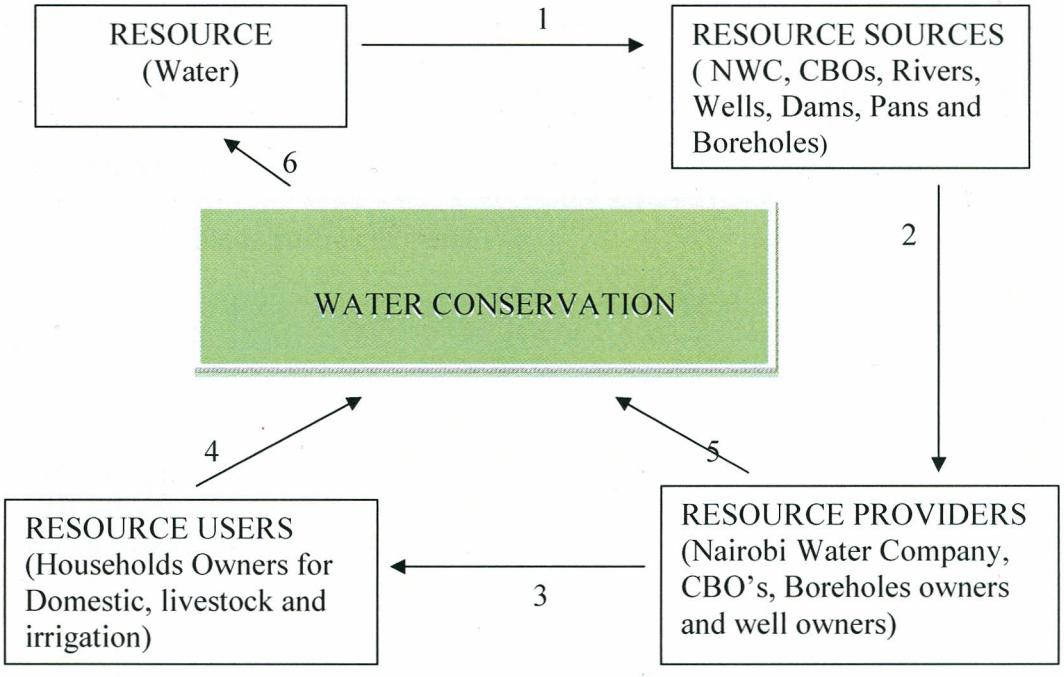

Figure 1.1: Conceptual framework for Water Management adapted from (Solei *et al*, 2010).

Interactions (1) between resource and resource sources shows the available water sources in the District that could be accessed by the residents for use in various sectors.

Interactions (2) between resource sources and resource providers shows the resources providers develop projects that could make the resource sources available for the resource users to access for various uses. Interactions (3) between resource providers and resource users shows the resource provider set rules and conditions for the resource user on the mode of accessing the resource, rate and mode of payment of water, mode of water distribution etc. Interaction (4) between resource user and resource conservation shows that the resource user plays a major role in ensuring that the available water is utilized well without waste while ensuring that the sources are protected. Interaction (5) between resource provider and resource conservation shows the resource provider ensures that the resource source is protected and increases the available resource source. Interaction (6) between the resource conservation and the resource ensures that the resource is available in sufficient quantity.

1.7 Definitions of Operational Terms

Adequate-Having enough water for use in a particular activity

Bucket Bath-Washing the body by splashing water on it from a bucket

Domestic water use- This includes everyday uses such as drinking, cooking, bathing, toilet flushing, washing clothes and dishes, watering lawns and gardens, maintaining swimming pools and washing cars among others

Levels of education-This is taken as (basic education or formal learning in an institution like Primary, Secondary and College where,

(a) Primary stands for the first 8 years of formal education,

(b) Secondary stands for 9-12 years of formal education,

(c) Tertiary stands for 13 years and above of formal education

Monthly Income-This is taken to mean the amount of money earned or given to a person per month

Peri-Urban Areas-These are areas found at the outskirts of towns or cities and are getting modernized from a rural set up to urban set up with developed means of transport, water supplies, industrial growth and with a high population living within small land fragments and work in those towns or cities

Reliability-This is the availability of water at the source during the time of need.

Shower-Stand upright under water sprayed from a nozzle

Utilization -This is the use of water for various activities

Water accessibility- This is the physical distance travelled to and from the water sources

Water actors- All institutions dealing with water activities

Water conservation- Reduction in water use accomplished by improved water management practices that enhance the beneficial use of water

Water conservation techniques- An action, behavior change, device, technology, improved design or process implemented to reduce water loss, waste or use

Water Crisis - This describes a situation where the available water within a region is less than the region's demand.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents the review of literature on water sources, availability and accessibility, reliability and utilization in the domestic, livestock and irrigation sectors. The chapter also presents review of studies on water conservation practices and the limitation of these practices as conducted in various parts of the world.

2.2 Water sources

Besides rain, the other natural water sources available to communities are either surface water or groundwater. Surface water is the traditional source of water for most rural and urban communities. This source type includes natural water bodies such as streams, pans, dams, lakes, rivers and springs. The resource may be accessed directly at the source, through water pipes to a water supply. Nowlan (2004) notes that the most convenient source of water for small communities is frequently a natural stream or a nearby river. Community water supply systems is mostly from surface water or groundwater sources.

Groundwater source is considered as the most economic source of rural potable water supply. It is usually tapped by the communities through the digging of boreholes and wells. Gyau-Boakye and Dapaah-Siakwan's (2006) established that 50.5% of the rural population depends on surface waters. Only 0.05% of the rural population depends on

rainwater harvesting due to the poor annual rainfall pattern in many parts of the country. While 40.7% depends on boreholes and wells and 0.7% rely on springs. In addition to these facts, another study mentioned in Katz, and Sara (2007) established that there are aquifers which underlie geographically large areas of the country which can be tapped at shallow depths close to the demand centers in response to the dispersed nature of the rural settlements. Furthermore, water stored in aquifers is almost protected naturally from evaporation, and well yields are in many cases adequate. Though, groundwater requires minimal or no treatment Branco *et al* (2005), McGregor *et al* (2006) warn that: "the increasing use of boreholes by communities and private individuals progressively increases the inifiltration of nutrients to groundwater resources".

2.3 Accessibility of the Water Sources

Life on earth depends upon water availability and accessibility, which supports all ecosystems within the planet. A number of studies have shown a decline in water sources, accessibility and reliability in various parts of the world. Findings from Annandale (2001) showed that overall per capita water available in urban areas dropped from 121.6 liters in 1967 to as low as 47.4 liters in 1997. In 2000, willingness to pay finding by UNEP (2002) in Nairobi, Mombasa and Kakamega urban areas found a low figure of 40 liters per capita water use per day. Findings from Smakhtin *et al* (2004), in their study on global assessment of environmental water requirement and scarcity also found a low figure of 36 liters per capita water use per day.

The decline in water availability and accessibility has been as a result of the increase in population, lack of sustainable management of the resource base plus global climate change which has changed precipitation patterns and other local climate conditions (UNEP, 2001). This deteriorates forest growth that forms the water catchment areas and leads to reduced water supplies in many parts of the world. Herweijer *et al* (2006) described North America as experiencing frequent droughts due to climate change. The droughts are causing rivers and shallow wells to dry up due to the lowering of the water table leaving the communities with limited alternative sources. The affected communities have to walk for long distances in search of water beside spending a lot of money in buying water and drilling of boreholes.

It is projected by Vorosmarty *et al* (2004) that under current trends, two thirds of the world population may be subject to high water stress by 2025. It is also expected that the world will need 17 per cent more water for domestic use and agriculture to support the increasing world population (UNEP, 2002). Vorosmarty *et al* (2004) proposed that, to sustainably plan for water, there is need to know how much water is needed globally for domestic use, irrigation and for livestock in order to control withdrawals to ensure equitable distribution. This information is lacking in most peri-urban areas such as Ruiru District.

The available methods of accessing water from various sources for most uses in developing countries are inefficient and inadequate (Selborne, 2000). In the Middle East

and North Africa water at homes is availed by traveling long distances to the water sources (Brooks *et al;* 2007). People carry water in large quantities over long distances on their backs, using carts and large water tankers. There is need to establish alternative means of accessing water so that people can pursue other productive and beneficial activities in terms of education and development. This can be done by appreciating the various problems people face while accessing water from various sources with a view to obtaining information on what can be done to solve these problems. Information on water accessibility in peri-urban areas is lacking hence the need for the study to fill this gap. This study in the peri-urban areas of Ruiru District on water management is important so as to capture all the necessary information on how the community access water in peri-urban areas and other related areas with a view to suggest possible solutions to these problems.

The exploitation and distribution of water resources in Kenya is normally controlled through an appropriate mechanism provided for in the Water Act of 2002 in which a permit is issued for diversion, extraction, obstruction and use of water. This enables water to be made accessible to most users who need it for various functions. UNEP (2002) revealed that groundwater is a major supplement of surface water for communities in Nairobi and Mombasa due to high demand resulting from rapid growth of the population and also due to unreliability and degradation of surface water in these areas. The peri-urban areas of the country have a rapid increase in population resulting from migration of people from rural areas seeking employment. Urban population are

also shifting to these areas for settlement. The impacts in decline in per capital water availability from the sources in these areas is high. From the literature review, there were no such studies carried out in the peri-urban areas particularly those of Ruiru District. This study seeks to reveal the available sources of water and establish the alternative water sources that can be accessed by the communities.

