DETERMINING THE CAUSES OF WATER SCARCITY IN MAAI MAHIU DIVISION, NAKURU COUNTY, KENYA

BY

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university. No part of this thesis may be reproduced without the prior written permission of the author and/or the University of Nairobi.

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Supervisor's Declaration.

This thesis has been submitted for examination with my approval as a University Supervisor.

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DEDICATION

To my lovely wife

Mary,

my son

Caleb

and my daughters

Keren and Gladwell.

DEDICATION

To my lovely wife

Mary,

my son

Caleb

and my daughters

Keren and Gladwell.

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ABSTRACT

Water exists as a scarce resource which is critical to social and economic development, and directly affects the behaviour of society. In the next century, more than a quarter of the world's population, or a third of the population in developing countries live in areas that will experience severe water scarcity. The purpose of this study was to determine the causes of water scarcity in Maai Mahiu Division, Nakuru County. The study used mixed methods approach hence both survey and ethnographic designs have been used. Open ended and closed questionnaires were administered in the survey while open-response questions and the researchers' participation were design. The main sampling techniques used in the design were simple random sampling which was used to determine the households and water vendor respondents while snow balling was used in the selection of key informants. Questionnaires, observations, photography, images focus, group discussions and document analysis guide were used for data collection. The collected data was analyzed both descriptively and inferentially. The findings of the study reveal that; water sources are in existence either as surface water or as underground water and are affected by various factors which can be classified into human factors, environmental factors and the effect of climate change. Increased human settlement and population growth coupled by the activities that arise due to this two are the major human factors that contribute to water scarcity. Low rainfall, general aridity, low ground water supplies and the presence of few water bodies are the main environmental factors leading to water scarcity. The effects of climate change have resulted in weather variations, which is a contributing factor to water scarcity. The researcher concludes that, despite the presence of all this factors, water scarcity issue is one that can be addressed and tackled effectively if proper planning, encompassing water management and conservation as its core, is undertaken. The researcher recommends that rain water harvesting and water source conservation be undertaken as an immediate short-term measure to address the problem of water scarcity. The Government of Kenya, through the concerned agencies should create conservation buffer zones for the existing water sources and waterways as an integral long-term mitigation measure of addressing water scarcity. The research finally recommends that an integrated local development plan for Maai Mahiu be formulated and should put special attention on protecting, conserving and managing water resources for posterity.

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ABBREVIATIONS AND ACRONYMS

ASAL	Arid and Semi-Arid Lands
CAACs	Catchment Areas Advisory Committees
DANIDA	Danish International Development Agency
ECA	Economic Commission for Africa
FEWSNET	Famine Early Warning System Network
GOK	Government of Kenya
IDPs	Internally Displaced Persons
IPCC	Intergovernmental Panel on Climate Change
IWMI	International Water Management Institute
KANU	Kenya African National Union
M.o.W & I	Ministry of Water and Irrigation
NWCPC	National Water Conservation and Pipeline Corporation
NWMP	National Water Master Plan
PEV	Post-Election Violence
PLO	Palestinian Liberation Organization
SAP	Structural Adjustment Programmes
SPSS	Statistical Package for Social Sciences
U.O.N	University Of Nairobi
UN	United Nations
UNDP	The United Nations Development Program
UNECA	United Nations Economic Commission for Africa
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
WHO	World Health Organization
WRMA	Water Resources Management Authority
WRUA	Water Resource Users Associations
WSRB	Water Services Regulatory Board
WSTF	Water Services Trust Fund strategies
WWV	World Water Vision
NARC	National Rainbow Coalitions
WSTF	Water Service Trust Fund

CHAPTER ONE

INTRODUCTION

Water is the most important natural resource, indispensable for life and at the same time the backbone of growth and prosperity for mankind. According to the United Nations Development Program (UNDP) more people die of water related diseases than in military conflicts around the world (Kenya, 2007).

In releasing the United Nations World Water Development Report 3, the United Nations Educational, Scientific and Cultural Organization (UNESCO) Director General stated that, "despite the vital importance of water to all aspects of human life, the sector has been plagued by a chronic lack of political support, poor governance and underinvestment. As a result, hundreds of millions of people around the world remain trapped in poverty and ill health and are exposed to the risks of water-related disasters, environmental degradation and even political instability and conflict. Population growth, increasing consumption and climate change are among the factors that threaten to exacerbate these problems, with grave implications for human security and development" (UNESCO, 2009).

Water is a basic human need without which sustainable development cannot be achieved. Sustainable development is a development path along which the maximisation of human well-being in today's generations does not lead to decline in quality of life for the future generations. This is a path that can only be attained by eliminating those negative factors that are responsible for natural resource depletion and environmental degradation. It also requires securing those public goods that are essential for economic development to last, such as those provided by well-functioning ecosystems, a healthy environment and a cohesive society. Sustainable development further stresses the importance of retaining the flexibility to respond to future shocks, even when their probability, and the size and location of their effects, cannot be assessed with certainty (Organisation for Economic Co-operation and Development, 2011). Therefore, water being a vital component in the human survival need to be managed sustainably and efforts put in place to eliminate those negative factors that are responsible or can cause its depletion.

Water scarcity can be perceived as the limiting factor for both agriculture and industry in many developing countries and as the most probable source of conflict between countries, it has been a source of increasing competition between usage in rural agricultural areas and in the urban industrial sector. It is also conventionally perceived as a scarce natural resource, an absolute shortage that limits development. Managing water scarcity by definition entails dealing with scarcity with the intention of overcoming it, either by supply-side increases or demand-side regulation.

Water resources have complementary and conflicting uses. Flow resource scarcity may be more pressing problem than resource exhaustion. Rees, (1994) argued that water scarcity is at present a third world problem. Endemic water shortages affect nearly 50% of the world population by lowering health and welfare standard and hampering agricultural production. Since water is a basic need, scholars and policymakers should assume leadership in its management so as to deal with its scarcity. Thus, the phenomenon of water scarcity need to be addressed as a matter of priority as it affects all spheres of life. For the planners, understanding the various causes that contribute to water scarcity is key to determining the various approaches that can be taken to address the problem of water scarcity to the benefit of many generations to come.

The past is the key to the future. Actions that have been taken or not taken by one generation bear both short and long-term implications on all other generations that follow. When we seek to know the conditions that have operated in the past we are able to come up with better predictions that can aid us in planning.

Having this is mind; the researcher seeks to determine the causes of water scarcity in Maai Mahiu Division, Nakuru County – Kenya. The area falls in the ASALs which is a fragile ecosystem. The researcher examines the existing water sources in the division and also takes a look into the past water sources as known by the elders of the various communities living in the area. The various causes of water scarcity, which for the purpose of this research have been grouped into human activities, environmental factors and climate change, are also determined with an aim of providing sectoral and spatial water planning for the entire division. This is emphasized along with the management of

the various water development programs and projects so as to strengthen the communities for sustainable development.

1.1 The Background of the Problem

Water scarcity is a top pressing issue of our time. The vast majority of the Earth's water resources are salty water, with only 2.5% being fresh water. Approximately 70% of the fresh water available on the planet is frozen in the icecaps of Antarctica and Greenland leaving the remaining 30% (equal to only 0.7% of total water resources worldwide) available for domestic consumption. Eighty seven percent of the freshwater is allocated to agricultural purposes (Intergovernmental Panel on Climate Change, 7). These statistics are particularly illustrative of the dire problem of water scarcity facing the world.

According to the Comprehensive Assessment of Water Management in agriculture, one in three people are already facing water shortages in the developing countries (ibid). Around 1.2 billion people or almost one-fifth of the world's population, live in areas of physical scarcity, while another 1.6 billion people, or almost one quarter of the world's population living in developing countries lacks the necessary infrastructure to take water from rivers and aquifers.

According to the Global Water Scarcity Map (figure 2.1), over 50 % of the African continent is in a situation of Economic Water Scarcity. Globally however water resources are abundant, relative to water use, with less than 25% of water from rivers drawn for human purposes. This is due to lack of infrastructure to draw it. Vast areas could benefit from adequate supply of water, but human and financial capacities are limiting. The Global Map for fresh water availability by World Resources Institute in 2007 classifies Kenya as being among Nations that had less than 1,000 cubic metres per person per year hence making it water scarce nation.

According to International Water Management Institute, 1995 Kenya was drawing less than 10% of its total available water, though it is projected that by 2025 it would be drawing more than 40% of its total water available. The United Nations Economic Commission for Africa (UNECA) findings agreed with International Water Management Institute (IWMI) when it postulated that by 2025, Kenya will have less than 1000

m3/person/year making it a water scarce state. However central African countries will not face the same problem as their water resources are comparatively greater.

Kenya's water withdrawals of 40% by year 2025, is comparable with the projection for South Africa and Northern Africa countries. According to Water Resource Institute, 2000 Kenya had a water stress indicator of 30%, confirming its water scarcity status while Uganda and Tanzania will not have reached water scarcity level by 2025, unlike Kenya which will have reached the water scarcity by then.

A comparative graph drawn in 1999 by the by the United Nations Economic Commission for Africa (UNECA) (figure 2.4), projected that Kenya would be among those countries that were under water scarcity and the situation would worsen by the year 2025. The country would move from a situation of water scarcity of below $1000m^3$ per year per person to less than $500m^3$ per year person by 2025. Gray, (2008) also re-states the position of water scarcity. His emphasis is that, water scarcity is not only a problem in the poor arid countries, but throughout the developing and developed world.

There is a strong link between water scarcity, international security and conflicts (Gray, 2006). Gleik (2006) argued that exclusive water control by a nation, state actors or non-state actors, different stakeholders is a breeding ground for conflicts. Gray (2008) echoed Pearce (2006) and called for a new ethic where the water cycle is managed to benefit all. The United Nations Development Program (UNDP) Human Development Report "Beyond scarcity: Poverty and the Global Water Crisis" stresses that, while there is sufficient water globally to currently meet the needs of human consumption, agriculture and industry, some 700 million people are living below the minimum water stress threshold of 50 liters per capita per day, i.e.(5 litres for drinking 20 litres for sanitation, 15 litres for bathing and 10 litres for food preparation.), the so called water poverty level. The number of people living below this minimum is estimated to increase to 3 billion by 2025. The report attributes these shortages to inadequate water policy guidelines and water underpricing, rather than absolute physical scarcity. Water scarcity is expected to become an ever-increasing problem in the future, for various reasons. First, the distribution of precipitation in space and time is very uneven, leading to tremendous temporal variability in water resource worldwide. (Oki et al, 2006).

Secondly, the rate of evaporation varies a great deal, depending on temperature and relative humidity, which impacts the amount of water available to replenish groundwater supplies. The combination of shorter duration but more intense rainfall combined with increased evapotranspiration and increased irrigation is expected to lead to groundwater depletion (Konikow and Kendy, 2005).

Thirdly, according to the IPCC, (2010) the world population has tripled in the last century. It is projected to rise from the present 6.5 billion to 8.9 billion by 2050. At this rate of population growth, water resources in the sub-tropical regions are likely to become more stressed, especially as climate change intensifies. At the same time increased urbanization is expected to significantly raise amount of domestic water used by each person. IPCC pointed out that Climate change will shrink freshwater resources, and increase water scarcity. It would change the hydrological cycle and increase concentration of greenhouse gases in the atmosphere. There would be changes in the seasonal distribution and amount of precipitation, frequent increase in precipitation intensity, changes in the balance between snow and rain, increased evapo-transpiration and a reduction in soil moisture, changes in vegetation cover (resulting from changes in temperature and precipitation, accelerated melting glacial ice, increased coastal inundation and wetland loss , rising sea level; and rising CO_2 levels and its effect on plant rise and the effects on plant physiology, e.g. reduced transpiration all which aggravate the global water scarcity (Goudie, 2006). Changes in the hydrological cycle have affected precipitation patterns, thus interrupting ground water recharge. Consequently ASALs are expected to experience a decrease and seasonal shift in flow patterns. With increased temperatures, intensification of the water cycle will be more extreme, hence variations in weather patterns and, droughts will becoming prolonged. (Huntington, 2005). Water availability is likely to be further exacerbated by poor land management, overuse from increasing populations, and an increase in water demand primarily from increased agricultural production (IPCC, 2007).

Water scarcity affects one in three people on every of the globe's continent. The situation worsens as needs for water rise along with population growth, urbanization and increases in household and industrial uses. Water scarcity has driven up the use of wastewater for agricultural production in poor urban and rural communities. More than 10% of people

worldwide consume food irrigated by wastewater that can contain chemicals or disease-causing organisms. Millennium Development Goal number 7 and number 10 aims to halve the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015. Water scarcity however could threaten progress to reach this target.

According to a 2010 report on lessons learnt and good practices in the support to the water sector by DANIDA, Kenya, has since independence seen major political, social and economic changes taking place that were closely related to the mega trends of the water sector. The Kenya water sector has since independence gone through many challenges. The key challenges that have faced this sector over time include: inadequate sector financing, confusion of roles , conflicts of interest, poor management of water resources, collapse of the Water Resources Information Systems, weak capacity at local authority and community level, conflict over diminishing resources , poor governance and high level of corruption (corruption in relation to weak permitting, water allocation practices and compliance; over exploitation and illegal abstraction of water), unsustainable water and land use policies, laws and institutions.

Water plays a major role in development and poverty eradication. Emerging water scarcity has affected both learning in schools in the Kenyan rural areas. The impacts of water scarcity on social, cultural, economic and ecological aspects have aggravated poverty in rural areas. The large scale destruction of the forest resources has led to flash floods, micro-climate change, and soil erosion and dried up lakes. Wanton destruction, threatens the very existence of the forest and consequently its role in the ecosystem. The majority of the population of Kenya lives close to and relies upon the main "Water Towers" providing water security for livelihoods (Motley, 2010).

Maai -Mahiu was chosen as a case study because it lies in an ASAL area which is a fragile ecosystem. Water provision is also a serious issue in Kenya. As the key to economic growth, equitable access to this resource is paramount in addressing poverty (Notley et al, 2010).

1.2 Statement of the Problem

Water scarcity may be the most underestimated resource issue facing the world today. As the world water demand has more than tripled over the last half-century, signs of water scarcity have become commonplace. Some of the more widespread indicators are rivers running dry, wells going dry, and lakes disappearing. Under pressure from rising population, extravagant lifestyles, intensive agriculture and industrialization, water has become a scarce resource. The World Bank estimates that demand for water will exceed 40% by 2030. United Nations water suggests that 1.8 billion people live in regions already classified as water scarce. Two thirds of the global population could experience water stress by 2025. The stresses already imposed on water security and access to drinking water will be accentuated by climate change. Almost a third of the World Bank's long term water projects are assessed to be at risk from changes in water runoff by 2030. While Kenya had some 1,500 m^3 per person per year in renewable fresh water in the early 1970's, this figure dropped to approximately 600 m^3 per person per year in 2007. It had been projected in 2010 that Kenya would have a renewable freshwater supply of just over 500 m^3 per capita per annum. By way of comparison, Kenya's neighbors', Uganda and Tanzania, have annual per capita renewable water supplies of 2,940 and 2,696 m^3 per capita respectively. Such figures are, however, inextricably linked to the population and its rate of growth (United Nations Economic Commission for Africa, 1999).

Water scarcity in Kenya has been an issue for decades as only a small percentage of the country's land is optimal for agriculture while the remaining land is mostly arid with harsh climate. Kenya's natural resources also do not ensure water supply in every region of the country and the country's water basins only extend to some regions (ibid). The country's water politics are also unique as there has been a divide between areas that have been privatized and sectors where investors have been discouraged from developing.

According to the Water Services Trust Fund (WSTF) Strategic Plan 2008- 2013, water contributes to the economic and social growth. The plan notes that in some areas of the country, water scarcity has become a hindrance to economic development. The WSTF strategic plan acknowledges Kenya's effort to ensure access to water, and sanitation for all her citizens since independence.

To facilitate this process, the Government of Kenya developed the National Water Master Plan (NWMP) in 1979, which became the guiding plan for water development until 1992 when the second NWMP was formulated together with the national development plans and Cap 372, the NWMP informed the legislation and management of the sector until 1999, when the National Policy on Water Resources Management and Development was developed to address the emerging challenges and ensure consistently with the liberalized approach pursed by other water related sectors of the economic. This policy was followed by the enactment of the Water Act 2002.

Kenya's population has doubled since the mid 1980's. Population growth has led to a steady influx of people into not only to the catchment areas but also to arid and semi-arid lands, inhabited traditionally by pastoralist groups. This influx has led to overstretch of the already scarce water resource thereby creating conflicts between different groups of people in the Division. Though Maai Mahiu lacks sufficient water supply schemes, the events that led to post election violence in Kenya, in 2007, led to the Division being a host to a high number of IDPs from Narok, Eldoret and other parts of the country. This led to an unanticipated population increase. It is with this in mind that this research is being undertaken to determine the factors that cause water scarcity in Maai Mahiu.

1.3 Purpose of the Study

The researcher sought to determine the causes of water scarcity. By a case of water scarcity Maai Mahiu Division, the researcher examines the causes of water scarcity with consideration of the human activities that lead to water scarcity, environmental pressures resulting to water scarcity and climate change as a factor in water scarcity.

1.4 Scope of the Study

This study was carried out in Maai Mahiu Division, Nakuru County. It assessed the existing water supply and distribution channels and sought to determine the causes of water scarcity in the division. The research was able to cover all the four locations that make up Maai Mahiu Division.

1.5 Research Objectives

1.5.1 General Objective

To evaluate the extent of water scarcity in Maai Mahiu Division, Nakuru County.

1.5.2 Specific Objectives

1. To assess the existing water supply and distribution channels in Maai Mahiu Division.
2. To determine the human activities that lead to water scarcity.
3. To determine the environmental factors that lead to water scarcity.
4. To determine how climate change leads to water scarcity.
5. To provide intervention measures that will help in reducing water scarcity in Maai Mahiu Division.

1.6 Research Questions

1. What is your source of water for domestic use?
2. What are the human activities that lead to water scarcity?
3. What are the environmental factors that lead to water scarcity?
4. How does climate change contribute to water scarcity?

1.7 Significance of the Study

The study is of great significance as it will give an insight into the problems of water scarcity in Maai Mahiu Divisions. The findings will form a data bank for future reference by policy makers in the Ministry of Arid and Semi-Arid Lands and the Ministry of Water and Irrigation. For the planners, this study discusses the various causes of water scarcity and offers suggestions of how the various causes can be tackled to enhance proper water management and alleviate water scarcity. The information gathered will form a basis of addressing water scarcity with an aim of enhancing sustainable development and will assist decision makers, water managers, engineers, social scientists, agronomists other professions and their students in formulating coherent, harmonious and consolidated views on the issue of water scarcity in the division.

1.8 Assumptions of the Study

The following assumptions have been taken into consideration:

- That all locations in the division are bedeviled by a common problem of water scarcity.
- All respondents gave accurate and honest responses to the items in the questionnaire and interview schedule.
- The entire Maai Mahiu Division lies in the ASAL.
- The current water demand for Maai Mahiu surpasses the supply.

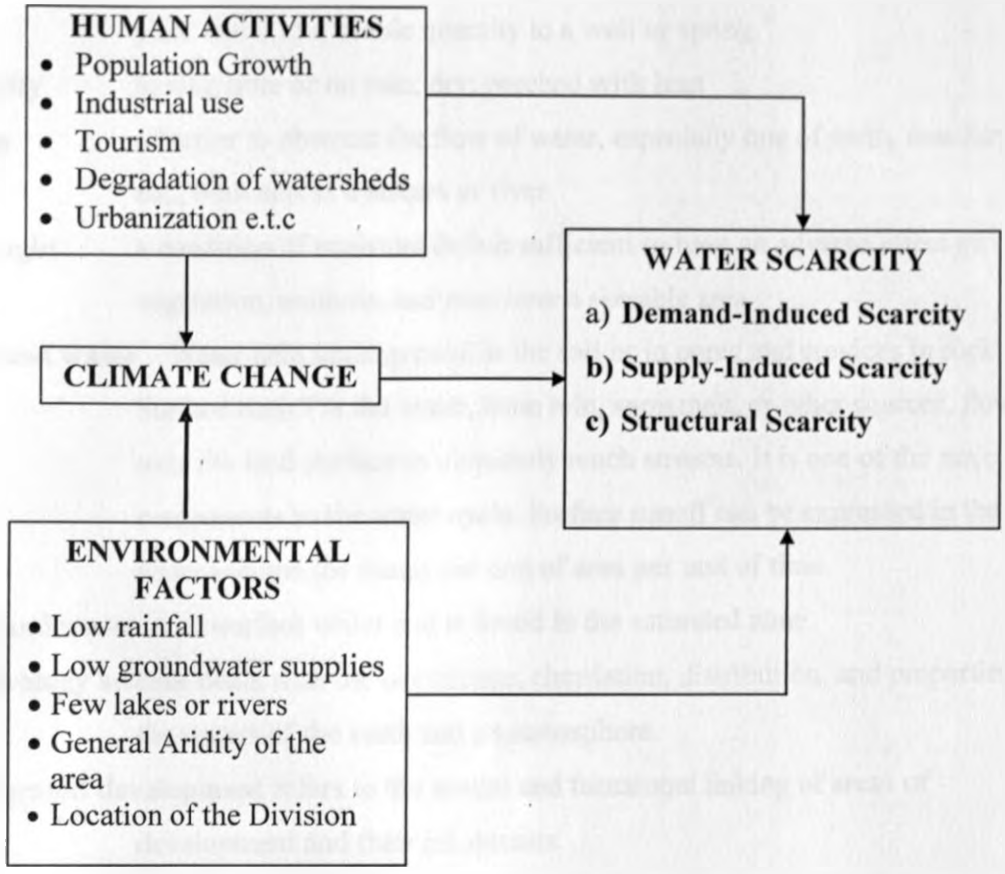
1.9 Theoretical Framework

This thesis deals with the causes of water scarcity. Unlike other natural resources, water may be considered to be a special resource due to its low economic value but its crucial importance, and its fugitive nature (Böge 2003:12,13). Based on the characteristics of water as a resource, the researcher chooses to operate on the theoretical concept of water as a scarce resource. By definition scarcity implies diminishing resources and/or a pressure on the supply of available resources from an increasing demand. Three types of scarcity are often depicted (Ohlsson 1999:2):

a) **Demand-Induced Scarcity** ensuing from the water needs of increasing populations
b) **Supply-Induced Scarcity** caused by rivers running dry, lowered water tables, and polluted groundwater and surface water courses
c) **Structural Scarcity** as more powerful segments of water users confiscate a larger part of the scarce resource, resulting in the ecological and economic marginalization of the less powerful.

1.10 Conceptual Framework

Figure 1.1: Conceptual Framework



Compiled by the Author and adapted from Vlachos and James, 1983

Human activities, environmental factors and climate change, as indicated in the conceptual framework above, are the independent variables that directly affect water scarcity which in this case is the dependent variable. To arrest and address the issue of water scarcity these three are the factors that have to be addressed. The researcher looks at ways in which the factors have contributed to water scarcity in Maai Mahiu Division, Nakuru District.

1.11 Definition of Terms

Aquifer A water-bearing layer of rock, or of unconsolidated sediments, that will yield water in a usable quantity to a well or spring."

Aridity having little or no rain; dry; parched with heat

Dam a barrier to obstruct the flow of water, especially one of earth, masonry, etc., built across a stream or river

Drought a condition of moisture deficit sufficient to have an adverse effect on vegetation, animals, and man over a sizeable area.

Ground water Water held underground in the soil or in pores and crevices in rock Surface runoff is the water, from rain, snowmelt, or other sources, flowing over the land surface to ultimately reach streams. It is one of the major components in the water cycle. Surface runoff can be expressed in the water volume (or mass) per unit of area per unit of time

Ground water is subsurface water and is found in the saturated zone.

Hydrology science deals with the occurrence, circulation, distribution, and properties of the waters of the earth and its atmosphere.

Integrated development refers to the spatial and functional linking of areas of development and their inhabitants.

Mitigation: The elimination or reduction of the frequency, magnitude, or severity of exposure to risks, or minimization of the potential impact of a threat or warning.

Riparian Reserve is the designated width from the stream where restrictions on what can be done are placed in order to protect the functions of the land and water in that reserved area.

Sampling process used in statistical analysis in which a predetermined number of observations will be taken from a larger population.

Sustainable development: Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Water scarcity a situation where the amount of renewable fresh water available for each person per is below 1000m3 per person per year.

CHAPTER TWO
LITERATURE REVIEW

2.0 Introduction

As stated by Mugenda and Mugenda, 1999, the review of the literature involves the systematic identification, location and analysis of documents containing information related to the research objectives. This chapter comprises the literature review of the study and takes a look at the various water resources and offers literature on water scarcity. It further highlights the global perspective of water distribution and scarcity. The scarcity of potable water presents a plethora of problems to various regions of the world and often breeds conflict and affects the achievement of sustainable development. The chapter also gives an insight into water scarcity in Africa, taking a look at the Nile Basin which is a source of livelihood to millions of people and further discusses the issue of water scarcity in Kenya.

2.1 Water Scarcity

Water scarcity is broadly understood as the lack of access to adequate quantities of water for human and environmental uses (Global Water Forum, 2012). Water scarcity is commonly defined as a situation where water availability in a country or in a region is below 1000 m3 per person per year. Many regions in the world experience much more severe scarcity, living with less than 500m3 per person per year, which could be considered severe water scarcity. The threshold of 2000 m3 per person per year is considered to indicate that a region is water stressed since under these conditions populations face very serious problems when a drought occurs or when man-made shortages are created (Luis et al, 2002).

The term 'water scarcity' is usually used by the media, government reports, non-governmental organizations (NGO's), international organizations e.g. the UN and OECD, as well as in various academic literatures to refer to water resource as being as under pressure. Despite its frequent use, there is no consensus between scholars on how water scarcity should be defined or measured (Global Water Forum, 2012). The most commonly used methods of defining and measuring water scarcity are:

- Falkenmark indicator or Water Stress Index.
- Criticality Ratio.
- International Water Management Institute (IWMI) Index
- Water Poverty Index

a) Falkenmark indicator or Water Stress Index.

It defines water scarcity in terms of the total water resources that are available to the population of a region. It measures water scarcity as the amount of renewable freshwater available for each person per year. If it is below 1,700m^3 per person per year then that region/country is said to be water stressed. If it is below 1,000m^3 per person per year then the region/country is experiencing water scarcity and if it is below 500m^3 then the region has an absolute water scarcity (Falkenmark, Lundquist and Widstrand, 1989) .

b) Criticality Ratio

This approach measuring water scarcity as the proportion of total annual water withdrawals relative to total available water resources. Using this approach, a country is said to be water scarce if annual withdrawals are between 20-40% of annual supply, and severely water scarce if they exceed 40%.

c) International Water Management Institute (IWMI) Index

This approach defines and measures water scarcity in terms of each country's water infrastructure e.g. the water in desalination plants, measure of water availability and limits measurement of water demands to consumptive use. It measures the adaptive capacity of a country by assessing its potential for infrastructure development and efficiency improvements.

d) Water Poverty Index

This approach takes into account the role of income and wealth in determining water scarcity by measuring the following:

i. the level of access to water;
ii. water quantity, quality, and variability;
iii. water used for domestic, food, and productive purposes;
iv. capacity for water management; and
v. environmental aspects

For the purpose of this research the researcher opts to use the Falkenmark indicator or Water Stress Index as the measure of water scarcity.

As Luis et al, 2002, points out, regions where water has been always scarce gave birth to civilizations that have been able to cope with water scarcity. These societies developed organizational and institutional solutions as well as water technologies and managerial skills within the local cultural environment. This allowed for appropriate water use for domestic, food production and local industrial purposes. Lifestyle and development changes during the last decades have created new needs for water, provided contradictory expectations on cultural and institutional issues, and led to very strong increases on the demand for water. The existing balances between demand and supply have been broken and new equilibria are required.

Water scarcity issues and the way they are addressed will affect the successful achievement of most of the Millennium Development Goals (MDGs) as well as environmental sustainability goals. The eradication of poverty and hunger in rural areas is related closely to fair and equitable access to basic livelihood assets (including land and water) for domestic and productive uses. Increased demand usually threatens the sustainability of the environment in situations of scarcity.

2.1.1 Types of Water Scarcity

2.1.1.1 Physical water scarcity

This is a situation where the water demand cannot be met by the existing water sources. This is a situation that is frequently experienced in arid regions. It also occurs where water seems abundant but where resources are over-committed. This can happen where there is overdevelopment of hydraulic infrastructure, often for irrigation. Symptoms of physical water scarcity include environmental degradation and declining groundwater. This term was first defined by Molden in 2007 in a wide ranging 2007 study on the use of water in agriculture.

2.1.1.2 Economic Water Scarcity

Molden 2007 describes economic water scarcity as a situation where there is an availability of water but the populace cannot afford it. It is caused by a lack of investment in water or insufficient human capacity to satisfy the demand of water. Symptoms of

economic water scarcity include a lack of infrastructure, with people often having to fetch water from rivers or lakes for domestic and agricultural uses. Large parts of Africa suffer from economic water scarcity; developing water infrastructure therefore, could help to reduce poverty.

2.2 Water Sources

There are two types of water sources:

i. Surface water
ii. Ground water

Ground water is a critical component of any nation's water resources. Groundwater resources globally dwarf surface water supplies. Alley 1999 estimates that 25% of the earth's total fresh water is stored as ground water, while less than 1% is stored as surface water while the rest of the freshwater supply is locked away in polar ice and glaciers.

Surface water is occurs in rivers, lakes and soil moisture while ground water is in aquifers. Hutson 2004, talks of ground water being the main source of water for streams and rivers, especially during periods of drought or low flow. Ground water is accessed through:

i. Dug Wells

This consists of an excavation into a shallow aquifer. The typical depth of a dug well is 4.5 to 8 metres (15 to 23 feet).

ii. Drilled wells

Drilled wells usually obtain water from deep aquifers. The depth of a drilled well is about 60 metres (200 feet). IT is constructed by boring a hole into the aquifer.