2.4 Reliability of the Water Sources

The reliability of water is essential for development in all aspects of life. Gleick *et al* (2002) stated that one billion people worldwide lack access to reliable water supplies. The global consumption of water is known to be doubling every twenty years, and it is estimated that by 2025, if present rates of water consumption are maintained, five billion out of the world's 7.9 billion people will be living in areas where it will be difficult to meet basic water requirements. It is therefore, important to establish the methods that can be used to conserve available water and to improve reliability of the water sources in various parts of the world.

In developing countries, there is frequently uncertain access to reliable supplies of portable water. Commonly, the peri-urban populations lack modern water distribution systems. Following the decreased surface water sources due to global warming effect, people are depending on groundwater for their water supply. This therefore calls the need for a study to establish the reliability of the available water sources in the peri-urban areas.

The unreliability of water supplies becomes a great challenge on socio-economic development as more financial resources that could be used in development activities are allocated to supplying people with relief food and water for consumption (Warner *et al* 2006). People living in urban and rural areas are disproportionately affected as they spend several hours every day collecting water, either from communal taps or directly from streams and rivers.

The unreliability of water sources increases the level of poverty among the people. The poverty level can be reduced by providing the communities with developed water supply systems and also through increased water conservation measures that can improve availability and reliability of water in these water scarce areas. Although such plans have been successful with utilities in big cities, according to the literature review that were conducted, we have no evidence that this would be true for utilities in smaller towns and other areas. Further more, most case studies are focused on a few countries and there is not a global perception. So there is a place for a study that could go a step further by studying the reliability of water sources and the possible limitations in small towns and in particular in peri-urban areas.

2.5 Water Utilization

Access to and continued supply of water for domestic, livestock and irrigation constitutes the most universal and most pressing of water use in the rural and urban areas. These activities require flows that are reliable in quantity. On a global scale, about 67 per cent of all water accessed for human use is absorbed by agriculture mostly in the form of irrigation. Domestic use accounts for 9 per cent while industry uses 25% (Rosegrant and Ringlier, 2000). The global water consumption averages vary from one region to another depending on whether it is a developing continent or a developed continent. In Europe Conca (2005) found that from the bulk of water accessed 45 per cent was supplied to the industry, agriculture's share was 39 per cent while domestic consumption took up 14 per cent. In Africa, however, Mc Cornick *et al* (2003) estimated that agriculture in Ethiopia consumes 63 per cent of all the water withdrawn for human use, while the proportion used for domestic purposes is 8 per cent while for industry it was 4 per cent. This shows that industry and agriculture are the major sectors that use a lot of water as compared to domestic water use. The impact of these major sectors on the environment as a consequence of their use of water and their methods of returning used or surplus water into the system for other uses are significantly different. Waste water from some industries and agricultural activities can not be put to any use and sometimes their interaction with the environment can be very destructive (Nowlan, 2004).

Laban (2007) estimated the amount of waste water from household uses in the urban areas of Cape Town, South Africa to be 40% of the initial water used. He found that

domestic activities pollute water that could be used in other sectors. He recommended installation of technical appliances that would enable less domestic water consumption. Some of the water saving options suggested for use at the household level are re-use of water from the kitchen, use of economy shower heads, using toilets with flushing interceptions and the utilization of rain water. Unfortunately these appliances have not been used and their benefits realized in many regions of the world today because of the negative attitude that people have of them while others have not received the technology yet (Tsagarakis *et a;* 2002).

In Kenya, the ever-increasing demand for water especially in the urban areas is caused by increasing demand by increasing populations and expanding urban areas. Urban residential development draws off increasing quantities of water thus reducing water recharge (Annandale, 2001). The combination of rapid population growth, groundwater depletion and poor drainage causes potential threats for many large populations. The studies reviewed focuses water utilization on a global scale and urban areas in few countries and has not focused on peri-urban areas and therefore need for the study to address this gap.

2.6 Water Conservation

Water conservation is a very useful activity among all water users because it increases the water supply for use in times of water scarcity (WHO, 2005). To meet the water demand required in domestic, irrigation and livestock in the peri-urban areas, water

conservation has to be given first priority. This therefore predicts the need for a study to understand the methods of water conservation used so as to find the possible solutions to water conservation techniques. Among the techniques identified by Meinzen and Rosegrant, (2001) for semi-arid areas include proper design of water sources and distribution network, appropriate plant selection, use of efficient irrigation methods such as drip method, mulching and appropriate maintenance in water scarce areas. These particular techniques have proved to solve most of the water problems in rural areas with low population densities and large farm sizes but we have no evidence that this would be true for utilities in peri-urban areas. So there is a place for a study that could go further to establish the methods used to conserve water and asses their limitations in peri-urban areas.

In the agricultural sector, Attia (2005) reported that water savings in the irrigation sector can be achieved through the application of five major on-farm irrigation water conservation practices. The five practices include LEPA sprinklers, surge flow furrow irrigation valves, drip irrigation, soil moisture measurement and use of on-farm underground water distribution pipelines. Tsagarakis *et al* (2002) noted that water recycling and reuse has solved many of the water shortages in Greece and proposed the adoption of similar techniques elsewhere so as to meet some of the water demand in various sectors.

In Kenya, the Water Act of 2002 recognizes the need to promote integrated water resource management through the involvement of various stakeholders. In pursuant to Section 15(5) of the Act, the Catchment Management Strategy is meant to encourage and facilitate the establishment and operation of Water Resource Users Associations (WRUAs) for co-operative management of water resources. The involvement of stakeholders in water resources conservation is supported by Cremers *et al* (2005) who considered this action to be central in improving access, development and use of water resources.

In spite of the rising demand for water, very little is being done to conserve water especially in the urban areas of Kenya due to financial constraints, lack of knowledge and lack of technology (Gichuki *et al,* 2000). To avoid this situation there is need to educate people in various water conservation techniques and also conservation of the environment in general. Ghettuba (2004) established that the first priority any community needs is accessing clean drinking water followed by water for livestock, then water for crop production and finally water for other activities like pottery, recreation and transport, among others.

Guleid (2002) found that water for crop production in dry areas of Ethiopia is harvested by diverting run-off water from rainstorms and concentrating it into the field where crops are grown. The study by Getachew (2005) on water harvesting, found water harvesting to be a security for mitigating the impact of drought in Ethiopia. The study

suggested that further work was needed to establish more suitable techniques for use in water conservation particularly in areas with limited water sources and areas with high human and livestock populations. He also suggested further work to establish the limitations of these techniques with a view to finding suitable solutions and / or improve the ones now being used in other parts of the country.

The majority of research projects have focused on highlighting the current water shortage and conservation in the urban and rural areas. Research in water conservation in cities has been restricted to the capital. There is a gap of studies relating to other cities especially small and medium size ones and in particular the peri-urban areas. Most of the information about water use and conservation is reported within figures for total annual water consumption or is contained in information about existing problems. There appears to be no specific information about water conservation in domestic, livestock and irrigation in peri-urban areas. This Research is therefore important to fill this gap particularly in the peri-urban areas of Ruiru District. The methodology used to analyze the data gathered from the field is described in the next chapter.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Introduction

This chapter describes the location of the study area, design of the study, the sample and sampling procedures used, the data collection procedures, types of data collected and the methods that were used to analyze the data. The chapter also details the process of cluster formation, how sample sizes were arrived at as well as how the collected samples were handled, prepared and analyzed and the statistical tools employed to analyze the data.

3.2 Location of the study area

Ruiru District is in Kiambu County in Central province. The District is new and was officially inaugurated on February 2009. It was part of larger Thika District. It is boarded by Districts Gatundu and Githunguri to the north, Kiambu to the west, Thika to the east while Nairobi North and Kangundo Districts are to the south. The District is at the periphery of Nairobi city and hence has a lot of influence from the city since it is about 20 kiometers from the city centre. The District has a population from different ethnic communities. It is a fast growing industrial area due to opening up of Thika road which cuts across the District. The district has two means of transport the railway and road transport. Ruiru District was chosen for the study due to its high rate of increase in population as significant population working in Nairobi city and Thika towns are shifting to the District looking for places to settle. This therefore increases water demand

to the District looking for places to settle. This therefore increases water demand leading to water scarcity in the area. The district includes within its boundaries 2 Divisions, 6 locations and 10 sub-locations (Figure 3.1)