Table 2.1 Advantages and Disadvantages of Surface and Ground Water Sources

Type of Water Source	Advantages	Disadvantages
Surface Water	• Capacity may not be restricted	• Contain microorganisms, such as bacteria, viruses, and parasites that can cause fatal illnesses. • require proper treatment before being used for domestic purposes • A high maintenance cost • High operational cost

Ground Water		
Dug well	• less expensive than drilled wells • draws water from sand and gravel deposits that are less likely to contain contaminants associated with bedrock aquifers • Easy to dig	• Installed in unconfined aquifers, which may be more susceptible to contamination from surface and near surface sources, such as from septic systems. • affected by seasonal water table fluctuations • possible only if the water table is relatively high on the property to be serviced • well can run dry with high water use • maximum depth limited by method of installation • well construction often not sufficient to prevent vermin from entering well, which may lead to bacterial contamination • ultraviolet light water disinfection is often recommended due to the higher potential for bacterial contamination
Drilled Well	• can access deeper, confined aquifers • increased protection from surface sources of contaminants and bacteria • reduced vulnerability to drought conditions • water depth can be increased to increase water column and available storage capacity • has high yields	• High cost of installation • can penetrate formations that yield water of undesirable quality • health related contaminants, such as arsenic or uranium, that are more common in bedrock formations can be present, requiring treatment • Yield depends on geological formation • Drawdown can be large thus affecting adjacent wells especially in aquifers with low permeability. • higher electricity cost

Compiled by the Author

2.3 Global Perspective of Water Scarcity

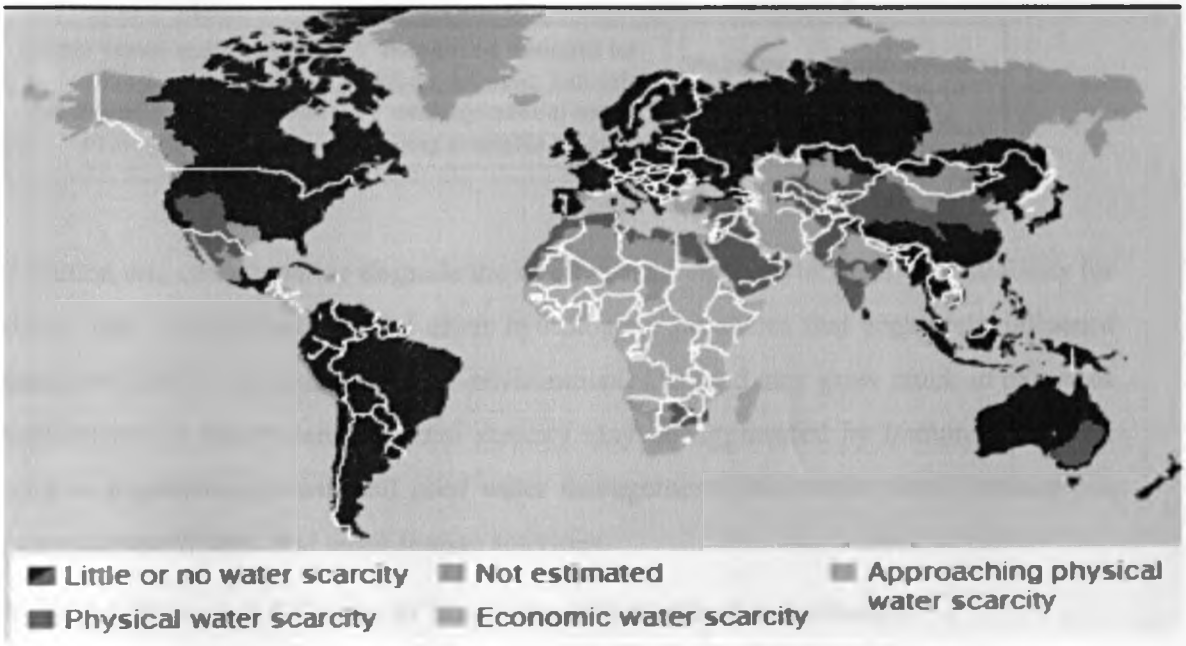
According to Luis et al, 2002 water scarcity is among the main problems being faced by many societies in the World in the 21st century. Many regions in the World experience severe scarcity, living with less than $500m^3$/person/year. Regions with a threshold of 2000 m^3/person/year are considered to be water stressed, since under these conditions populations face severe problems when a drought occurs or when man-made water shortages are created, Luis et al, 2002.

Lloyd (2010), stated that the amount of freshwater on the planet is finite. Three percent (3%) of the total water in the world is fresh and less than one percent (1%) is readily available for human use. In the 20th century, there were massive advances in technology and in the human ability to harness nature productively. Societies developed large dams and infrastructure projects to supply irrigation, hydropower, industrial and urban development. However, this success came at a cost, rivers and aquifers in many parts of the world dried up and the consequences have become dire for ecosystems and for many people who rely on over-exploited water resources. Lloyd, 2010 points out that change in different aspects is the major reason the worlds water supply will become more stressed. He outlined these changes as follows:

a) Population growth: The world's population is expected to peak at about nine billion by 2050. The additional food and water requirements that will thus be needed will be significant considering that most of the three billion additional people will live in the developing world. This will definitely lead to increased water stress.
b) Change in the living standards will result in higher per capita water requirements.
c) Economic growth: Water is needed for increasing domestic, agricultural and industrial use. This therefore calls for more water supplies.
d) Water infrastructure development: To meet water and energy needs requires alteration of freshwater systems for abstraction. This results in conflicts between upstream communities and their downstream "rivals" for water.
e) Climate change: Greater variability in rainfall patterns in many parts of the world, the melting of ice packs has reduced water availability in terms of quality and quantity.

These changes are likely to be exacerbated by the lack of strong and politically independent water management institutions across much of the developing world, which restricts our ability to effectively use water in a changing world (Lloyd's, 2010). The increasing water scarcity unless addressed will lead to conflict and protectionism as well as raise fundamental questions for the future. Countries and companies will be judged, not by the fact that water will become increasingly scarce, but rather by the way in which they jointly manage and share this precious resource

Figure 2.1 The Global Water Scarcity Map



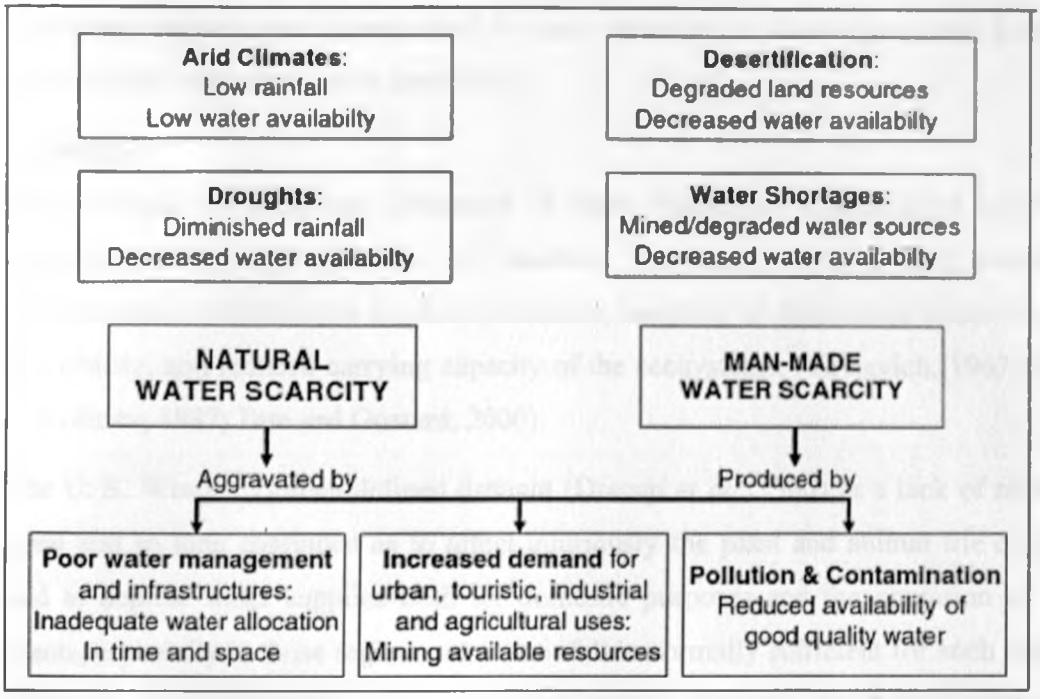
Source: International Water Management Institute

2.3.1 Causes of Water Scarcity

Water scarcity may result from a range of phenomena. These may be produced by natural causes, may be induced by human activities, or may result from the interaction of both, as indicated in Table 2.2. (cf. Vlachos and James, 1983).

Figure 2.2, below illustrates the causes for water scarcity, which may be natural, dominated by climate and man-made features.

Figure 2.2 Causes of Water Scarcity



Source: Vlachos and James, 1983

Pollution and contamination degrade the water quality and lead to water unavailability for many uses. Degradation of land alters hydrological processes that negatively influence water availability for human and the environment. Demand may grow much in excess of availability. In other words, natural scarcity may be aggravated by human influences, such as population growth and poor water management. Man-made water scarcity is a consequence of these and other human activities.

Table 2.2 Nature and Causes of Water Scarcity in Dry Environments

Water Scarcity	Regime Nature Produced	Human induced
Permanent	Aridity	Desertification
Temporary	Drought	Water shortage

Compiled by the Author

1. Aridity

Aridity is a natural permanent imbalance in the water availability consisting in low average annual precipitation, with high spatial and temporal variability, resulting in overall low moisture and low carrying capacity of the ecosystems. Aridity may be defined through climatological indices such as the Thornthwaite moisture index, the Budyko radiation index of dryness, or the UNESCO precipitation/evapotranspiration

index (Sanderson, 1992). Under aridity, extreme variations of temperatures occur, and the hydrologic regimes are characterized by large variations in discharges, flash floods and large periods with very low or zero flows.

2. Drought

It is a natural but temporary imbalance of water availability, consisting of a persistent lower-than-average precipitation, of uncertain frequency, duration and severity, of unpredictable or difficult to predict occurrence, resulting in diminished water resources availability, and reduced carrying capacity of the ecosystems, (Yevjevich, 1967; Wilhite and Glantz, 1987; Tate and Gustard, 2000).

The U. S. Weather Bureau defined drought (Dracup *et al.*, 1980) as a lack of rainfall so great and so long continued as to affect injuriously the plant and animal life of a place and to deplete water supplies both for domestic purposes and the operation of power plants, especially in those regions where rainfall is normally sufficient for such purposes. Generally, these definitions clearly state that drought is mainly due to the breakdown of the rainfall regime, which causes a series of consequences, including agricultural and hydrological hazards which result from the severity and duration of the lack of rainfall.

2.4 Water Scarcity in the Gaza Strip

Water scarcity and mismanagement significantly aggravates community conflict. A case in question is the Arab Israeli conflict in the Gaza Strip (Homer-Dixon and Kelly 1995). According to Fred Pearce, author of "When the Rivers Run Dry," quotes the commander of the Israeli forces as saying,

> *"while the border disputes were of great significance, the matter of water diversion was a stark issue of life and death."*

In part, the Arab-Israeli issue is a conflict over water and future negotiations will include water control. The situation in the Gaza Strip serves as a prime example of the effects of water of scarcity and the extent to which it can lead to conflict similarly to the scenario in Maai Mahiu.

The Gaza Strip is a arid area that is generally composed of sandstone and its aquifer is thought to be highly permeable (Palnet). Its replenishment capacity is 65 MCM and it is

thought to be tapped by 2500 wells and boreholes which extract 45 MCM. The population growth is estimated at 5.5% with a total fertility rate of 7.74 children born per woman. These events of the Arab-Israeli War of 1948 produced a massive exodus of approximately 250,000 Palestinian refugees into the Egyptian sector of Gaza. The huge influx of refugees in 1948 increased the Gaza Strip's population by more than 300% and was accompanied by resource-loss, the disruption of domestic trade, and an unstable economic situation (Homer-Dixon and Kelly 1995).

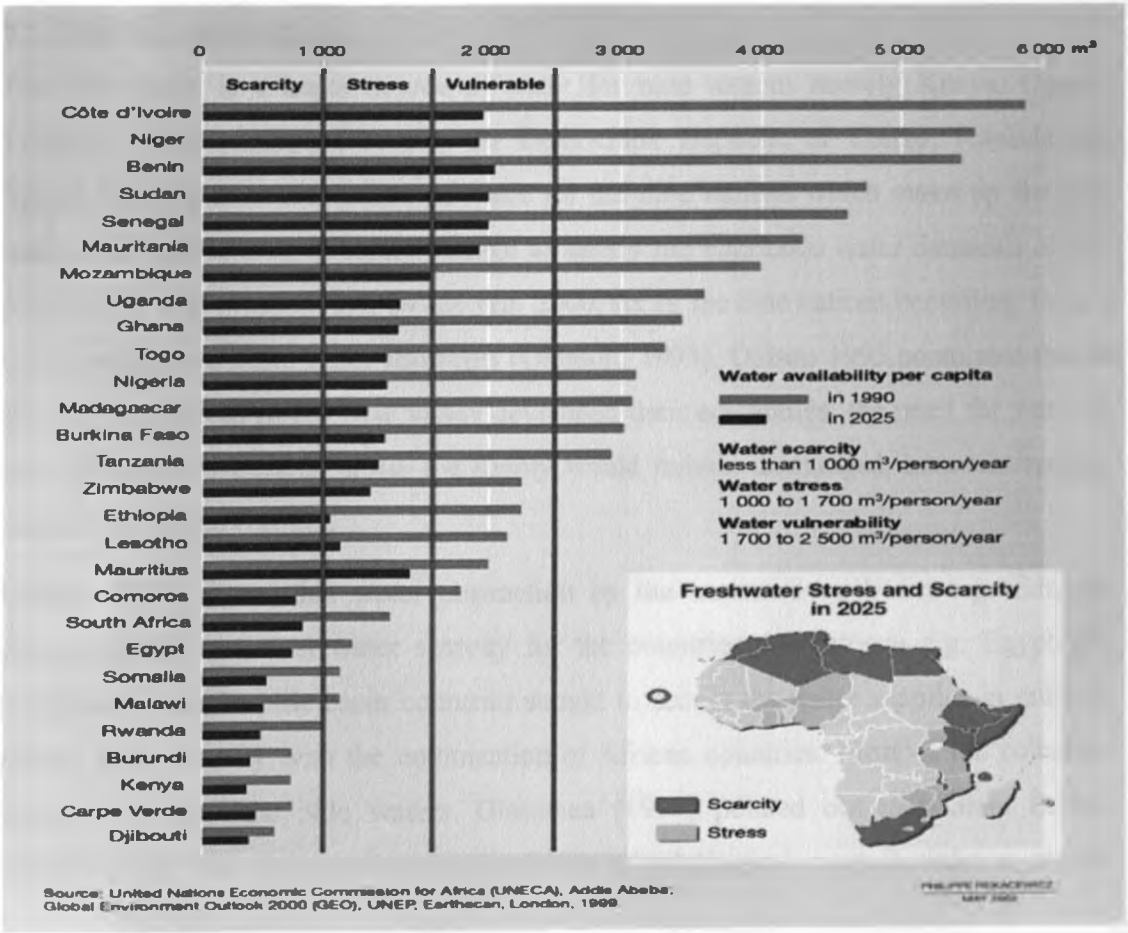
Structural water scarcity is as a result of the inequitable distribution of water in the Gaza Strip. The Israelis have been favored through selective appropriation of agricultural land having the best groundwater quantity and quality, and uneven pricing schemes. Demand-Induced Water Scarcity is as result of a rapid increase in population. The Gaza Strip Aquifer has been thought to be over-pumped for some time, outstripping its sustainable supply of 65 MCM. Moreover, Israel has been tapping this aquifer and its replenishment from outside Gaza (Shawa, 1994). Consequently, the aquifer's water table has been pumped far below its recharge rate, making it susceptible to severe saltwater intrusion and causing supply-induced scarcity (Isaac, 1997). Supply-induced scarcity, a drop in renewable resource supply due to water degradation or depletion, has existed in the Gaza Strip since Egyptian control (Elmusa 1994). Due to high water abstraction rate the water table falls, saltwater from the Mediterranean and nearby saline aquifers introduces itself into the Gaza aquifer. Saltwater intrusion from the Mediterranean Sea has been detected up to 1.5 kilometers inland, and continues to threaten the entire aquifer. In many parts, the water is so saline that it may damage soil and crop yields, and hence is unsuitable for irrigation.

Water scarcity has been aggravated by non-point pollution. Since the aquifer is close to the surface, it is highly susceptible to this type of pollution. There has also been serious contamination of the aquifers by the improper disposal of waste matter due to lack of appropriate solid and waste disposal methods. These various contaminations of the Gaza water supply have drastically decreased the amount of potable water available (Bellisari, 1994).

2.5 Water Scarcity in Africa

According to the World Water Forum (2002) fourteen countries in Africa were already experiencing water stress and another eleven countries are expected to join them by 2025. It was estimated that that nearly 50 per cent of Africa's predicted population of 1.45 billion people will face water stress or scarcity. Nearly 51 per cent (300 million people) in sub-Saharan countries lack access to a supply of safe water and 41 per cent lack adequate sanitation. More than 80 of Africa's river and lake basins e.g. the Niger River, the Nile River, River Limpopo e.t.c are shared by two or more countries and many countries depend on water flowing from outside their national boundaries. Some large-scale water infrastructure projects including dams may exacerbate the impacts of flooding and drought, threatening people's livelihood and further reducing their access to water (World Water Forum, 2002).

Figure 2.3 The Water Availability per Capita Projection for African Countries



Source: UNECA (1999)

The UNECA chart above makes a comparison of water availability for African Countries from 1990 to 2025. UNECA estimates that by 2025 all African countries will be in a state of water vulnerability with most being countries experiencing water stress or water scarcity.

For African development water is a crucial resource with great implications. In regards to freshwater as a resource, the situation for the African nations is not encouraging. Of the estimated 800 million people who live on the African continent, more than 300 million live in water-scarce environment. Lack of water hampers development through constraining food production, health and industrial development. For Africa, the key issues lie in investing in the development of Africa's potential water resources, reducing drastically the number of people without access to safe water and adequate sanitation, ensuring food security by expanding irrigation areas and protecting the gains of economic development by effectively managing droughts, floods and desertification (Economic Commission for Africa, 2006).

2.5.1 The Nile River Basin

The Nile Basin is a major source of water for nine nations namely Kenya, Uganda Tanzania, Sudan, Egypt, Ethiopia, the Democratic Republic of Congo, Rwanda and Burudi River is the main source of water for the nine nations which make up the Nile basin. The Nile as it is, is barely enough to satisfy the enormous water demands of this countries. It was expected that by the year 2000, six of the nine nations benefiting from it would experience acute water shortages (Ohlsson, 1995). Ohlson 1995 postulated that as more of the nations in the Nile valley developed their economies, the need for water in the region would increase while the supply would remain unchanged, hence increasing chances for armed conflict.

Collins (1990) stated that water abstraction by the countries upstream e.g. Ethiopia always caused structural water scarcity for the countries downstream e.g. Egypt. He emphasized that the Nile basin countries sought to secure the water supplies in order to reduce water scarcity with the colonization of African countries. Most of the colonizer sought to control the Nile waters. Glassman (1995) pointed out that Great Britain sponsored the Nile agreement and commission a hydrological study in order to reduce

water scarcity. This resulted in the 1958 Nile valley plan. However, it was not successful since it had severe environmental concerns.

Although war has not yet broken out between the nations involved, some believe growing demands may eventually lead to armed conflict. Signs of this trend are already surfacing. There have been numerous skirmishes between Sudanese and Egyptian troops as well as a number of statements made. The nations of the Nile basin have also classified access to the waters of the Nile River as a vital national interest over which they would be willing to go to war. For now, there has been enough water to satisfy most of the nations' needs, but in the near future those resources which have been left top them will cease to suffice.

2.6 The Water Situation in Kenya

The Kenya National Water Development Report (KNWD) 2005, noted that Kenya was classified as a water scarce country with 647 cubic metres of renewable fresh water per capital. The report emphasized that the same is characterized by high spatial and temporal variability and extremes of draughts and floods. The WRMA performance report of 2010 stated that, the problems related to reduction in water resources availability has been compounded by an increase in population resulting in decreasing per capita fresh water availability. The gives the bulk of Kenya's renewable water resources as being derived from an average annual rainfall volume of 322.77 billion cubic metres translating to an annual runoff of 20 Billion cubic metres. The 1992 National Water Master plan pegged the total safe abstraction rate at approximately 193 million cubic metres per year.

The report cites climatic variability, increasing demand for water as a result of development and population pressure factors that the water sector may not be able to control but could initiate mitigation measures to ensure sustainable water resource. Kenya's problem and challenge in the water sector include a growing population. The Kenyan water situation is considered to be that one of chronic water scarcity with the nation having a limited natural endowment of fresh water. Kenya is chronically water scarce with a limited natural endowment of fresh water. In view of the foregoing, the report argued that Kenya's water resources are not only scarce but this resources base is vulnerable to depletion while the country's socio-economic development is highly dependent on water. From Table 2.3 and Figure 2.6 the per capita availability is projected

to fall to 359 cubic meters by 2020 as the population is increasing and could be even less if the resource continues to be depleted

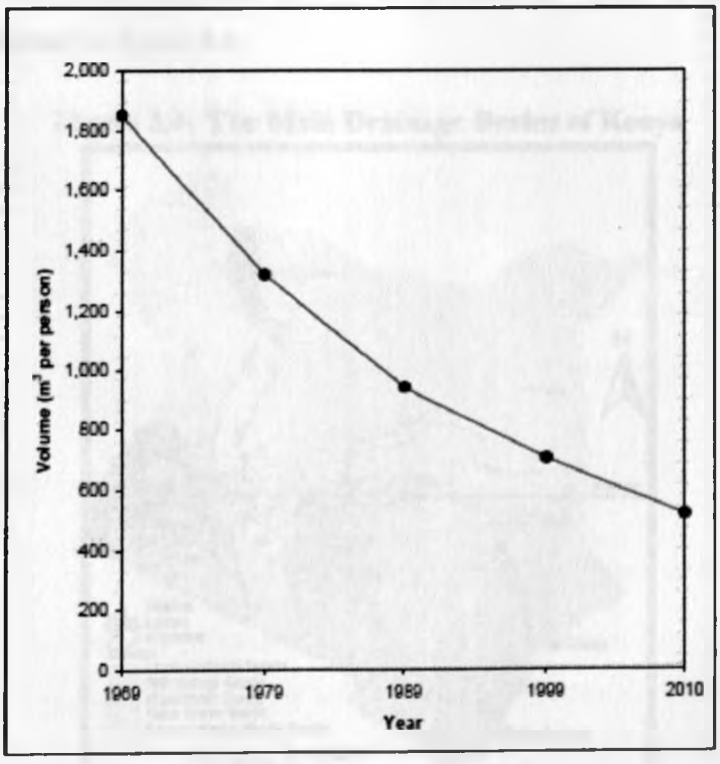
Table 2.3 Water Availability per Capita in Kenya (1992)

Year	Population	Per capita water availability M^3/yr
1969	*10.942.705	1853
1979	*15.327.061	1320
1989	*21.448.774	942
1999	*28.686.607	704
2010	**40.311.794	503
2020	**56.481.427	359

Source: Government of Kenya (1992)

The 1992 master plan projections showed that by the year 2020 Kenya will have a population of 56,481,427 and will be water scarce with a per capita availability of 359 M^3per year. Kenya is bedeviled by the problem of water scarcity. The Kenya National Water Development Report, 2005 evaluated the per capita water availability. In1969 the per capita water availability was at 1860 M^3/person and it projected that the figure would decrease to less than 600 M^3/person by the year 2010. (See the figure 2.6).

Figure 2.3 Estimated Trends in Kenya Water Availability Per Capita



Source: KNWD report (2005)

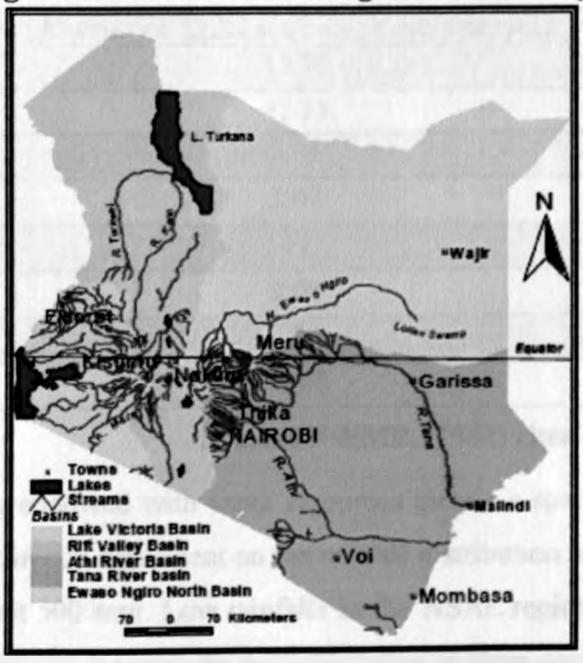
Climate variability and water resources degradation in Kenya have resulted into catchment degradation, drying up of rivers, receding of lake levels, heavy siltation in dams and pans as well as deterioration of water quality (KNWD, 2005). Increased runoff flash flooding, reduced infiltration erosion and siltation were results of catchment degradation. Due to the challenges mentioned above the Kenya government through the ministry of water and irrigation set a water sources development plan to meet the threshold of water scarcity (1,000m^3/day).

Kenya's water politics are also unique, as there has been a divide between areas that have been privatized and sectors where. Rural areas of Kenya are left without water and urban areas aren't much better off, as Kenya's virtually bankrupt government does not have the funds to run pumping stations and existing piping systems are often pirated and in disrepair.

2.6.1 Water Availability

The 2005, national water project report states that two thirds of the country is arid or semi-arid, most rivers are seasonal and only carries water during or shortly after the rains. Kenya is endowed with five main water towers from where the major river systems originate as indicated in figure 2.4.

Figure 2.4: The Main Drainage Basins of Kenya



Source: United Nations Water Report (2006)

In terms of variability of mean annual runoff and proportion used, Lake Victoria basin though being the smallest, has more than 50% of the national surface water resources. The rift valley within which the study area lies abstracts on 1.7%. Table 2.4 below shows spatial variability of average annual surface water availability.

Table 2.4: Spatial Variability of Average Annual Surface Water Availability

Drainage area	Volume in million cubic meters per year	Percentage of water abstracted
Lake Victoria	11,672	2.2
Rift valley	2,784	1.7
Athi River	1,152	11.6
Tana River	3,744	15.9
Ewaso Ng'iro	339	12.4
National	20,291	5.3

Source: United Nations Water Report (2006)

Water availability is dependent on the hydro-geological characteristics. Kenya consists of three major rock types; metamorphic basement, intrusive rocks and sedimentary rocks. These are closely linked with the ground water aquifers. From the hydrogeological map of Kenya (Figure 2.4), the study area lies within an area of poor ground water potential. By year 2003, Kenya had about 14,000 boreholes being used for different purposes with valid abstraction rates.

Table 2.5: Estimated Abstraction Rates by Use

Bore hole use	Abstraction in million cubic meters per year	Percentage of total
Agriculture	11.75	24.17
Public water supply	11.13	19.45
Domestic (Private)	3.46	6.04
Livestock	1.07	1.87
Exploratory	0.1	1.17
Observation	0.08	0.14
Others	7.89	13.79
Unknown	19.65	34.35

Source: NWMP, (1992) cited in UN-Water (2006)

Despite, Kenya being endowed with water resources there's a spatial variation of water availability which is directly dependent on the rainfall distribution pattern. Kenya's mean annual rainfall is about 500 mm. Low rainfalls in the ASAL region coincides with high evaporation rates and hence it limits the available water in these regions. The table below

shows the distribution of water resources and their uses. The rift valley in which the study area lies has 3.4% of the total national water resource potential (UN-Water, 2006).

2.6.2 Problems Affecting Water Resources Availability in Kenya

Kenya water resources have four main characters

1. The country has a limited endowment of just 650m^3 per capita per year as compared with its neighbor, hence making it water scarce.
2. High variation in water availability in space and time. The country experiences both floods and droughts.
3. Mismanagement of the only five available water catchment since all major rivers originates from these specific mountainous areas.
4. Over half of Kenya's water resource (54%) both ground and surface waters are shared with its neighbors.

Due to the above characteristics of the water resource in Kenya as the KNWR, 2005 points out that there are problems affecting water resources availability.

These problems include but are not limited to

a) Physical Characteristics

Since 80% of Kenyan land is ASAL, the lands have limited soil and water resources and support only 25% of the human population in the country. The report postulates that water scarcity is the main limiting factor to development of ASAL areas.

b) Limited Natural Endowment of Water

Since Kenya is water scarce not all the country's water can be exploited.

c) Highly Variable Climate

Kenya experiences wide climatic variations with most of the parts having two rainy seasons (March – May) for long rains and (October- November) for short rains. The rainfall received ranges from 250mm per year in ASAL to 2000 mm per year in the high mountain areas. About two thirds of the country receives less than 500 mm of annual rainfall. Due to this variation floods and droughts constantly affect the ASAL areas. The report noted that droughts had become endemic in some parts of Kenya. The ASAL areas being the poorest areas of the country are areas mostly affected by drought.

2.6.3 Water Supply in Kenya

In 2005, access to safe water was estimated at 89% in urban areas and 49% in rural areas. However this has been declining in terms of quality and quantity reliability and nature of access. The Ministry of Water and Irrigations (MWI) runs 628 rural water supplies out of which 200 schemes are gazetted for revenue collection. Water usage in rural areas is based on land potential classified due to the amount of rainfall. These are high potential, medium potential or low potential.

2.6.4 Water Social Aspects

i) Water and Gender

KNWR, 2005, states that women are responsible for ensuring that their families have water for daily living. It argues that water scarcity causes untold suffering to women because of their role as domestic water providers, caregivers and household managers. Water scarcity has adversely affected women and girls who spend alot of time walking long distances or queuing to fetch water for use at home. It has adversely affected the girl child education and the women's abilities to engage in other income generating activities, cultural and political involvement, rest and recreation (ibid). Barton (2007), argues that, Kenya is overwhelmed with problems of water scarcity. The population most affected by this is women. Women in Kenya are at a paradox; they are responsible for providing water for their families but are less likely to have safe access to it than men. These women risk their health and well-being to collect contaminated water .Women in Kenya are regularly confronted with violence during their chores, like gathering water, or when relieving themselves in public. Women in Kenya worry about water's power to control their lives: they fear frequent droughts and an increasing lack of water access, violence as they go to use a public water source, diseases from water and the health of their families.

ii) Water, Health and Safety

When women access to water is deficient, a number of negative health and social; impacts results, these includes, threats to family health and wellbeing (WEDO, 2003). These illness drain the limited households budgets since the funds are diverted to medical expenses. Kenya's water shortage also means that a large population of women and children spend up to one-third of their day fetching water in the hot sun from the nearest fresh water source. This backbreaking work leaves roughly half of the country's

inhabitants vulnerable to serious dangers and exposure to the natural elements and risk of attack by predators. The primary water gatherers are also the most susceptible to water-borne diseases. Water pathogens are a huge health problem in Kenya, as the people have been left unprotected against sporadic epidemics such as cholera and parasitic worms.

iii) Water and Children

Children often spend long hours collecting water at the expense of vital time to attend school and learn. Every day, women and young girls carry over 20kg of water from sources over 7km from their homes and villages in Kenya. This leaves little time for education which is critical to changing the long term prospects of developing nations. Schools cannot run programs if they cannot provide water to students, faculty and their families. Because so many adults are sick from unclean water, children are often left to manage homes, provide food and look after the sick. With the many additional burdens that a lack of clean water brings, education simply becomes less of a priority. This sets up an unfortunate cycle of poverty as without a proper education, there is little chance of improving one's situation later in life (ibid). Obera (2007) argues that water scarcity in many primary schools is driving pupils away from classrooms to fetch for at least drinking water where they trek at a distance of more than 30 kilometers especially during the dry spells to draw water from rivers, springs, and wells etcetera. He notes that this little water is mainly used for cooking, washing, drinking, some for domestic animals and finally the little remaining is preserved for cleaning. Surprisingly, this same water from the unprotected source is used for drinking without further treatments.

iv) Water and Poverty Eradication

Access to water for human consumption, agricultural and livestock use is a major problem in rural areas. The KNWR 2005, indicates that in ASAL areas people have to trek long distances to water their cattle and women have to go further in search for water for domestic use. Water scarcity exposes the rural poor to poverty. This is because they mainly depend on land and natural resources.