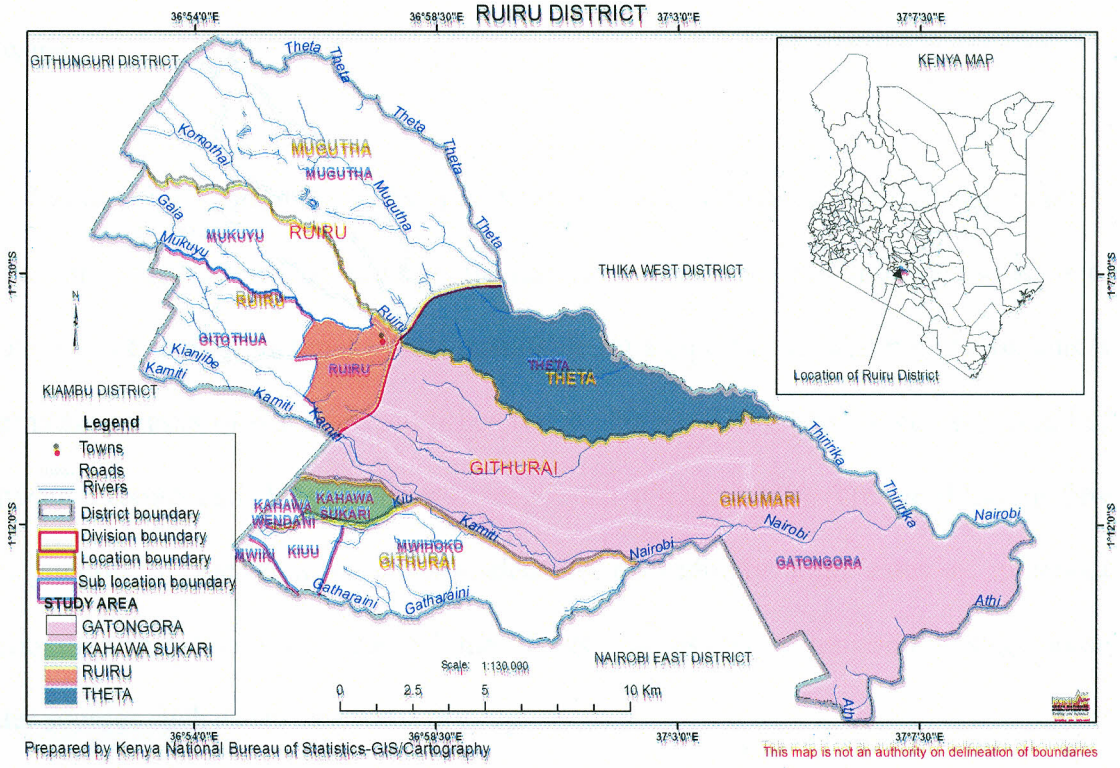

Figure 3.1 Administrative boundaries of Ruiru District (GOK, 2009)

Ruiru District is dominated by peri-urban activities and because of its proximity to Nairobi and Thika towns, a significant population involved in economic activities in these towns resides in Ruiru Districts and its environs. GOK, (2009) revealed that the population of Ruiru District had grown at approximately by 10% from the previous census of 1999. This has significantly increased the population densities and has

population of Ruiru District had grown at approximately by 10% from the previous census of 1999. This has significantly increased the population densities and has increased the demand for water in the District especially due to increased water usage in the multiple economic activities. This is because the residents are involved in small scale but intensive crop and livestock production systems which require a significant amount of water.

The District falls within the category of the arid and semi-arid lands of the country. These are fragile environments with relatively shallow and infertile soils with unpredictable rainfall that make them unsuitable for supporting a large population unless alternative sources of water are estblished (GOK, 2009). The District receives rainfall of between 116mm and 965mm in an average year (GOK, 2009). This problem of low precipitation in the area is compounded by exceedingly high rates of potential evaporation that also affects the volume of water accessible to households since some water sources such as surface wells dry- up.

Agricultural activities in the District have been affected by lack of sufficient water. The farmers grow crops like maize, beans, bananas and Napier grass. The rain that falls in the District doesn't support crops to maturity. As a result the farming lands are being subdivided into small plots of quarter and an eighth of an acre for residential purposes due to shifting production activities and little benefits from crop farming.

Existing records shows that the number of livestock has decreased drastically due to water shortages that have affected the livestock farming for the available water is first used for domestic purposes before other uses. The number of chicken, on the other hand, are on the increase because many people keep them and also possibly because of the many people settling in the area who provide good markets for their products.

3.3 Study Design

In this study, a multistage design involving stratified and random sample survey was carried out with the help of household questionnaires. The purpose of the survey was to obtain information of the sample so as to generalize for the population so that inferences could be made about certain parameters. The information required from the study included establishing the main sources of water for use in the domestic, livestock and irrigation activities, their accessibility and reliability as well as establishing how much water was used in the domestic and livestock sectors. The study also examined the various techniques used to conserve water together with the limitations hindering the practices of these techniques in the District. The design allowed for collection of both quantitative and qualitative data at the same time.

3.4 Sample and Sampling Procedures

3.4.1. Random sampling

Ruiru District has two Divisions (Ruiru and Githurai). These are subdivided into six

locations and ten sub-locations. Simple random sampling method was used to select representative sub-locations for the study. Each sub-location was assigned a random number. Using shuffled numbered sub-location specific balls, a ball was picked at random without replacement. The process was continued until 40% of the total number of sub-locations was attained. Kahawa Sukari, Gatongora, Theta and, Ruiru sub-locations were selected and were used as field study areas.

3.4.2 Cluster sampling

The study area has plot sizes ranging from 40x60 feet to several acres (GOK, 2009). Because of multi-demand in terms of water needs and usage, the study formed clusters as structure of the study based on plot sizes. The study was carried out on 3 types of plot sizes: 100x100 square feet, 200x250 square feet and 200x650 square feet which were considered as cluster (1) small plot sizes, cluster (11) medium plot sizes and cluster (111) large plot sizes, respectively. This is because these plot sizes are owned by the majority in the peri-urban areas of the study sites and are considered to have multiple water uses such as domestic water use, livestock water use and water use for irrigation.

A list of all residential estates in the three sub-locations was then obtained from the Ruiru District listing of 2006. Using the list obtained, only the residential estate that had the above plot sizes were marched to one of the three clusters thus giving rise to the formation of 19 estates. Random sampling was then used to select 40% of the estates

from each cluster for use in the study. The sample size was calculated based on (Bartlett, *et al,* 2001) formula.

$$n = z^2 pq / d^2$$

Where

n = required sample size

z =Confidence level at 95% (standard value of 1.96)

p = the proportion in the target population estimated to have characteristics being estimated (90%)

q = 1-p

d = Margin of error at 5% (standard value of (0.05)

Computation of the formula and calculation of design effect yielded 276 samples. The sample was further increased by 5% to account for contingences such as none response. Therefore the sample size for household interviews was 290.

The number of selected households was distributed proportionally in the three selected clusters based on population densities. Therefore, 109 households were selected in cluster (1), 97 in cluster (2) while 78 households were in cluster (3) (Table 3.1). In each selected estate systematic random sampling started centrally then moved eastwards then to other directions until all the selected households were visited. Every 5th household was considered until the last respondent was obtained from each cluster. In the case where the key representative of the household was not available, the next household was

considered. The head of the household or anybody above 18 years was taken as the respondent for the household.

Table 3.1 Selected characteristics for cluster formation

Cluster	Characteristics	Estates	Selected Estates
Cluster (1) Small Plot/sizes	100x100 square feet	Kahawa Sukari, Gitothua, Finance, Manguu, Wendani, Fourty, Githurai Kimbo post, Ruiru and Ting'ang'a	Kahawa Sukari, Ting'ang'a, Finance and Ruiru
Cluster (2) Medium plot /sizes	200x250 square feet	Gatong'ora, Kihunguro, Iriuko,	Gitambaa, Gatong'ora
Cluster (3) Large plot/sizes	200x650 square feet	Zone A, B, C, M, N, P and R.	Zone A, M and P

3.4 Data Collection Tools

The household questionnaires, key informant guides, focus group discussion guides and observation record sheets were the tools used to collect data in the field. These tools are described in the following sub-sections.

3.5.1 Household Questionnaires

Household questionnaires were the main data collection method and the tool used for the study (*Appendix 1*). It involved administering questions to the selected 290 household respondents. The questionnaire was divided into three parts. Part A was on general information which was to establish how it related to water sources, water use at home,

use by livestock and how it related to water conservation practices. Part B was designed to collect data on water sources, use and reliability while Part C was designed to collect data on water conservation practices in the area and the constraints experienced while practicing the conservation measures. Both qualitative and quantitative data was collected from the study.

3.5.2 Key Informant Guide

Key Informant interviews were conducted among 5 community resource persons, that is, two Assistant-Chiefs, one elder and Heads of Water Institutions (Irrigation and Livestock Officers) of the District. They were interviewed on the type of water sources, accessibility, reliability, utilization and conservation techniques that are practiced in the area and the problems the people face in the process of managing their water resources *(Appendix 2).* In the process both qualitative and quantitative data was collected.

3.5.3 Focus Group Discussion Guide

A total of five focus group discussions were conducted with chosen representatives of women / men self-help water groups in the area to obtain information on water sources, accessibility, reliability, utilization, conservation and the problems that the people experience in the process of managing their water (Appendix 3). The sizes of the focus groups varied between 10 to 20 people. This was done to verify the information obtained from the household interviews and collection of the qualitative and quantative data.

3.5.4 Observation Record Sheet

The record sheet was used for recording any observation on water sources, uses and conservation practices carried out in the area such as rivers, boreholes, wells, dams, water tanks and other water conservation techniques in use. A digital camera was used to photographically record observations. The information gathered was important in verifying the responses from the respondents.

3.6 Data Management and Analysis

The raw data from the questionnaires was coded, thoroughly cleaned and analyzed according to the objectives of the study. Cross tabulation was used to compare availability of the water sources, their accessibility and reliability for domestic, livestock and irrigation activities in the study clusters. Tables of ranking, frequencies and percentages were computed to show the priorities the community give to various techniques used to conserve water and the various limitations associated with these water conservation practices. The results obtained from the analysis are presented and discussed in the next chapter.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and discussions on the management of water resources in the peri-urban areas of Ruiru District.

4.2 Socio Demographic Characteristics

The general background information of the respondents in Ruiru District is summarized in Table 4.1. 0verall, 284 household respondents were interviewed during the study with (62%) being females as they are normally the people responsible for taking care of water in the household. A large proportion of the respondents had formal education (>50% in the three clusters), where 17%, 35% and 33% in the three clusters had attained primary, secondary and tertiary education and only 11% of the total respondents were without any formal education.

From the table, 48% of the total respondents had family size between 4-6 members with cluster (1) 59(54%), cluster (2) 45(46%) and in cluster (3) 33(42%). Family income varied in all the clusters.

Table 4.2: Socio-Demographic characteristics of the study respondents

	Description	Responses			
		Cluster (1) n=109	Cluster (2) n=97	Cluster (3) n=78	Total n=284
Sex	Male	47(43%)	39(40%)	22(28%)	103(38%)
	Female	62(57%)	58(60%)	56(72%)	176(62%)
Marital status	Single	12(11%)	9(9%)	9(12%)	30(11%)
	Married	83(76%)	77(79%)	61(78%)	221(78%)
	Separated	2(1%)	3(3%)	3(4%)	8(3%)
	Window/Widower	6(6%)	5(5%)	3(4%)	14(5%)
	Divorced	3(3%)	0	2(3%)	5(1%)
	None Response	4(4%)	3(3%)	2(3%)	9(3%)
family size	1-3	31(28%)	21(22%)	19(24%)	71(25%)
	4-6	59(54%)	45(46%)	33(42%)	137(48%)
	7 and above	29(27%)	31(32%)	26(33%)	86(30%)
Level of Education	No formal education	0	14(14%)	18(23%)	32(11%)
	Primary	6(6%)	21(22%)	22(28%)	49(17%)
	Secondary	35(32%)	38(39%)	27(35%)	100(35%)
	Tertiary	55(50%)	22(23%)	17(22%)	94(33%0
	Non Response	5(5%)	2(2%)	2(3%)	9(3%0
Family income per month	Below 20,000	22(20%)	37(38%)	47(60%)	106(37%0
	20,000-40,000	35(32%)	41(42%)	19(24%)	95(33%)
	Above 40,000	52(48%)	19(20%)	12(15%)	83(29%)

Results from Table 4,1 show respondents of cluster (1) majority 52(48%) earned above Kshs. 40,000 per month as most of them had attained tertiary education and therefore were able to get high paying jobs such as senior civil servants and good businessmen while cluster (2) majority 41(42%) earned between Kshs. 20,000 and 40,000 and in cluster (3) majority 47(60%) earned below Kshs. 20,000 per month as most of them were farmers and housewives.

4.3 The main water sources accessibility and reliability

There are various sources of water that are used in the District. They include piped water, boreholes, rivers and wells. The summary of the main water sources their accessibility and reliability for use in domestic, livestock and irrigation activities in the District are presented according to clusters mentioned in Chapter Three.

4.3.1 The main water sources accessibility for domestic use

Table 4.2 shows the results of main water sources and their accessibility in the three study clusters. The table shows that the major sources of water used in the district are NWC mains, CBO mains, boreholes, rivers and wells. 100% of the respondents of cluster (1) access NWC mains, 64% of respondents of cluster (2) access borehole water while 42% of the respondents of cluster (3) access CBO mains.

Table 4.2 Main water sources and their accessibility for domestic use

Main water sources accessibility	**STUDY CLUSTERS**				**Significant level**
	Cluster (1)	Cluster (2)	Cluster (3)	Total	
NWC mains	109(100%)	0	0	50%	χ^2=282
CBO mains	0	14(14%)	33(42%)	17%	
Boreholes	0	62(64%)	17(22%)	32%	df=3
Shallow wells	0	0	5(6%)	2%	
Rivers	0	21(22%)	23(29%)	17%	p<0.05
Total	**109(100%)**	**97(100%)**	**78(100%)**	**284(100%)**	

Table 4.2 indicate that there are significant differences in the accessibility of the main water sources for different domestic activities in the three clusters ($p<0.05$). The Table shows that 100% of respondents of cluster (1) accesses NWC mains, 42% respondents of cluster (3) accesses CBO water mains through in house water connections and stand pipes, while 64% of respondents of cluster (2). The percentage water sources accessibility in the study clusters could be explained by the fact that cluster (1) households have piped water distributed in the whole area and that the connection fee was reported to be affordable. It was observed that in cluster (2) and (3) residents queued for water at the water kiosks indicating that these clusters were significantly underserved with water ($p<0.05$) thus increasing water accessibility difficulties in the two clusters. Due to this water scarcity in cluster (2) and (3) as a result of most of the rivers being seasonal, example (plate 4.1), some residents were motivated to drill private boreholes for their own water use and also sell to the community members. Previous studies elsewhere have demonstrated similar findings where due to long queues at the water sources some individuals drill boreholes to sell water to the community in an attempt to solve the problem Nowlan, (2004) and Abu-Eid, (2007).

Results in Table 4.2 also show that only 17% of the respondents had access to rivers for domestic water use, cluster (2) 28% and cluster (3) 29% while none of the respondents in cluster (1) reported accessing river water for domestic water use for the respondents perceived the quality of river water to be polluted. This presumably reflected attitude

towards river water quality, rather than simply distance to the water source. This may be because the rivers pass through highly populated estates that are not connected to the sewerage system and thus dispose their domestic waste along trenches that drain into these rivers. Further, Ruiru District has several industries which the residents suspect, dispose their waste into the ground. This may find their way into the water sources.

The results show water accessibility disparities favoring residents in cluster (1) over residents in cluster (2) and cluster (3). This could possibly be the case due to its high population density settlements in the area and improved infrastructure as compared to clusters (2) and cluster (3) which have low population densities settlements and poor infrastructure. The results were consistent with studies carried out in South Africa which show that water demand and supply for urban and poor urban settlements are less favorable (Macy, 2001).

Plate 4.1 Gatong'ora river at the bridge to Gitambaa in cluster (2) (29th September, 2006)

This Gatong'ora river is seasonal and flows for two to three weeks after the rains. During the flows, the resident accesses the river for domestic, irrigation and livestock water use.

4.3.2 The main water sources reliability for domestic use

The results in Table 4.3 show the results of main water sources reliability for domestic activities in the study area. The results show that reliability of all the main water sources was reported to be average 50% with 55% from cluster (1), 50% from cluster (2) while 43% were from cluster (3).

Table 4.3 Main water sources reliability for domestic use

Main water sources reliability frequency	STUDY CLUSTERS				
	Cluster (1)	Cluster (2)	Cluster (3)	Total	Significance level
Reliable	15(15%)	21(22%)	15(20%	19%	χ^2=253 df=3 p<0.05
Average reliable	56(55%)	47(50%)	32(43%)	50%	
Unreliable	31(30%)	26(28%)	27(36%)	31%	
Total	**102(100%)**	**94(100%)**	**74(100%)**	**270(100%)**	

The frequency of main water sources reliability in each cluster was observed to differ significantly ($p<0.05$). Up to 50% of the total respondents reported average reliability of main water sources majority of whom were from cluster (1) 55% followed by cluster (2) 50% and least in cluster (3) 43%. Other respondents reported main water sources as unreliable 31%. The majority of those were from cluster (3) 36% followed by cluster (1) 30% and finally cluster (2) 28%. Among the total respondents 19% reported main water sources as reliable. Among them 22% were from cluster (2), 20% from cluster (3) while 15% were from cluster (1).

There was a strong association between the frequency of the main water sources reliability and study cluster ($p<0.5$). Some of the reasons why respondents in cluster (1)

and (3) reported average piped water sources reliability were due to the fact that there was no continuous supply of water from the water pipes while respondents of cluster (2) reported that borehole water sources were reliable due to the fact that most of the boreholes were always operating.

There are 20% of respondents in cluster (2) and 23% of cluster (3) who reported that rivers and boreholes were average in reliability due to the fact that the water sources were mainly accessed through vendors who lacked consistency in supplying the water. This means that there exists inadequate and inconsistent reliability of water sources in cluster (2) and (3). The respondents reported that they are not connected to Nairobi Water Company mains who are the major water service provider in Athi Water Catchment where Ruiru Division belongs. This could be explained by the fact that cluster (2) and (3) have unplanned settlements hence less likely to attract planned and focused services. The result are consistent with findings by Postel *et al* (2005).

The results revealed that the sources of water available to the communities are not enough to meet the water demand of the communities for different sectors. For cluster (1) the water lacked pressure because of the many connections that have been done arising from the many people who have migrated to the area. The key informant (Water officer) reported that the existing water serving pipes were designed for a small population and therefore predicts the need for expansion of the main water pipes to correspond with the population density target in vision 2030. For cluster (2) and (3) all

the sources of water aside the river and rain water are privately owned. These private owners determine when the water from their sources is made available to the public and also have full control over the prices. It is therefore not reliable for the community to continue depending on these sources for water.

Most people depend on boreholes for drinking but the boreholes can only be used when there is electricity. The frequent power-cut in the area makes it difficult for people to access water from the boreholes all the time. This explains why a number of people in the area own hand dug wells. These wells are not reliable sources of water because they dry up during the dry season. All respondents of cluster (1), 30% and 20% of respondents of cluster (2) and (3) respectively hardly use nearby rivers and streams for domestic activities since the people perceive the water from these sources to be polluted. This is because a lot of polluting activities take place along the riverside like car washing, washing of clothes and dumping of waste by institutions around Ruiru town.

4.3.3 The main water sources and their accessibility for livestock use

Table 4.4 show the results of main water sources and their accessibility for livestock use in the study area. The results show that only 98(35%) of the total respondents kept livestock where 21% were from cluster (1), 31% from cluster (2) and 45% from cluster (3). Among the total respondents, 31% reported that their animals mainly accessed river water sources followed by 28% who accessed NWC mains, 20% mainly accessed CBO

mains , 10% reported that their animals accessed shallow wells and finally only 9% of the total respondents watered their animals with water from boreholes.