2.6.5 Water Resource Management

Demand management strategies are lacking, and water resources allocation decisions related to surface and groundwater abstractions are made without adequate data. It is

estimated that more than 50 percent of water abstractions are illegal. The percentage of people with access to safe water is 68 percent in urban areas and 49 percent in rural settlements; the level of water scarcity in many regions of Kenya has become a serious limiting factor for development activities. There is a great need to change the scattered structure and functioning of the water management system. Whilst approved standards for drinking water quality and effluent discharges exist, the relevant rules and regulations are not strictly enforced due to a lack of skilled personnel and limited funds. As a result, water pollution from urban and industrial wastes continues to degrade water quality; the heavy use of pesticides and fertilizers in agriculture leads to deterioration of surface water and underground resources; deforestation for firewood production continues at an increasing pace; and the overall exploitation of the country's resources remains an inminent threat to ecosystems.

The Economic Recovery Strategy for Wealth and Employment Creation (2003-2007), which charted the country's economic course from 2003 to 2007 and asserted that past institutional arrangements were simply insufficient to win the battle against poverty, promoted initiatives that would facilitate the achievement of MDGs, it recognized water as a pivotal element in poverty reduction and emphasized the importance of providing services to the poor while ensuring adequate water for competing demands. It suggested the undertaking comprehensive institutional reforms to facilitate 'pro-poverty water and sanitation programmes'. In this context, Kenya's poverty reduction strategy programme, initiated in 2000, committed the government to providing water and sanitation services to the majority of the poor at a reasonable distance (less than 2 km). The proposed strategy was to involve communities and local authorities more actively in the management of water and sewerage systems and services.

2.6.6 The Evolution of the Water Sector in Kenya over Time

According to a report by DANIDA, "Lessons Learnt and Good Practices in the Support to the Water Sector", the major political, social and economic changes taking place in Kenya directly affect the trend that the water sector conforms to. The sector thus has had tremendous changes over this period. The researcher takes a look at the various water sectors in Kenya as discussed by Notley, 2010 and classifies them into five dispensations:

a) The Post-Independence to the Mid 1970's,
b) Mid 1970's to Early 1980's,
c) 1980's to Mid 1990's,
d) Mid 1990'S – 2000,
e) 2000 Onwards

After Kenya got its independence from its British Master, the Water Development Department was formed under the Ministry of Natural Resources. The Water Act, Cap 372 of the time vested the overall ownership of water resources in the government. During the process of redistribution of land previously owned by white settlers, Kenyatta used the process as a means to sustain political stability and as a reward for political patronage. In the process ignoring the objectives of the exercise which was to; relieve tensions in densely populated areas, distribution of a politically acceptable minimum level of social services in which water was a key sector. This led to unplanned settlements which have affected us to date.

1. Free water For all: the Post-Independence to the Mid 1970S

After having promised Kenyan citizens quick improvement to their well-being and wealth for all Kenyans, the KANU regime found itself in a tight spot three years after independence. This was due to the high expectations that their post-independence promises had raised in the minds of Kenyans. In drawing the National Development Plan of 1964 and revised in 1966, the plan emphasized hard work and self-help, Harambee, as key to sustainable development at the same time through the Sessional Paper No. 10, African Socialism and its Application in Kenya, the government emphasized political equality, social justice, and human dignity.

In the Agenda of these policies was among others to provide free basic services, water and health included, to all Kenyans. Apart from there being minimal involvement of other sectors, e.g. the private sector, service delivery was minimal. This was as a result of politicization of the water provision issue and the providence of water delivery services in rural areas was done to reward political patronage. This in the long resulted in the government not being able to meet its targets of 'Free Water for All'.

2. Mid 1970 – Early 1980's

Within this period, the 'Harambee Spirit' had gained root and most projects at the various local level were being carried out in the spirit of pulling together – Harambee. Water being a key resource was prioritized and this gave birth to over 2,500 projects all aimed at provision of water.

Harambee was a key tactic in hastening the rural development after the independence and has been estimated to have contributed to about 30% of the rural development investment. In 1974, the Water Development Department was upgraded and became the Ministry of Water Development. During this period the first National Water Master Plan was developed and it proposed development of many water supply and sanitation utilities with the goal of "Water for All by 2000".

With the help of different development partners the government embarked on implementation of the projects proposed in the plan. This period was characterized by large regional and provincial water and sanitation programmes supported by different development partners. The water services coverage grew rapidly in many provinces due to water funding by donor agencies, but was later perceived to have several weaknesses, specifically in relation to sustainability which included; piecemeal planning, leading to little incentive to minimize costs, compromised technical standards and gradual undermining of the government systems especially at local level.

Despite considerable all these considerable improvements in the water services coverage in many parts of the country, rapid population growth proved to be overwhelming. The demand exceeded supply thus the number of people without adequate water provision remained high. This was made worse by the deterioration of water projects that had been handed over to the government and which ended up being run-down.

3. 1980'S– Mid 1990'S

This was the Structural Adjustment Era. Structural Adjustment Programmes (SAP) was introduced in Kenya in 1980/81 as Aid condition by the World Bank and International Monetary Fund. The aim of SAP emphasized that the state role should be limited to creating an enabling environment for individuals and business community. This was in the ideology of Free Market operations.

In 1983, the "District Focus for Rural Development was promulgated by the government with the intention to decentralize the planning and administration to local level. In line with the 1983 District Focus for Rural Development Plan water service provision was decentralized to Local Authorities in 1986, creating a number of locally-run utilities. This included the National Water Conservation and Pipeline Corporation (NWCPC) in 1988, with the objective to commercialization of the water sector operations with the aim of achieving financial autonomy in water operations.

These developments slowed down the provision of water services as community participation slowed down due to the commodisation of water – "a social good". This was an extreme deviation from the previous era's goal of water provision for all by 2000.

4. Mid 1990'S to 2000

This period saw the introduction of multiparty politics in Kenya. The planned reforms in the water sector were slow to take root and the handing over of ministry-run utilities and water systems to local government authorities or community organizations was progressing badly. Business-like operation, efficient service production, cost recovery and community management was still wanting in the water sector. The GOK carried out a "Delineation study of the Water and Sanitation Sector in Kenya (1992)", strongly recommending far-reaching institutional reforms for the water and sanitation sector.

Despite several developments and changes in policies and institutional arrangements described above, the water and sanitation services remained unsatisfactory. The rapid growth in coverage gained during the early 1990s slowed and came to a standstill and water coverage figures stayed level or even declined. The development of water services could not keep up with the rapid population growth and percentage of the population covered decreased. There were several reasons for the non-performance of the water sector included the socialist legacy, water was still regarded as social good, making willingness to pay and cost recovery difficult; uncertainty of the policy regime and regulatory framework was a major constraint in the sector management; centrally managed monopolistic public enterprises or government departments were still providing water services; the centralized system of managing water utilities made efficient operations difficult; and Lack of performance standards for the water utilities.

The study of the water sector in 1992 described that the GOK was neither able to operate water supplies efficiently nor maintain adequate service level due to financial constraints. (Delineation study on the Water sector in Kenya) The share of the water sector of the overall GOK annual budget was decreasing substantially over the years. Water consumption was estimated to be below 25% of production capacity. Tariffs were too low, and only a small portion of the revenue was collected.

5. 2000 Onwards

Prior to 1999, the water sector in Kenya was guided by priorities set in the Five-Year National Plans. Water related legislation consisted of Water Act Cap 372 and some additional 30 Acts relating to water issues.

In 2002, the Moi government established a taskforce to review the Water Act, Cap 372 and to draft a bill to replace the Water Act, Cap 372. This led to the publishing of the Water Bill 2002 on the 15 March, 2002. The bill was passed by parliament on 18 July 2002 and gazetted in October 2002 as the Water Act, 2002 which was took effect in 2003 (CAB International 2007).

When the NARC Government took over power from KANU in December 2002 it recognized the problems and the need to reform the water sector. It embarked on a long process of addressing water issues. This was because the government felt that the provision of water services had deteriorated and the water supply was not adequate for the already rapidly growing population. The regime believed that this inadequacy in water supply was as a direct consequence of decades of poor management, corruption, lack of political resolve, environmental degradation leading to; drying and pollution of rivers, lakes, wetlands, aquifers and their catchments. This applied particularly on the major water towers that sustain Kenya's rivers during the dry season. The lack of a coherent water policy was to blame for the above impediments to water supply.
The government therefore, decided to implement the Water Act, 2002 in full.

2.6.7 Act No. 8 of 2002 - Water Act

The Act provides for the regulation of riverine forests, catchment forests, and protection of wells and springs in the forest and supports the user pays principle for water benefits and therefore opens opportunities for catchment forest management and conservation

by forest communities and revenue generation through payments for ecosystem services. The water policy aimed at achieving sustainable development and management of the water sector it provided a frame work for selling the desired targets/ goods in water resources management, water supply and sewerage development, institutional arrangement and financing of the water sector.

The Water Act, 2002 stipulates that every water resource is vested in the state. It provides for the powers and duties of the minister; who shall have and may exercise control over every water resource. It provides for the Minister to promote the investigation, conservation and proper use of the water resources throughout Kenya. The right to the use of water from any water resource is vested in the Minister.

The water Act provides for the establishment of an authority known as Water Resources Management Authority (WRMA), which shall be a body with perpetual succession and a common seal and shall have power in and by it corporate name, to sue and be sued in the exercise and performance of its power and functions. Part III section 8 of the Water Act provides for the powers and function of the WRMA. It states that the authority shall have the power to:

1. To monitor and from time to time re-assess the national water resources management strategy.
2. To receive and determine application for permits for water use.
3. To monitor and enforce conditions attached to permits for water use.
4. To regulate and protect water resources quality from adverse impacts.
5. To manage and protect water catchments.
6. In accordance with guidelines in the national water resources management strategy, to determine changes to be imposed for the use of water from any water resource.
7. To gather and maintain information on water resources and from time to time publish forecasts, projections and information on water resources.
8. To liase with other bodies for better regulation and management of water resources.
9. To advise the minister concerning any matter in connection with water resources.

Part III section 10 points out that the WRMA shall establish regional offices in or near any catchment area which shall be established in through a gazette notice, designating a defined area from which rainwater flows into a water course.

Under section 11, the public consultation is highlighted as a key aspect of formulation of a national water strategy, in accordance with which the water resources of Kenya shall be managed, protected, used, developed, conserved and controlled. In sub- section (2) it provides for the revision of the strategy from time to time. The Act charges the National Water Resource Management strategy to prescribe the principles objectives, procedures and institutional arrangements for management, protection, use, development, conservation and control of water resources and in particular, determining the requirement of the reserve for each water resource; classifying water resources and identifying areas which should be designated protected areas and ground water conservation areas. Section 12, stipulates the classification of water resource and resource quality objectives. Section 13 provides for the determination of reserve for the whole or part of each water resource, to ensure that adequate allowance is made for each aspect of the reserve.

Section 15 (3) outlines that the role of a management strategy shall:

1. Take into account the class of water Resource and resource quality objectives for the water.
2. Be consistent with the national water resource strategy.
3. Prescribe the principles, objectives, procedures and institutional arrangements of the authority for management, use, development, conservation and control of water resources within each catchment area.
4. Contain water allocation plans which set out principles for allocating water.
5. Provide mechanisms and facilities for enabling the public communities to participate in managing water resources within each catchment area.

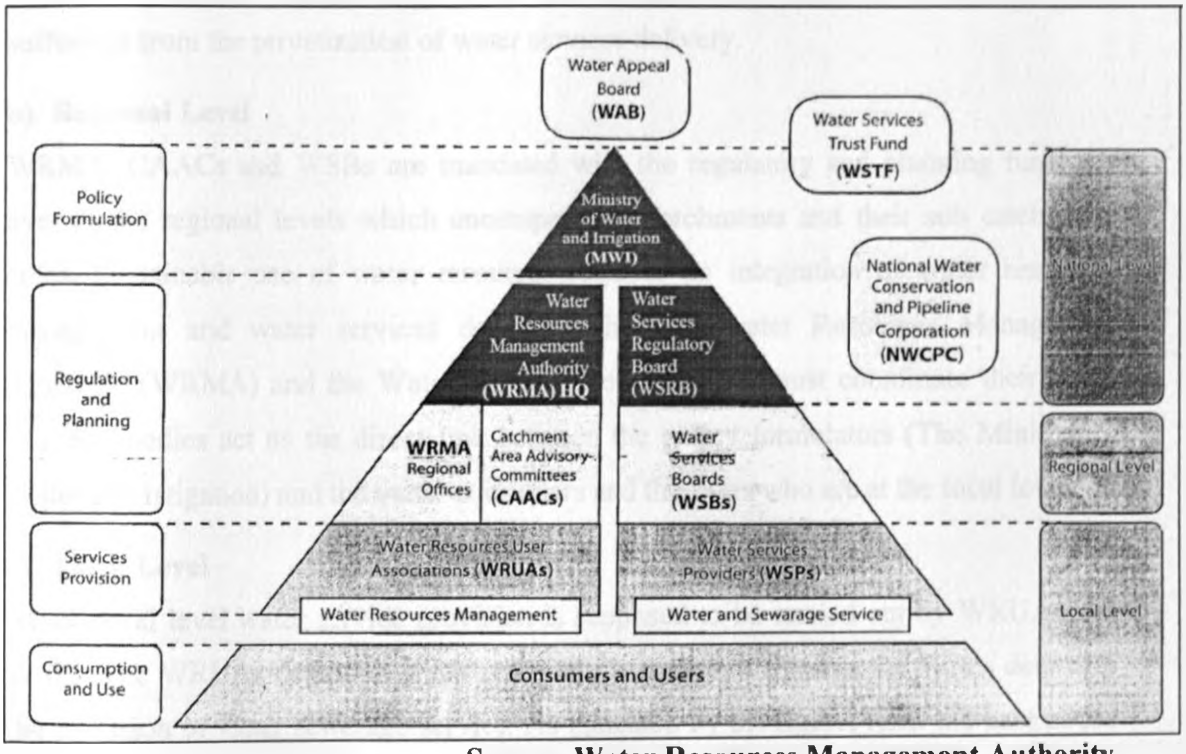
2.6.8 The Institutional Set-up of the Water Sector

The Water Act, 2002 introduced comprehensive and radical changes to the legal framework for the management of the water sector in Kenya. These reforms included the following:

1) The separation of the management of water resources from the provision of water services
2) The separation of policy making from day-today administration and regulation;
3) Decentralization of functions to lower-level state organs; and
4) The involvement of nongovernment entities in both the management of water resources and the provision of water services.

The institutional framework resulting from these reforms is represented diagrammatically in figure 2.8.

Figure 2.5: Institutional Framework under the Water Act 2002



Source: Water Resources Management Authority

The Ministry of water and irrigation is at the top followed by Regional authorities and catchment area advisory authorities. The communities form the base of the pyramid. The Act provides for differentiation between service delivery and water resources management tasks. The Act defines that services provided through the seven water services Boards. Six Catchment Areas Advisory Committees (CAACs) carry out water resources management tasks.

a) National Level

Minister in charge of water affairs is in charge of the policy formulation on water and related issues. WRMA and WSRB are mandated with the task of regulation and planning. This is level is manadated with the task of overall coordination and control of the water sector in the country.