Table 4.4 Main water sources accessibility for livestock use

Main Water Sources Accessibility	**STUDY CLUSTERS**				**Significant level**
	Cluster (1)	Cluster (2)	Cluster (3)	Total	$\chi^2=107$
NWC mains	19 (90%)	0	8(18%)	28%	
CBO mains	0	9(28%)	11(24%)	20%	df=3
Boreholes	2(10%)	3(13%)	4 (9%)	9%	
Shallow wells	0	6(20%)	4 (9%)	10%	$p<0.05$
Rivers	0	12 (50%)	18 (41%)	31%	
Total	**21(100%)**	**31(100%)**	**45(100%)**	**98(100%)**	

Table 4.4 shows that there were significant differences in the accessibility of the main water sources for livestock use in the study clusters ($p<0.05$). Majority of respondents in cluster (1) mainly watered their animals with water from NWC mains 19(90%) while majority of respondents in cluaster (2) used river water for their animals 12(50%) and majority of the respondents in cluster (3) reported that their livestock mainly accessed river water sources 18(41%) which was accessed away from their home compounds. According to the results, approximately 20% and 9% of respondents in cluster (2) and (3) respectively water their animals with water from shallow wells while 28% and 24% of respondents of cluster (2) and (3) water their animals with water from CBO mains. No such practice was reported in cluster (1). A significant 50% and 41% of respondents

in cluster (2) and (3) use river water to water their animals. This can be explained by the fact that cluster (2) and (3) had animal watering zone along the rivers (Plate 4.2). Cluster (1) did not have animal watering zone at the rivers and therefore none of the respondents watered their animals at the river while majority of the residents preferred accessing other water sources.

The frequency of animals accessing well water sources in the three clusters was less significant ($p<0.05$) 6(20%) and 4(9%) in cluster (2) and (3) respectively. The wells were reported to be unprofessionally dug and therefore dried up a few weeks after the rains. This explains why wells were not popular sources of water among the respondents.

The available water sources in all the clusters are significantly inadequate for livestock use. The respondents of cluster (2) reported that lack of reliable water sources made the respondents reduce the number of livestock owned and that others died for lack of enough water. Previous studies have demonstrated near similar findings (Akhilu *et al*, 2001; Peden *et al,* 2003 and ILRI 2005).

Plate 4.2 Animal watering zone in ruiru river at Gitambaa in cluster 2 (17th September, 2006)

The river bank at this animal watering zone is degraded because of the many animals drinking water at this zone. These have loosened the top soil and caused erosion to a point where the rocks are almost bear as a result of which there is need to construct animal watering structures away from the river.

4.3.4 The main water sources adequacy for livestock use

Table 4.5 presents the results of main water sources adequacy for livestock use in the study clusters. The results show that the main water sources for livestock use were average adequacy 45%, 39% inadequate and 18% adequate.

Table 4.5 Main water sources adequacy for livestock use

Main water sources adequacy	STUDY CLUSTERS				
	Cluster (1)	Cluster (2)	Cluster (3)	Total	**Significant level**
Adequate	3(14%)	6(25%)	4(14%)	18%	χ^2=177
Average adequacy	14(67%)	8(33%)	11(38%)	45%	df=3
Inadequate	5(24%)	10(42%)	14(48%)	39%	p<0.05
Total	**21(100%)**	**24(100%)**	**29(100%)**	**74(100%)**	

Results in Table 4.5 show that majority of the respondents in the study clusters reported average adequacy of the main water sources. This was reported to be due to the fact that residents of the study clusters reported that the available water was given first priority to domestic water use while other uses come after. This explains why there was 24% and 34% of the respondents in cluster (2) and (3) respectively who reported the water sources as inadequate. Some of the reasons why borehole water sources were regarded as inadequate for livestock use were because the water sources were privately owned, the community boreholes were not operational, and also due to long distances to the water sources. Respondents of cluster (1) and (2) reported piped water sources as inadequate source of water for livestock use due to lack of continuous flow and low pressure. These results compare favourably with the findings reported by Akhilu *et al* (2001) and Peden *et al* (2003).

4.3.5 Main water sources and their accessibility for irrigation use

Table 4.6 shows the results of the main water sources and their accessibility for irrigation use in the study area. The results show that among the total respondents only 72 respondents that carried out irrigation activities in the study clusters where 28 were from cluster (1), 21 were from cluster (2) and 23 were from cluster (3).

Table 4.6 The main water sources accessibility for irrigation use

Main Water Sources accessibility	**STUDY CLUSTERS**				**Significant level**
	Cluster (1)	Cluster (2)	Cluster (3)	Total	
NWC mains	21 (75%)	0	0	29%	$\chi^2=128$
CBO mains	0	0	8(35%)	11%	
Boreholes	2(7%)	2(15%)	3(13%)	10%	df=3
Rivers	5(18%)	19(85%)	12(52%)	28%	
Total	**28(100%)**	**21(100%)**	**23(100%)**	**72(100%)**	$p<0.05$

The findings in Table 4.6 indicate that accessibility to water sources by the respondents for irrigation water use differ significantly from each cluster ($p<0.05$). According to the results approximately 75% of respondents in cluster (1) accessed NWC mains compared to 11% of cluster (3) respondents who accessed CBO mains. This water is normally treated and therefore huge amounts of treated water is lost through irrigation. River water sources were accessed by 18% from cluster (1), 85%, from cluster (2) and 52% were from cluster (3). The frequency of the respondents accessing borehole water for irrigation activities in the three clusters is less significant ($p<0.05$) 2(7%), 2(15%) and 3(18%) of clusters (1), (2) and (3) respectively. This could be because most of the

boreholes are privately owned and the few community boreholes are most of the time not operating due to management and maintenance problems. Sansom *et al*, (2005) in his study found similar problems with community water supplies where most of water supplies were abandoned.

4.3.6 Main water sources adequacy for irrigation use

Table 4.7 presents the results of main water sources adequacy for irrigation use in the study clusters. The results show that the main water sources for irrigation use were adequacy 49%, 37% said the main water sources were average dequate and 14% of the respondents said the water sources were adequate majority 20% were from cluster (1), 11% from cluster (2) and 10% were from cluster (3).

Table 4.7 The main water sources adequacy for irrigation use

Main water sources reliability	**STUDY CLUSTERS**				
	Cluster (1)	Cluster (2)	Cluster (3)	Total	**Significant level**
Adequate	5(20%)	2(11%)	2(10%)	14%	$\chi^2=93$ df=3 $p<0.05$
Average adequate	11(44%)	7(39%)	5(25%)	37%	
Inadequate	9(36%)	9(50%)	13(65%)	49%	
Total	25(100%)	18(100)	20(100%)	63(100%)	

Table 4.7 shows that the frequency of main water sources adequacy for irrigation activities was observed to differ significantly ($p<0.05$). The main water sources were regarded by the majority 49% of the total respondents as inadequate with 36% respondents from cluster (1), 50% from cluster (2) and 65% from cluster (3). Among the

reasons given include priority, distance to water sources and cost involved in accessing the water sources. The respondents reported that available water is given first priority to domestic water use while all other uses came later. This explains why the majority of respondents indicated the main water sources as inadequate for irrigation activities.

The findings also indicate that significant proportions of the residents in the three clusters do not carry out irrigation activities ($p<0.05$). Among the reasons given include inadequacy of the water sources due to the fact that the District falls within the semi arid areas of Thika District which due to the hot climate and land degradation make several sources of water to dry and others seasonal. This therefore makes irrigation activities difficult.

In cluster (1) majority of respondents 80% reported that the available water sources was averagely adequate to inadequate for irrigation activities. This was reported to be due to lack of continuous flow of pipe water and that the boreholes were privately owned. Due to the cost of availing enough water for irrigation only (20%), (2%) and (10%) from cluster (1), (2) and (3) respectively reported that the water sources were adequate. The unprotected water sources were considered by the majority as inadequate except the rivers. This was reported to be due to the fact that most of them were seasonal as well as competition with other uses such as domestic and livestock use and also distance to the sources. These findings were consistent with finding from Shivoga, (2002).

4.4 The quantity of water utilization

Different domestic, livestock and irrigation activities in Ruiru District use varying amounts of water per day. The average amount of water used in those categories per day as reported by the respondents was calculated and the results are presented according to clusters in Tables 4.8, 4.9 and 4.10.

4.4.1 Water consumption for domestic activities

Table 4.8 presents estimates of the average amount of water consumption rates and mean monthly expenditures per cubic meter of water per household for the three clusters in the study area. The results show that the mean household water consumption rate in the area was 73.3 liters per day translating to 18.3 liters per person per day. This rate is slightly below the WHO (2005) recommended per capita consumption rate of 20 liters per person per day.

Table 4.8 Amount of water used per day per cluster in domestic activities

Parameters	**Clusters**	**Average household water consumption per day (liters)**	**Average water consumption per capital per day (liters)**
	(1)	120	30
	(2)	40	10
	(3)	60	15
Average total		73.3	18.3
significance level		f=651.8; df=3 p<0.0.05	f=27.9; df=3; p<0.05

Table 4.8 shows that there are significant differences in the amount of water used in domestic activities in the three clusters (P<0.05). Cluster (1) used the highest total

amount of water for different domestic activities 120 liters followed by cluster (3) 60 liters and finally cluster (2) 40 liters. The residents of cluster (1) used approximately 30 liters of water per person per day compared with approximately 10 and 15 liters per person per day used by residents of cluster (2) and (3) respectively. This implies that residents of cluster (1) had access to significantly high quantities of water as compared to residents of cluster (2) and (3) who access water of low quantity. These results compares favorably with findings reported by Scanlon, et al (2004), Turton *et al*, (2002) and Tsagarakis *et al*, (2002).