The Act provides for the composition of WAB and the WSTF.

The WSTF is an agency meant to finance, micro-projects at community level. It provides direct funding for small communities which would otherwise be disadvantaged. The fund is there to support marginalized areas and marginalized people and alleviate their sufferings from the privatization of water services delivery.

b) Regional Level

WRMA, CAACs and WSBs are mandated with the regulatory and planning functions over at the regional levels which encompass the catchments and their sub catchments areas. Sustainable use of water resources requires an integration of water resources management and water services delivery. Thus the water Resources Management Authority (WRMA) and the Water Services Board (WSB) must coordinate their work. The two bodies act as the direct link between the policy formulators (The Ministry of Water and Irrigation) and the water consumers and the users who are at the local level.

c) Local Level

At the local level water service provision is supposed to be carried out by WRUAs and WSPs. The WRUAs deal with water resource management whereas the WSPs deal with the provision of water sewerage service. As indicated by the figure, form the base of the pyramid and indication that they are base on which the water supply rest on. They fall at this level as the consumers and users of water. Edalia, 2011 argues that in the past there was no legal framework to provide a formal arrangement for communities to participate in Water Resource Management. The Water Acts 2002 provides for community involvement in Water affair by providing for the formation of water Resource Users Associations. A WRUA is an association of water users, riparian land owners or other stakeholders who formally and voluntarily come together as a group to cooperatively share, conserve and manage a common water resource.

According to WRMA, Water News, Edalia, 2011 state that the WRUA provides a formal forum for community based participation in water Act 2002 Management. Section 15 of the Water Act 2002 gives the legal framework for WRUAs as a conflict resolution and co- operative management of water resources in catchment areas. The activities carried out by WRUAs in managing water catchment and water resources management includes;

- Riparian Land pegging
- Tree planting
- Water Abstraction surveys
- Monitoring and reporting on water pollution
- Soil Conservation activities (gabion construction)
- Rainwater harvesting demonstration structures
- Sand dams development for water conservation
- Construction of common intakes for better water abstraction control

At the community level it is simply impossible to separate water service delivery from sustainable water resources management. The reform introduced tariffs for water use. These tariffs pay providers for the services they deliver. Water services providers charge people for the services rendered. There also other sources of revenue. There is money transferred from the Ministry of Finance to the Ministry of Water and Irrigation as well as money paid by users and polluters. These tariffs include payments for water permits granting individuals the right to water abstraction. The Water Act defines how this capital is to be invested. A defined share is used for water services delivery and another for water resources management.

The operationalization of the Water Act has had challenges, constraints and successes. Michael (1978) asserts that an integrated policy of water resources management, efficient, utilization of resources for optimum crop-production, human and livestock consumption, provide for flood control, hydro- electric power- generation, recreation and navigation. Very low levels of investment in water resources management, including storage, improved water use efficiency, data management, irrigation, etc.

2.6.9 The National Water Services Strategy (NWSS) 2007 – 2015

Section 107(2) of the Water Act, 2002, gives powers to the Director of Water Services to formulate a national water services strategy for the development, management and monitoring of water and sewerage services.

2.6.9.1 Summary of the National Water Services Strategy (NWSS 2007 – 2015

In seeking to consult with public on the contents of the draft strategy of the NWSS, the Director of Water Services in the Ministry of Water and Irrigation, Eng. R. N. Gakubia argued that in Kenya the WSS situation is poor for a majority of people. He states that sustainable access to safe water is around 20% in the settlements of the urban poor where half of the urban population lives. He further notes that with a population growth of up to 10% in the low income urban settlements many 'hot spots' continue to develop in many towns and therefore sustainable access to safe water is declining. Sustainable access to safe water in the rural setting is estimated at 40%.

The NWSS defined some of the following strategic goals and strategic actions designed to provide an effective and efficient response to the challenges identified in the WSS subsector as presented in the table below.

Table 2.6 NWSS Strategic Goals and Actions

Actions	Goals
Reach at least 50% of the underserved urban population with safe and affordable water by 2015 (MDG) and thereafter, move to access to all by 2030	• Review tariff guidelines periodically to cover justified costs • Sector investments shall focus on infrastructure development and improvements of operation • Service provision according to minimum standards specified in the sector benchmarks • Increasing funding and leadership of GoK in the sector • Foster good corporate governance
Achieve the MDG by fast tracking affordable and sustainable access to safe water in the settlements of the urban poor.	• Ensure increased service provision in the settlements of the urban poor with minimum requirements and standards through GoK or DP subsidy in infrastructure development and empowering to manage facilities • Accelerate sustainable access to safe water in the settlements of the urban poor by formalizing connections, setting pro-poor tariffs, providing appropriate outlets • WSRB, WSBs and WSPs shall develop and implement strategies to extend formalized service provision to the urban poor

	• Water sector reports to include advances in service provision to urban poor. • Institutional development aimed at building capacity to be prioritized to develop local level management of WWS provision
Reach at least 50% of the underserved in rural areas with safe and affordable water by 2015 (MDG) and thereafter move to sustainable access for all by 2030	• Promote increase in investments and ownership for sustainable access to water in the rural areas • Improve water quality of water sources by enforcing water quality standards and effective policing by WRMA etc • Sustainability of rural water systems by promoting beneficiary participation in planning, implementation and management • Improve monitoring of existing water supplies to update baseline data for timely intervention. • GoK, DPs to channel funds through WSTF to ensure compliance to national standards • Investment in rural will aim at supplying water for both human and livestock. • WSB shall promote PPP where viable Support to user groups shall focus on good governance.

Source: Ministry of Water and Irrigation, Kenya

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.0 Introduction

This chapter focuses on the research design, target population, sample and sampling procedures, research instruments, instruments validity and reliability, data collection procedures and data analysis procedures.

3.1 Research Design

According to Borg and Gall (1996) a research design is a logical and valuable way of looking at the world. In this study, the researcher used both survey design and ethnographic design.

Survey design is an attempt to collect data from members of the population in order to determine the current status of that population with one or more variables respectively. Being a self report it requires the collection of quantifiable information from the samples. It involves descriptive, explanatory or involves advanced statistical analysis. According to Mugenda (2003) it is the best method available to social scientists. Surveys enable gathering of data at a particular point in time with the intention of describing the nature of existing conditions or identifying standards against which existing conditions can be compared or determining the relationship that exist between specific events (Cohen L. and Marion, 2007).

The researcher chose to use this method because he was interested in collection original data for the purpose of describing a population which was too large to observe directly. In this study the survey design enabled the researcher to look into the many interrelating factors that cause water shortages and which are divided into: human activities, environmental pressures and climatic change.

The researcher was also able to use ethnography. Ethnographic design relies on observations in which the researcher is a participant in the situation and collects the required information (Orodho, 2009). For the purposes of this design, the researcher in person visited various parts of the division and made observations on the various aspects such as; the water sources, manner in which water is fetched and used, visible indicators of water scarcity, possible conflicts arising in sourcing and water use among others. The

researcher further chose to use this method since it provided a complete picture of the environment being studied and would be able to observe over a period of several months the longitudinal perspective which would not have been possible with many other types of research methods. Hence, the analysis of the data collected was done without constraining, manipulating or controlling the variables.

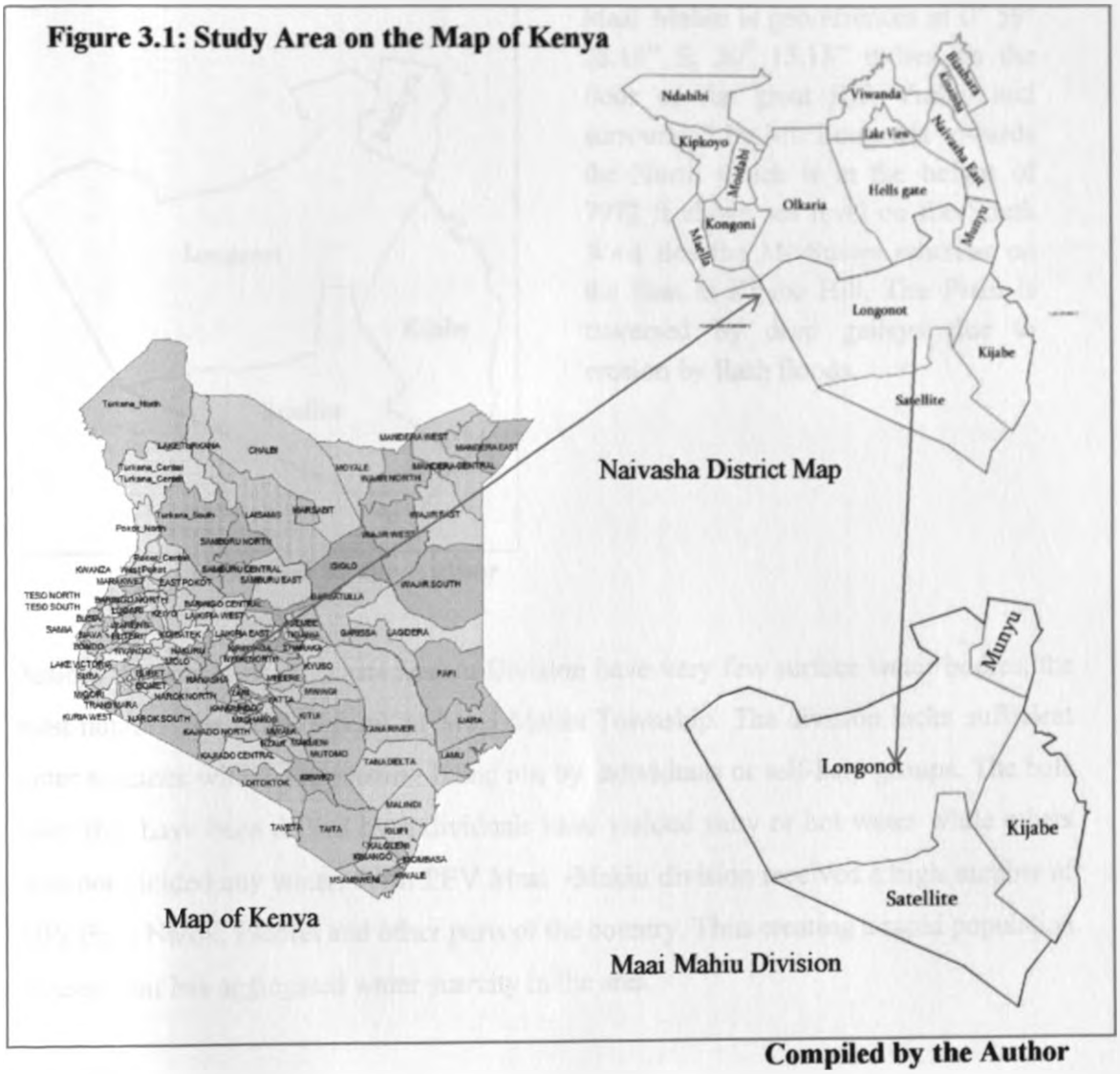
3.2 Study Location

The study was carried out in Maai Mahiu Division, Nakuru County which is located 43 km North West of the capital city, Nairobi. The study area comprised of four locations namely: Kijabe, Satellite, Longonot and Munyu locations. The area lies at the foot of several geographical features which include Mount Longonot, The Kikuyu Escarpment, Mount Margaret and Mlima Panya Ridge. The choice of this location was based on the following factors: the area lies in ASAL area, there has been a presence of human-animal conflict as a result of water scarcity and that the area harbours pastoralists, small scale farmers and large scale farmers as well as having town centres and various industries.

Figure 3.1 below indicates the area of study on the Kenyan map. Administratively Maai Mahiu is a Division within the larger Nakuru County. The figure shows the Nakuru County and later indicates the entire composition of Maai Mahiu Division in terms of location.

The areas climate is influenced by nearness to the equator, the topography and the Inter-Tropical Convergence Zone (ITCZ). The influence of the ITCZ is modified by the altitudinal differences, giving rise to varied climatic regimes. Annual rainfall in Kenya follows a strong bimodal seasonal pattern. Generally, the long rains occur in March – May, while the short rains occur in October – December, but with variations. It has a low rainfall of 200- 800mm per annum, Maai –Mahiu falls into what is classified as Arid and Semi- Arid lands (ASAL). The area was named after River Tongi Tongi which was known for its hot water. It had its origin from the Kikuyu Escarpment near Kijabe Hill.

Figure 3.1: Study Area on the Map of Kenya



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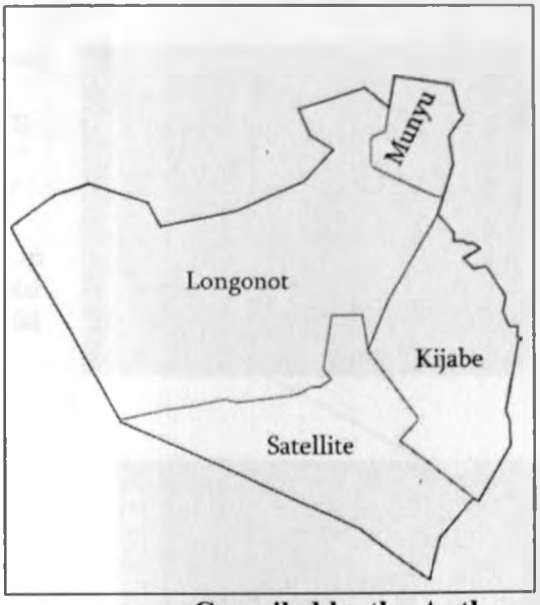
According to Hutchison (1977) in the tropics Arid Lands receive an annual rainfall between 25 and 250mm of rainfall. Figure 3.2 below indicates the map of Maai Mahiu Division.

Figure 3.2: Sketch Map of the Study area showing the Respective Locations



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Maai Mahiu is georefrences at 0^0 59' 28.19" S, 30^0 15.18" it lies on the floor of the great Rift Valley and surrounded by Mt. Longonot towards the North which is at the height of 7972 ft above sea level on the South West lies the Mt Suswa whereas on the East is Kijabe Hill. The Plain is traversed by deep galleys due to erosion by flash floods.

Besides the low rainfall, Maai- Mahiu Division have very few surface water bodies; the most notable one being a dam at Maai Mahiu Township. The division lacks sufficient water schemes with those existing being run by individuals or self-help groups. The bole holes that have been drilled by individuals have yielded salty or hot water while others have not yielded any water. With PEV Maai –Mahiu division received a high number of IDPs from Narok, Eldoret and other parts of the country. Thus creating a rapid population increase that has aggregated water scarcity in the area.