Results in Table 4.8 show that cluster (2) respondents spend about ksh.350 for every 1000 liters of water consumed as opposed to their counterparts in cluster (1) and (3) who spend approximately ksh.173 and 250 for every 1000 liters of water consumed respectively. This is because while the residents of cluster (1) receive water directly from Nairobi Water Company, the residents of cluster (2) and (3) obtain water from borehole sources, water kiosks and from vendors. The borehole water, at water kiosks and vendors normally sell water in 20 liters containers at the rate of between ksh.5 to 10 each. Consequently, cluster (2) residents are the highest paying consumers of water per cubic meter.

The quantity of water used for the different clusters was also established to be due to the time spent in the process of accessing water from the sources. Respondents of cluster (1) spent approximately (3.5 min) to get to their water sources than those of cluster (2) who

spend between one hour to one and a half hours and cluster (3) who spend between 30 minutes to one hour to fetch water. This accounts for the difference in quantity of water used per day in each cluster. Most people in cluster (1) use approximately 120 liters a day for domestic activities, while the people in cluster (2) use 40 litres a day while respondents of cluster (3) uses approximately 60 liters of water for the same purpose (Table 4.8). Carter et al (2007) commented that consumption of water increase significantly when sources lie within a few minutes. Also, in cluster (2) and (3) most people depend on the river water for domestic activities like washing, cooking and bathing but those who live far from the spring have to walk for quite a long time before reaching the source. This limits the quantity of water they can fetch from the spring for the day. Although the boreholes are close to the inhabitants, it requires some money for them to collect the water. This may eventually limits the people's ability to fetch enough water for the household.

4.4.2 Water use for livestock activities

Table 4.9 shows the average amount of water used for animals per day and the mean monthly expenditure per 1000 liters of water per household in the study clusters.

Table 4.9 Daily water use for livestock activities

Study clusters	Average daily household water consumption by animals (liters)	Mean monthly expenditure per 1000 liters of water (Kshs)
(1)	80	60
(2)	20	120
(3)	40	80
Total	140	86.6
Significance level	F=51.8; df=2 p<0.05	F=66.2; df=2; p<0.05

Table 4.9 shows that an average daily household water consumption by animals in the study area is 140 liters. Cluster (1) used an average of 80 liters of water for animals. In cluster (3) animals uses an average of 40 liters while cluster (2) animals uses an average of 20 liters of water per animal. Animals of cluster (1) mainly accessed piped water for animals within the compounds while residents of cluster (2) used water from boreholes and rivers and residents of cluster (3) mainly used piped water and river water sources to water their animals. This explains why residents of cluster (1) and (3) used more water for their animals as compared to cluster (2) who didn't access piped water for their animals and mainly accessed the water sources away from their home compounds. These results compare favorably with those reported by Akhilu *et al,* (2001) and Peden et al, (2003).

4.4.3 Water use for irrigation activities

This section presents results of irrigation activities carried out in the study clusters. Most of the farming is rainfed with few irrigation activities. The irrigation method carried out were bucket method, sprinkle and the furrow method where water is flooded in the

furrows where the plants grow. The farmers reported that they stop watering the plants according to the satisfaction of the farmer that the plants have had enough water. Farmers reported that they lacked knowledge on modern types of irrigation methods such as drip irrigation method and relied on traditional methods of flooding water in the farms. In cluster (1) the farmers mainly accessed (pipe water sources) which were within the compounds and were easily accessible where as in cluster (2) and (3) farmers mainly accessed river water sources for irrigation activities which were accessed away from their compounds by use of water pumping machines and bucket draw.

The farmers believed water logging reduces the frequency of irrigating. This is a contributing factor as to why the farmers were not benefiting from farming activities. The output from the plants were reported to be low. The results were consistent with the findings reported by Welch *et al*, (2000) and Kamara, *et al*, (2003) established farming methods as factors determining the quantity and quality of farm products which also determine prices at the markets. He established that good farming methods as ways of improving household food security.

It was estimated that a 20 liter bucket of water was used to water 10 plants which is equivalent to 2 liters of water per plant regardless of the type of plant. This amount is generally a lot for some plants and less for others. In order to optimize on water use for irrigation crop/plants water requirements need to be taught to the farmers who reported that they lack such information and rely on traditional methods of flooding all

crops/plants. This information would be very useful since it would improve on the quality and quantity of the yields from the farms which would also fetch good prices at the markets and therefore would improve the farmers standards of living (Rosegrant *et a;l* 2000).

4.5 Water conservation techniques

There are several water conservation techniques practiced in Ruiru District. These are discussed below.

4.5.1 Water conservation techniques practiced in the study clusters

Table 4.10 shows the results of water conservation techniques used in the study clusters. It was found from the focus group discussions and individual households interviewed that there are several water conservation techniques practiced in the study area as shown in Table 4.10 below. The order of priority follows 1= most practiced to 7= Least practiced.

Table 4.10 Ranking of domestic water conservation techniques

DOMESTIC WATER USE CONSERVATION PRACTICES	STUDY CLUSTERS		
	(1)	(2)	(3)
Roof rain water harvesting	5	1	1
Dual flush toilets	7	7	7
Use of efficient taps	4	6	5
Take short showers	3	2	2
Installation of water meters	2	5	6
Repair leaking taps/pipes	1	3	4
Water re-use	6	4	3

The results from Table 4.10 shows that there are differences in water conservation techniques in Ruiru District study clusters. In order of priority cluster (1) ranked repair of leaking taps/pipes as a first priority followed by installation of water meters as second priority and taking short showers as a third priority with use of dual flush toilets as the seventh priority and least technique practiced in this cluster. Cluster (2) gave roof rain water harvesting as their first priority followed by water reuse as their second priority and taking short showers during bath as their third priority, fourth priority was repair of leaking taps/ pipes and least was use of dual flush toilets as their seventh and least priority. Cluster (3) respondents reported that roof rainwater harvesting was their first priority in water harvesting techniques followed by taking short showers, water re-use as third priority and the least was use of dual flush toilets which was their seventh priority.

Table 4.10 also shows that dual flush toilets were not commonly used in the three clusters and were ranked last in all the clusters. This is an indication that this technology is not well known for it has been established as a major water conservation technique in many parts of the world (Cunningham *et al* 2001; Getachwe, 2005) and Macy, 2001). The major reason as to why roof rainwater harvesting was highly practiced in cluster (2) and (3) is because these areas fall within the region regarded as semi arid (GOK, 2009) and do not have a permanent water supply and therefore had to conserve as much as possible of any available water. This region also had few people living in the area to be served with water. The infrastructure in this locality has been poor which may be a limiting factor to the extension of water distribution systems. This explains why cluster

(2) and (3) have roof rain water harvesting as priority one in domestic water conservation technique.

Table 4.11 Ranking of irrigation water conservation techniques

IRRIGATION WATER USE CONSERVATION TECHNIQUES	STUDY CLUSTERS		
	(1)	(2)	(3)
Practice drip irrigation methods	3	6	4
Use of climate information to determine when to irrigate	5	2	3
Plant drought resistant plants	4	3	2
Mulching	6	5	5
Repair leaks in the irrigation systems	2	1	1
Installation of water meters	1	4	6

The results from the Table 4.11 show that there are differences in irrigation water conservation practices in Ruiru District study clusters. In order of priority table 4.11 shows that cluster (1) ranked installation of water meters as a first priority followed by repair of leaks in the irrigation systems as second priority and practicing drip irrigation as a third priority. Mulching is the sixth priority and least technique practiced in this cluster. Cluster (2) gave repair of leaks in the irrigation systems as their first priority followed by use of climate information to determine when to irrigate as their second priority and planting drought resistant plants as their third priority. Practicing drip irrigation methods is sixth and least priority. Cluster (3) respondents reported that repair of leaks in the irrigation systems was their first priority in water conservation techniques followed by planting drought resistant plants was second priority, use of climate information to determine when to irrigate was their third priority.

Table 4.11 also shows that repair of leaks in the irrigation sytems was common in the three clusters and ranked second in cluster (1) and took rank one in cluster (2) and (3). This could be explained by the fact that the study area is a water scarce region and therefore every drop of water has to be utilized optimumly. Mulching technique is not commonly practiced in the three clusters and ranked sixth, fifth and fifth in cluster (1), (2) and (3). This may be an indication that this technology is not well known and therefore needs to be introduced in this region.

4.5.2 Limitations associated with water conservation techniques

Results from Table 4.12 present the limitations associated with water conservation techniques used in the study clusters. The results show that financial constraints was the main factor limiting water conservation techniques in the study area with (66.6%) followed by lack of awareness (54%), dry weather conditions (41.7%) and least is family size 10.6%. In some cases the respondents could indicate that they practice more than one water conservation techniques.

Table 4.12 Limitations associated with water conservation

Limitations associated with Water conservation	STUDY CLUSTERS			Total	Significance level
	(1)	(2)	(3)		
Lack of awareness	39%	60%	63%	54%	
Financial constraints	36%	86%	78%	66.6%	χ^2=176
Negative attitude and culture	16%	21%	19%	18.6%	
Maintenance of these techniques	34%	18%	26%	26%	df= 3
Contamination of the water	12%	23%	16%	17%	
Drying up of the water sources	0	21%	25%	15.3%	
Family size	9%	17%	6%	10.6%	p<0.05
Dry weather conditions	35%	36%	54%	41.6%	
Total percentage %	**22.6%**	**32.4%**	**35.2%**	**30%**	

The results in Table 4.12 show that the most significant limitation associated with water conservation practices was lack of finances 66.6% at $p<0.05$) with cluster (2) reporting a frequency of 86% compared with cluster (3) and (1) 78% and 36% respectively. Other limiting factors include lack of awareness 54% dry weather conditions 41.6%. Maintenance of the water conservation techniques 26%, attitude and culture 18.6% were insignificant limiting factors affecting water conservation practices. Negative attitude and culture were only identified in cluster (1) and (2). Distance to water sources were only reported in cluster (2) and (3) which means they need particular attention when planning interventions to improve water provision services.

Financial constraints were most experienced in cluster (11) (86%) followed by cluster (3) (78%) and least in cluster (1) (36%). The respondents of cluster (2) reported that their main source of income is from farming activities which for a long time have failed for lack of rainfall. They reported that money available is used to buy food and other expenses follow. This, therefore, explains why financial constraints is leading in cluster (2) and least in cluster (1) where the majority reported that they have a monthly pay from employment and businesses of over kshs 20,000 equivalent to over 1 US dollar per capita per day These findings were consistent with findings from Taousanidis 2004 study in Kozani tow in Greece where financial constraint was a major factor limiting water conservation.

Approximately 54% of the total respondents lacked the awareness on water conservation practices majority of whom were from cluster (3) (63%) followed by cluster (2)= 60%, and least in cluster (1)=39%. This explains why use of drip irrigation and water reuse were practiced by few respondents 11% and 13% respectively (Table 4.7). With regard to attitude and culture towards water conservation, 21% were from cluster (2), 19% were from cluster (3) while 16% were from cluster (1). Other limitations include dry weather conditions with 54% from cluster (3) and (36%) from cluster (11) while 35% were from cluster (1). These findings are consistent with findings from Ethiopia (ILRI, 2005) and South Africa (Marcy, 2001) and Greece (Tasagarakis *et al*, 2002).

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This study has provided useful information on water sources, accessibility, reliability, utilization and conservation in Ruiru District. The information has focused on the main sources of water for domestic, irrigation and livestock sectors and the amount of water used in the domestic and livestock sectors. The techniques used to conserve water and the limitations associated with these water conservation techniques were established. In this chapter the conclusions and recommendations of the study are provided in two separate sections.

5.2 Conclusions

The study revealed that there are various main sources of water that are available to the community in Ruiru District. The sources are piped water, boreholes, rivers and wells. The residents in the District accessed specific main water sources for use in domestic, livestock and irrigation activities. The residents of cluster (1) access piped water for their domestic, livestock and irrigation activities, those of cluster (2) accesses boreholes and rivers while the residents of cluster (3) access piped water, boreholes, wells and rivers for their domestic, livestock and irrigation activities.

Despite the fact that there are various water sources in the District, most of them are regarded by the respondents as averagely reliable to unreliable due to lack of continuous

flow. Some are seasonal and others are non-operational while some are contaminated, located far away from residential areas and high costs of accessing them make them unreliable. The study revealed that the mean household water consumption rate in the area was 73.3 liters per day translating to 18.3 liters per person per day. This rate is slightly below the WHO (2005) recommended per capita consumption rate of 20 liters per person per day.

The study revealed that there are several water conservation techniques practiced in the area. In order of priority, taking short showers was given first priority followed by roof rain water harvesting, repair of leaking taps/pipes, installation of water meters, water reuse, use of efficient taps and installation of dual flush toilets. Considering that very few residents practice water reuse, use of efficient taps and installation of dual flush toilets hence a major potential in water conservation is lost which by any means should urgently be addressed so that unnecessary domestic water wastage can be avoided. In order of priority, irrigation water conservation techniques practiced include repair of leaks in the irrigation systems, planting drought resistant plants, use of climate information to determine when to irrigate, practice drip irrigation methods and mulching.

The various limitations that affected water conservation techniques in the district include lack of finances, lack of awareness, dry weather conditions, maintenance of these techniques, contamination of the water, attitude and culture. Lack of awareness was

reported by 54% of the respondents as a major limiting factor in water conservation pointing at a fact that without the relevant technology, they could not help in installation of dual flush toilets and use of efficient taps thus a lot of water wastage was noted. Up to 42% of the respondents felt that changes in climatic conditions sometimes worsened the situation since they could not plan. This is because at one time drought comes when they are expecting rains or heavy rains when they are not expected even destroying some constructions.

5.3 Recommendations

There are several recommendations that are made from this study. Some of them are for implementation by various actors that are involved in water management while others are for further research.

5.3.1 Policy Recommendations for Implementation

Based on the findings from the study

1. It is important to increase the number of the available water sources for accessibility in the domestic, livestock and irrigation activities by the people of Ruiru District particularly in cluster (2) and (3). This could be done through rehabilitating the water sources that are not operational and cleaning up the water sources that are believed to be polluted and ensuring that all channels that are sources of pollution for the water are prevented.

2. It is also important to improve water sources reliability in the three clusters by adopting several short term solutions such as water storage. In essence, this can reduce the number of visits made at various water source points such as rivers, boreholes and wells.
3. There is need to increase public awareness regarding protection of water sources, their use, and conservation in the District. This would play a major role for it would pass information to the residents/extension workers and students so that people can change their attitude and culture towards technology. This would be important to the community so that roof rain water harvesting, use of dual flush toilets and use of efficient taps could be increased and installed for its sustainability. Specific efforts should be made through the Ministry of Water and Irrigation and other related actors to increase water conservation awareness programmes through workshops, seminars, chiefs' barazas and public meetings to enable the people appreciate the importance of water management in the District.
4. Finally, promotion of appropriate irrigation technologies such as drip irrigation, mulching, installation of water meters, farmer operated and maintained systems needs to be encouraged. There is also need to promote marketing and processing of farm and livestock products so as to increase people's daily earning and so as to alleviate poverty in the District.

5.3.2 Recommendations for Further Research

1. Since other factors such as water pollution might have substantial influence on water conservation activities and considering that the area is dominated by a high population density and that it is not connected to sewage facilities and has several industries that dispose their waste water and other wastes to water sources, future studies should be done to establish the relationships between water supply and water pollution in the District.
2. It was difficult to match the water sources with the number of users because of the limitation of time during the collection of data and also that the District water records do not contain such levels of details. This type of information should be collected preferably over one year period so as to capture the temporal dynamics.
3. There is need for studies on the sociological factors that are likely to influence the people's response to water resource conservation programmes. The response of the community towards various policies, legal and new technologies needs to be examined. This would improve the policy formulation process by making them more community sensitive so that there is positive response towards the management and development of water resources in the District.

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APPENDICES

APPENDIX I: HOUSEHOLD QUESTIONNAIRE

CODE _____ DATE _____
INTERVIEWER_____
SUB-LOCATION_____LOCALITY_____
HOUSEHOLD NUMBER_____
CLUSTER _____

A PERSONAL INFORMATION

1.(a) Your name_____

(b) Gender _____

2. (a) Level of your education
(01)Primary ☐ (02) Secondary ☐ (03) Tertiary ☐ (04) None ☐

(b)Occupation_____

(c)Range of your income per month in Ksh. (Tick as appropriate)

(01) 0-20,000 ☐ (02) 20,000-30,000 ☐ (03)above 30,000 ☐

(d)What is the size of your family size (01) 1-3 ☐ (02) 4-6 ☐
(03) 7 and above ☐

3. What is the no. of animals do you keep?
(01) Cattle ☐ (02) Sheep ☐ (03) Goats ☐

(04) Poultry ☐ (05) Donkeys ☐ (06) None ☐

(4) What is the size of your farm? (Tick as appropriate)
(01) 0.25 to 2 acres ☐ (02) 2.1 to 3 acres ☐ (03)3.1 to 4 acres ☐

B WATER SOURCES

5. (a)Which is your main sources of water for domestic use activities?

(01) Rivers ☐ (02) Boreholes ☐ (03) Wells ☐

(04) Small dams ☐ (05) Springs ☐ (06) Rainfall ☐

(07) Others_____

(b) Which is your main source of water for livestock use?_____

(c) Which is your main source of water for irrigation activities? _____

(c) How do you access the main water source for?

(01) Domestic activities_____

(02) Livestock use_____

(03) Irrigation use_____

(d) What are the problems associated with the water sources?_____

6. (a) How much water do you use in liters for different domestic activities?

(01) Drinking ☐
(02)Washing food stuff before cooking ☐
(03) Washing utensils ☐
(04) Washing clothes by hand ☐
(05) Cooking ☐
(06) Basin Bath ☐
(07) Overhead Shower ☐
(08) Flushing toilet ☐
(09) Washing the house ☐
(010) Others_____

(b) Total water for domestic use per day ☐

(c) (1) How much water do you use per animal per day?

(01) Milking cow_____

(02) Zebu_____

(03) Goat_____

(04) Sheep_____

(05)Pig_____

(06) Poultry_____

(07) Donkey_____

(08) Others_____

(d) Total water for livestock use per day_____
(e) What type of irrigation do you practice?_____
(f) What type of plants do you irrigate?_____
(g) How many times do you irrigate your plants per week_____
(h) How much water do you use for irrigating one plant per crop per irrigation time ? _____
(i) How much water do you use in irrigating your farm_____

7. (a)Do you pay for water at the various sources (Tick as appropriate)

(01) Yes ☐ (02) No ☐

(b) If yes, which water sources do you pay for? (Please tick as appropriate)

(01) Tap water sources (02) borehole water (03) Water kiosk
(04) Rivers (05) Springs (06) wells
(07) Water delivered (08) Water tankers

(c) Whom do you pay?