Figures 3.3 Some of the Key Features of Maai Mahiu Division

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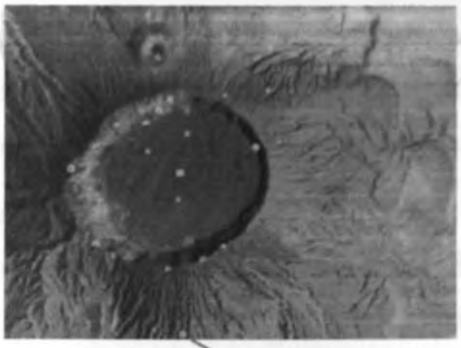
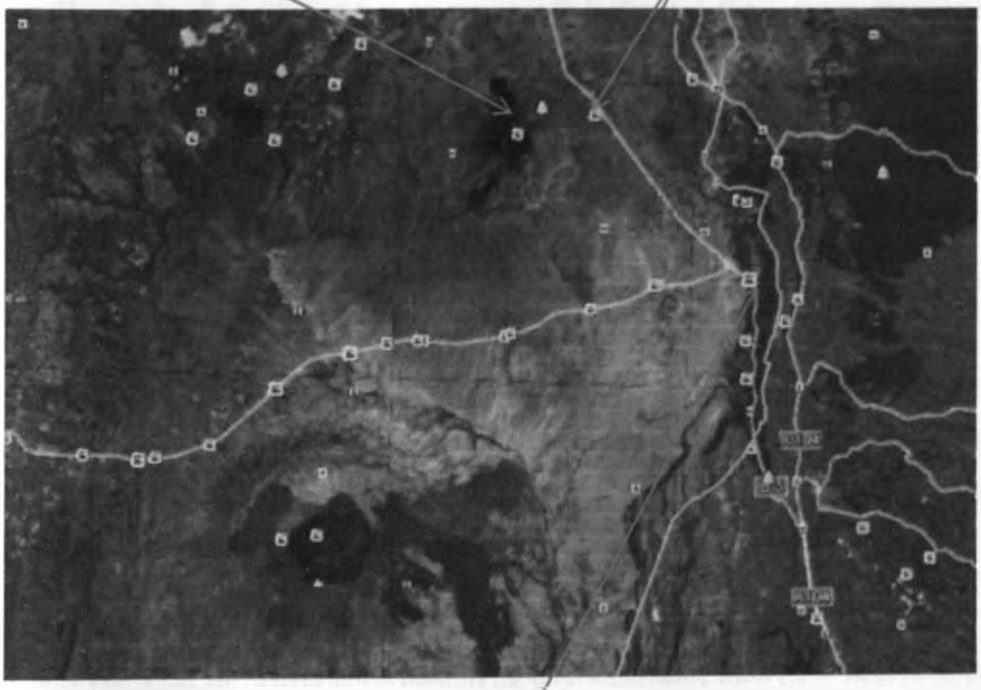


Old Naivasha Rd. A104 with a ribbon development along the road and Mt. Longonot at the background



Concentrated human settlement along the water source (Kikuyu Escarpment: **Nb:** the areas next to the Kikuyu escarpment are densely populated and those far away from it are sparsely distributed.

3.3 Target Population

According to Mugenda (1999), a population is a complete set of individual cases or object with some common observable characteristics. The study targeted the four locations of Maai Mahiu Division and which have a combined population of approximately 28,360 persons (National Census Data, 2009).

3.4 Sample and Sampling Procedures

According to Borg and Gall (1996) sampling is a research technique used for selecting a given number of subjects from a target population as a representative of the population. Mulusa (1988) emphasizes that a sample must represent the target population or the universe in all aspects. Sampling refers to a research technique for a given number of subjects from a target population as a representative of that population. Sampling is significant since it is not possible to study every member in the whole population. It enables one to learn something about a large group by studying a few lists of the members thus saving time and money. A large sample normally has more of the attributes of the universe than a small sample especially if the same method of selection is used. In this study all the four locations of Maai Mahiu District were involved. Snowball sampling technique was used to select the village elders and community heads as well the former leaders of former water groups. Simple random sampling was used to select two hundred households and fifty water vendors. All the locations were targeted during the entire research.

3.5 Data Collection Instrument

The study will use a set of instruments namely: a questionnaire, interview schedule and document analysis and observation schedule.

3.5.1 Questionnaire

This is a research instrument that gathers data over a large sample. As started by Orodho (2009) a questionnaire has a diverse number of merits upon which a researcher may opt to use it as an instrument to collect data.

The researcher therefore used the questionnaire for the following reasons:-

- The questionnaire enabled the researcher to collect information from a large number of people and the questions were easy to analyze.

- Questionnaire is anonymous and this helped produce more candid answers than was possible with the interview schedule.
- Questionnaire saved on time since the researcher was able to have the administered and collected later after the respondents hand filled them.

This method was used to solicit data from the selected members in the various households and also from the various selected water vendors. The questionnaires had open ended and closed ended format.

3.5.2 In-Depth Interview Schedules

The researcher used in-depth interview schedules as it enabled him to be in a position to use both open and closed ended questions in order to get a complete, clear and detailed understanding of causes of water scarcity in the area of study. The researcher collected information through personal interviews in a structured way which involved the use of a set of predetermined question which were asked in the form and order prescribed. These instruments were used to collect data from District Development Officers, WRUA officials, various self-help group leaders and WRMA officials.

The research interviews yielded a high response rate in the survey and they also allowed the researcher to clarify ambiguous answers and where appropriate, sought follow-up information. Their shortcoming was that they were time consuming and expensive.

3.5.3 Document Analysis Guide

Document analysis guide was used to assist in collecting in depth information on issues that needed confirmation such as number of boreholes, number of licensed water vendors, piping design and authorization among other. This was done to gather insight into the manner in which various government agencies carry out their duty in controlling, protecting and conserving the water resources.

3.5.4 Observation Schedule

This was used in order to obtain variable information on aspects of water conservation, conditions of water catchment areas, water use, water distribution and the quality of the water available. This was of importance in determining whether the water demands of households, farms and industry were affected. Since the method is independent of

respondents willingness to respond and it was relatively less demanding of active cooperation on the part of the respondents.

3.5.5 Photography

The researcher considers photographs as an important way of recording findings in the urban and regional planning field. Through photographs the researcher was able to capture important aspects of the study field. Many photographs were taken during the research work and the research had to take time to take selected excerpts which were most crucial for the research work.

3.6 Validity of Research Instrument

Orodho (2009) states that validity is the degree to which results obtained from the analysis of the data actually represent the phenomenon under investigation. Validity is concerned with "are you measuring what you think you are measuring? In order to ensure the validity of the instruments, the researcher prepared a questionnaire for households and water vendors and consulted with the supervisor. Piloting was done in selected areas of the division to check on phrasing, vocabularies and appropriateness of the questions in the questionnaire. The researcher also used a variety of instruments other than questionnaires such as interview schedules, observation and document analysis guide, in order to ensure methodological triangulation.

3.7 Reliability of the Research Instruments

This refers to the degree to which a test measures what it purports to be measuring (Orodho, 2009). The process of developing and validating an instrument is in large part focused on reducing error in the measurement process. Reliability estimates evaluate the stability of measures, internal consistency of measurement instruments. The reliability of a research instrument concerns the extent to which the instrument yields the same results on repeated trials. Although unreliability is always present to a certain extent, there will generally be a good deal of consistency in the results of a quality instrument gathered at different times.

The questionnaires, interview and observation schedule were examined, discussed and reviewed by the supervisor and the researcher who used the relevance of the content on

the instrument in relation to the purpose, objectives and research questions. Suggestions given were taken into account and the necessary adjustments in the instruments made.

A pilot study was carried out targeting eight households and four water vendors. One water vendor questionnaire and two household questionnaires were administered to randomly selected respondents from each location. Test-retest technique was used to test the reliability of the instruments. The questionnaires were administered within a space of two weeks. The scores of the first and the second tests were recorded and a mean score of each item as answered by each respondent in the first test and second were worked out. Pearson product moment correlation co-efficient was then worked out between the mean score of the results from the first and the second test. The correlation co-efficient yielded was considered sufficient as it yielded a value of 0.75 which was way above the minimum value of 0.5.

3.8 Data Collection Procedures

Primary data was collected through administration of questionnaires, observation and carrying out scheduled interviews. There were two types of questionnaires, i.e. structured and unstructured. They were prepared in advance and were definite, concrete and pre-ordained. The structured questionnaires were used to initiate formal enquiry, supplementing and checking previously accumulated data. The questions aimed at capturing water source, supply reliability, quality distance to source, and mode of transport and stakeholders willingness to participate in water scarcity alleviation projects.

The study involved administering mixed questionnaire to sampled population, in the four sub-locations namely Kijabe, Satellite, Longonot and Munyu Locations. The study had a fixed number of questions to each household selected in the sample and the response was systematically classified for quantitative analysis. Target group Discussion, entailed a set of questions which were asked and filled by interviewers. The investigator presented the questionnaire to the individuals whose responses were required. Group discussion was classified into observation, document evaluation and rating. Target group discussions were advantageous since the answers were not biased as the researcher was able to clear any doubt hence the response was accurate. The discussions were with selected

household heads, water vendors, water kiosk owners, water drawers, transporters and members of the public.

3.9 Data Analysis Procedures

The data generated by questionnaires, interview and observation schedules was checked, edited organized and coded by computer to reduce the mass of data obtained into a form suitable for analysis. The coded data was analyzed using Statistical Package for Social Science Programme (SPSS). The statistical analysis was then summarized into frequencies and percentages and presented in tables, bar charts and figures. Frequencies and percentages were adopted to present, discuss and interpret findings obtained. The research questions giving qualitative data were then analyzed using content analysis procedures. The findings obtained were discussed and formed the basis for the research findings, conclusion and recommendations.

CHAPTER FOUR

PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA

4.1 Introduction

This chapter will provide the presentation, analysis and interpretation of all the data collected from the area of study during the research period. Data was collected through various research instruments which included questionnaires targeting households and water vendors, interview schedule with key informants, focus group discussions with various community members and through an observation schedule which included photography.

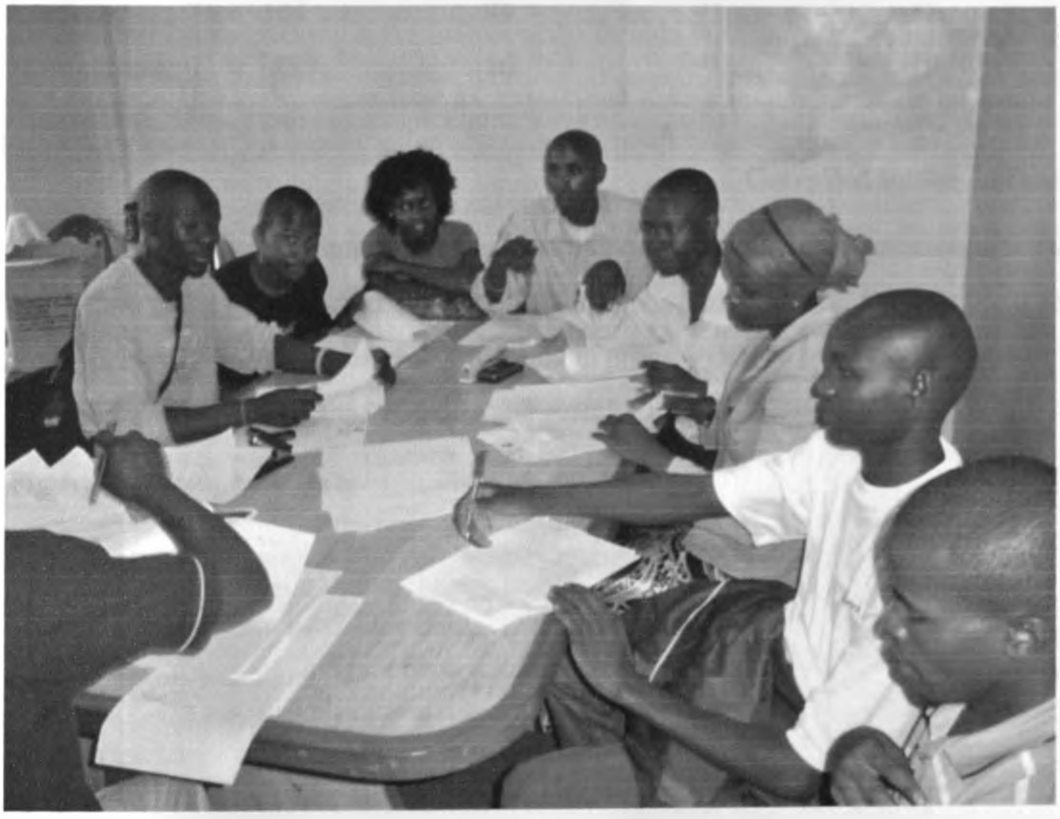
The quantitative data was analyzed using descriptive statistics and was presented in the form of tables, percentages, graphs and charts. The qualitative data was analyzed through the use of content analysis. Results of the data analysis provided information that formed the basis for discussion, conclusion, and interpretation of the findings and recommendations of the study. The Use of Statistical Package for the Social Science (SPSS) was extensively used by the researcher in statistical analysis, data management (case selection, file reshaping, creating derived data) and data documentation. Photographs were analyzed through subjective analysis as they were objective. Descriptive statistics was attained through cross tabulation, frequencies, and descriptive ratio statistics. Cross tabulation involved the process of creating a contingency table from the multivariate frequency distribution of statistical variables. Content analysis was used to analyse the qualitative data. This allowed for the classification, sorting and enabled the researcher to arrange information and examine the relationships in the data. The analyzed data was later exported to Microsoft Word where the researcher was able to come up with the conclusions of the analysis.

4.2 Inferences

The researcher administered two (200) questionnaires to various randomly selected households and fifty (50) questionnaires to randomly selected water vendors in the Maai Mahiu Division. The researcher was able to employ the use of research assistants who helped in administering of the questionnaires. Within the first week, the researcher took the research assistants through induction training on how they were to administer the questionnaires. The research assistants were taken through the process of gathering data

and how to administer the questionnaires. Within this period the researcher mapped the field and assigned the research assistants areas of which they were to carry out their assigned tasks.

Figure 4.1: Research Assistants in an Induction Session



Compiled by the Author

The households respondents were given two weeks to enable them to respond to the questionnaires. With the help of the research assistants the researcher was able to collect the questionnaires from the various respondents. A total of one hundred (168) households' questionnaires and forty one (41) water vendors' questionnaires were submitted back.

4.2.1 Response rate

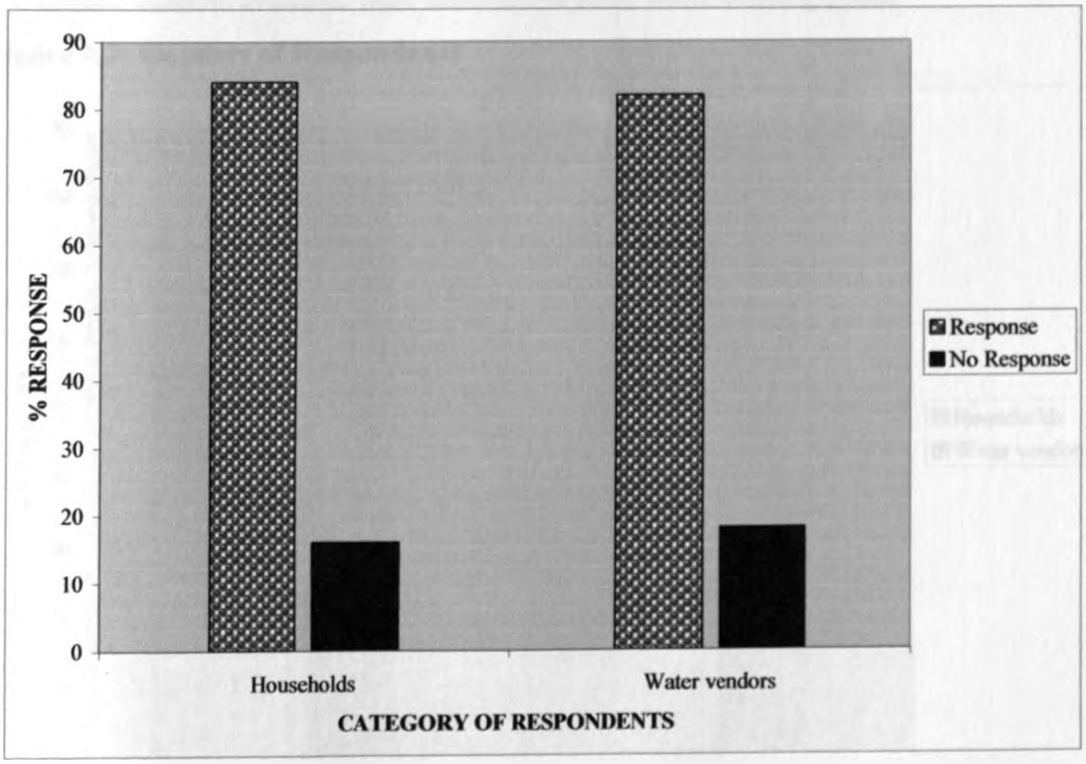
Table 4.1: Response Rate

	Households		Water vendors	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Response	168	84	41	82
No Response	32	16	9	18
Total	**200**	**100**	**50**	**100**

Compiled by the Author

The response rate was eighty four percent (84%) of the household questionnaires while eighty two (82%) of the water vendor questionnaires. This response rate was ideal for the study as it provided the researcher with enough primary data to analyse and come up with an informed decision on the issue of water scarcity in Maai Mahiu Division.