(01) Water company (02) Borehole owner (03) Others_____

(d) How much money do you pay per month? (Please tick as appropriate)

(01) 100-200 ☐ (02) 201-300 ☐ (03) <301 ☐

(e) Is the money paid for water? (Please tick as appropriate)

(01) A lot ☐ (02) Average ☐ (03) Little ☐

(f) Please explain your answer in 8(e) above_____

8. (a) How do you view the main water sources for domestic use? (Please tick as appropriate)

(01) Reliable ☐ (02) Average reliable ☐
(03) Unreliable ☐

(b) How do you view the main water sources for livestock use? (Please tick as appropriate)

(01)Adequate ☐ (02)Average adequate ☐ (03)Inadequate ☐

(c) How do you view the main water sources for Irrigation use? (Please tick As appropriate)

(01) Adequate ☐ (02) Average adequate ☐ (03) Inadequate ☐

(d) What do you do to solve the water problems in the area? Tick Appropriately

(01) Construct a dam ☐ (03) Dig wells ☐
(02) Dig a borehole ☐ (04) Others ☐
(03) Have storage tanks ☐ (05) Nothing ☐

(e) In your opinion, what should the government and donor agencies do to protect the water sources? (Please tick appropriately)

(01) Drill community boreholes
(02) Provide clean river water
(03) Provide soft loans to buy storage tanks

C WATER CONSERVATION PRACTICE

9. (a) Do you harvest rainwater? (01) Yes ☐ (02) No ☐

(b) If yes, which methods do you use to harvest rainwater? (Please tick appropriately)

(01) Roof harvesting ☐
(02)Rock Catchments ☐
(03) Dams ☐
(04) Others please specify _____

(c) How much rainwater do you harvest in liters? (Please tick appropriately)

(01) 100-500 ☐ (02) 501-1000 ☐ (03) Above 1000 ☐

(d) How is the harvested water stored? (Please tick appropriately)

(01) Plastic containers ☐ (02) dams ☐ (03) rock catchments ☐

(e) How is the water harvested utilized? (Please tick appropriately)

(01) Domestic ☐ (02) Irrigation ☐ (03) Watering livestock ☐
(04) Others ☐

10. Which domestic water conservation techniques do you practice ? (Please rank them according to priority from the 1= most practiced as first priority to 7=least practiced.

(01)Roof rain water harvesting
(02)Use dual flush toilets
(03)Use of efficient taps
(04)Take sort showers
(05)Installation of water meters
(06)Repair leaking taps
(07)Water reuse

11. Which irrigation water conservation techniques do you practice ? ((Please rank them according to priority from the 1= most practiced as first priority to 7=least practiced.

(01)Practice drip irrigation methods
(02)Use of climate information to determine when to irrigate
(03)Plant drought resistant plants
(04)Mulching
(05) Repair leaks in the irrigation systems
(06)Installation of water meters
(07) Others please specify_____

12. (a) What problems limits/hinders you from practicing the above water conservation methods. (Please tick appropriately)

(01) Financial constrains
(02) Lack of awareness
(03) Negative altitude and culture
(04) Maintenance of these techniques
(05) Contamination of the water
(06) Drying of the water sources
(07) family size
(08) Dry weather conditions
(09) Others_____

(b) How do you solve the above problems, please explain?_____
(c) In your opinion what should be done by the government and local authorities to solve the above-mentioned problems_____

13. (a) Does the farm size affect the conservation of water resources?

(01) Yes ☐ (02) No ☐

(b) Please explain your answer_____

14. (a) Does the distance to and from the water sources affect water conservation measures?

(01)Yes ☐ (02) No ☐

(b) Please explain your answer_____

15. (a) Does climate affect water conservation in the area?

(01) Yes (02) No

(b) Please explain your answer_____

APPENDIX 2: KEY INFORMANT GUIDE

A GENERAL INFORMATION

CODE _____ DATE _____
INTERVIEWER_____
NAME OF THE PERSON CONTACTED_____
RELATIONSHIP TO THE COMMUNITY_____
UB-LOCATION_____
CLUSTER_____

B WATER SOURCES

1. How many water sources are found in the area?
   (01) Rivers ☐ (02) Boreholes ☐ (03) Wells ☐
   (04) Small dams ☐ (05) Springs ☐ (06) Rainfall ☐
   (07) Others_____

2. (a) How do the community access the water sources?_____
   (b) How are the water sources utilized?_____
   (c)What are the problems associated with these water sources? _____

C WATER CONSERVATION

3. (a) Are there water community based self-help water groups in your area?
   (01) Yes ☐ (02) No ☐

   (b) If yes, what methods do these community groups do to improve the water situation in your area (Tick appropriately)
   (01) Construction of water sources
   (02) Financing of water sources
   (03) Protecting the water sources
   (04) Planning for the water sources
   (05) Others please specify_____

4. (a) Are there Non-Governmental organizations involved with the improvement of water facilities in the area?
   (01) Yes ☐ (02) No ☐

   (b) If yes, what do they do in terms of water conservation_____

5. (a) Does the community participate in Governmental water conservation projects in your area? (Tick appropriately)

(01) Yes ☐ (02) No ☐

(b) If yes, how do they participate (specify roles)_____

(c) If No, why not?_____

6. (a) Does the community reuse their water? (01) Yes ☐ (02) No ☐

(b)If yes, what do they use the recycled water for? _____

(c) If No, why not?_____

7. (a) What problems do the people experience while practicing water conservation techniques? (Please tick appropriately)

(01) Financial constrains (02) Cultural constrains

(03) Ignorance (04) Lack of education

(05) Climatic conditions (06) None

(07)Others_____

(b) Please explain your answer in 7(a) above_____

(c) What do they do to solve the above problems?_____

8. In your opinion how should the Local administration be involved to promote community participation in water conservation in the area?_____

9.In your opinion, what is the relationship between the levels of

(a) Education and water conservation?_____

(b) Income and water conservation_____

(c) Family size and water conservation_____

(d) Farm sizes and water conservation

APPENDIX 3 : FOCUS GROUP DISCUSSION GUIDE

A GENERAL INFORMATION

CODE _____ DATE _____
INTERVIEWER_____
NAME OF THE SELF HELP WATER GROUP CONTACTED_____
SUB-LOCATION_____
CLUSTER_____

B WATER SOURCES

1. How many water sources are found in the area?
   (01) Rivers
   (02) Boreholes
   (03) W ells
   (04) Small dams
   (05) Springs
   (06) Rainfall
   (07) Others_____

2. (a) What type of water supply system does your self help water group construct?_____

   (b) What criteria do you use in choosing the location of these water facilities?
_____

3. (a) Do you sell water to the community?
   (01) Yes ☐ (02) No ☐

   (b) Please explain your answer in 3 (a) above_____

   (c) If yes, how can you evaluate the water cost? _____

   (01) High ☐ (02) Low ☐ (03) Average ☐

(d) If No. how do the community access your water supply sources?_____
_____

(4) (a) Does the community help in deciding your self help water group water sources/projects location points in the area?

(01) Yes ☐ (02) ☐

(b) If yes, how do you reach the people? Please specify

(01) Community leaders
(02) Committees
(03) Churches
(04) Household surveys
(05) Others_____

(c) If No, why not?_____

(5) What are the problems associated with water sources in the area?_____
_____

C: WATER CONSERVATION

6. (a) What is your self help water group doing to promote water conservation activities in the area?_____

(b) What problems / challenges do you face in promoting water conservation in the area?_____
(c) How do you solve the problems?_____

(d) What type of water conservation techniques do you promote in the area?
_____

(e) How sustainable have these techniques been? Please explain your answers_____

7. (a) Do you promote water reuse in the area?
(01) Yes ☐ (02) No ☐

(b) If yes, what is the reused water used for_____

(c) If No, why not?_____

8. (a) Do you promote rainwater harvesting? (01) Yes ☐ (02) No ☐

(b) If yes, what is the water harvested used for?_____

(c) If No, why?_____

9. (a) Does your self help water group involve other community members in all the water conservation activities you undertake?
(01) Yes ☐ (02) No ☐

(b) If yes, please explain your answer in 9(a)_____

(c) If no, why not?_____

(d) What are the factors that hinder other community members from practicing water conservation in the area?_____

10. (a) What factors do you consider before giving a range of technologies and service level (please tick all the appropriate answers)

(01) Need and expectation of local people ☐
(02) Maintenance capabilities of users ☐
(03) Payment capabilities of local people ☐
(04) Others please specify _____

11. How does the government assist in promoting water conservation in the area?_____

12. What are some of the problem you encounter in promoting water conservation activities (Tick as appropriate)?

(01) Institutional weakness ☐ (02) Financial problems ☐
(03) Communication problems ☐ (04) Political problems ☐
(05) Others please specify_____

13. In your opinion, what can be done to solve these problems?_____

14. (a) Has your self help water group been successful in promoting water Conservation in the area? (01) Yes ☐ (02) No ☐

(b) If yes, which are the successful schemes_____

(c) If No, why not?_____

APPENDIX 4: OBSERVATION RECORD SHEET

CODE_____ DATE_____
SUB-LOCATION_____LOCALITY_____
HOUSEHOLD NUMBER_____
CLUSTER_____

Owner	Locality	Any water conservation technique observable	Any limitation associated with water conservation observed	No. of visible					
				Dams	Pans	Rivers	Bore hole	Well	Tap