Figure 4.1: Response Rate



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4.2.2 Gender of Respondents

The table below shows the gender of respondents.

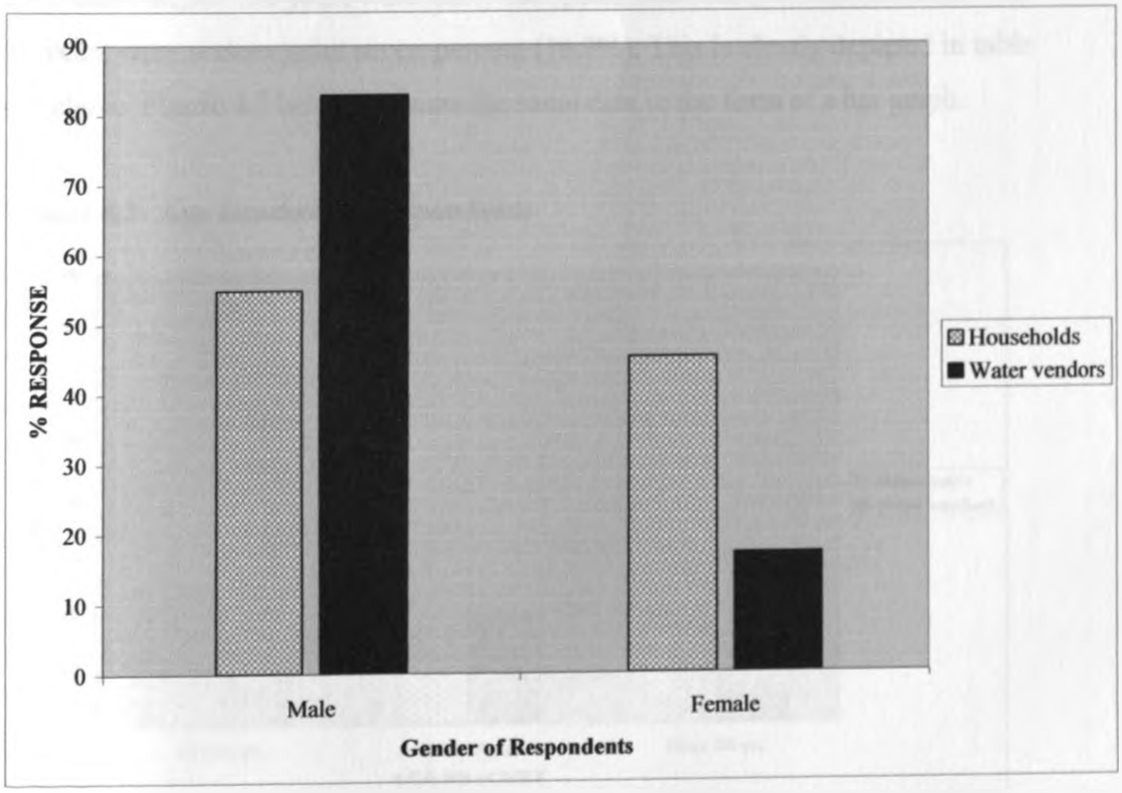
Table 4.2: Gender of Respondents

	Households		Water Vendors	
Gender	Frequency	Percentage (%)	Frequency	Percentage (%)
Male	92	54.8	34	82.9
Female	76	45.2	7	17.1
Total	**168**	**100.0**	**41**	**100**

Compiled by the Author

From the table above fifty four point eight (54.8%) percent of the household respondents were male while forty five point two (45.2%) were female. This was in contrast with that of the water vendors where a high number of them, 82.9%, were male as compared to seventeen point one percent (17.1%), being female. On enquiring further, the researcher was able to learn that most of the water vending in the area was carried out by males. The few female vendors available were stationed at fixed water vending points.

Figure 4.2: Genders of Respondents



Compiled by the Author

Figure 4.2 gives a pictorial presentation in the form of a bar graph showing the gender of the respondents. It is evident that a majority of the respondents were males. As for the households, this can be attributed to the fact that in most of the households the man was the head and thus was mandated to answer the questionnaires on behalf of the family.

4.2.3 Age Bracket of Respondents

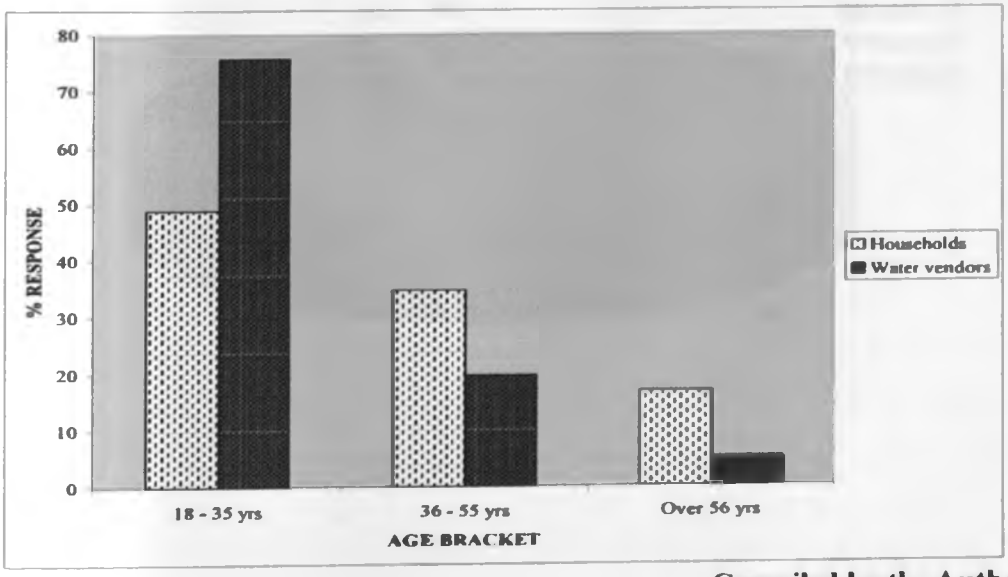
Table 4.3 Age Bracket of Respondents

Age	Households		Water Vendors	
	Frequency	Percentage (%)	Frequency	Percentage (%)
18 - 35	82	48.8	31	75.6
36 - 55	58	34.5	8	19.5
Over 56	28	16.7	2	4.9
Total	**168**	**100.0**	**41**	**100.0**

Compiled by the Author

A majority of the household respondents were aged between the ages of 18 – 38 years. Their percentage was forty eight point eight percent (48.8%) while those aged between 36 – 55 years were thirty four point five cent (34.5%) and those over 56 years were sixteen point seven percent (16.7%). This is clearly depicted in table 4.3 above. Figure 4.3 below presents the same data in the form of a bar graph.

Figure 4.3: Age Bracket of Respondents



Compiled by the Author

4.2.4 Marital Status of Households Respondents

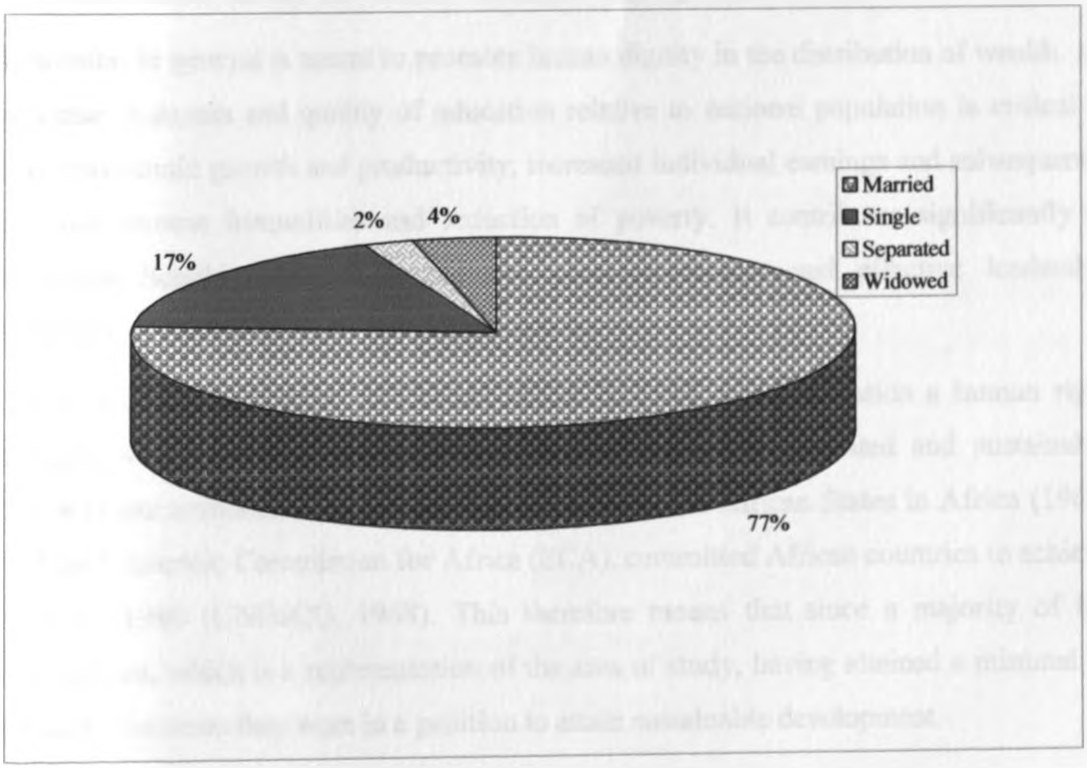
Table 4.4 Marital Status of Household Respondents

Status	Frequency	Percentage (%)
Married	129	76.8
Single	29	17.3
Separated	4	2.4
Widowed	6	3.6
Total	**168**	**100.0**

Compiled by the Author

Seventy six point eight (76.8%) of those household members interviewed were married, seventeen point three percent (17.3%) were single, two point four percent (2.4%) were separated while three point six percent (3.6%) were widowed. All this is clearly indicated in table 4.4 while figure 4.4 offers a pictorial presentation in the form of a pie chart. The percentages have been indicated by the side of each pie for ease of comprehension.

Figure 4.4 Marital Status of Household Respondents



Compiled by the Author

4.2.5 Respondents Highest Level of Education

Table 4.5 Respondents Highest Level of Education

Level	Frequency	Percentage (%)
Nursery	19	11.3
Primary	83	49.4
Secondary	51	30.4
College	15	8.9
Total	**168**	**100.0**

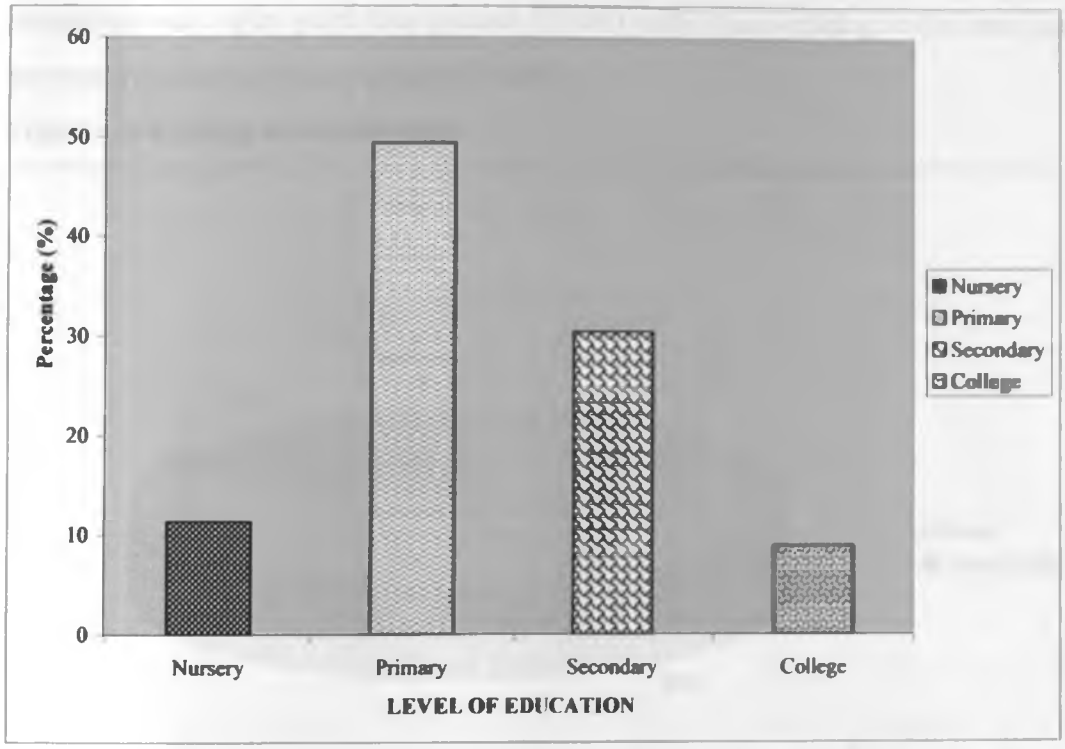
Compiled by the Author

It is evident from the table above that most of the respondents in this research did not have a post primary education. The highest percentage of the respondents, 49.4%, had their highest level of education at primary with eleven point three percent (11.3%) having had only nursery school education. Cumulatively this came to sixty point seven percent (60.7%) the percentage of respondents who had no education beyond the primary level. In short these respondents had only the basic education. The number of respondents who had acquired secondary education stood at thirty point four percent (30.4%), while those who had attained tertiary or college education being eight point nine percent 8.9%.

Education in general is meant to promote human dignity in the distribution of wealth. An increase in access and quality of education relative to national population is critical to socio-economic growth and productivity, increased individual earnings and subsequently reduced income inequalities and reduction of poverty. It contributes significantly to improved health, enhanced democracy, good governance and effective leadership (Ministry of Education and Technology, 2007).

The Universal Declaration of Human Rights in 1948 made education a human right through which poverty, ignorance and disease could be eliminated and sustainable development attained. The reports of the Conference of African States in Africa (1961) and the Economic Commission for Africa (ECA), committed African countries to achieve EFA by 1980 (UNESCO, 1968). This therefore means that since a majority of the respondents, which is a representation of the area of study, having attained a minimal of primary education they were in a position to attain sustainable development.

Figure 4.5 Respondents Highest Level of Education



Compiled by the Author

It is therefore in order to conclude that despite majority of the respondents failing to attain secondary and post-secondary education, they were in position to understand and answer question dealing with issues affecting their daily lives: water scarcity being one of them.

4.2.6 Settings of Households

The table below indicates the household settings in Maai Mahiu. This has been classified into rural and town centres which for purposes of this research have been considered as the urban centres of Maai Mahiu Division.

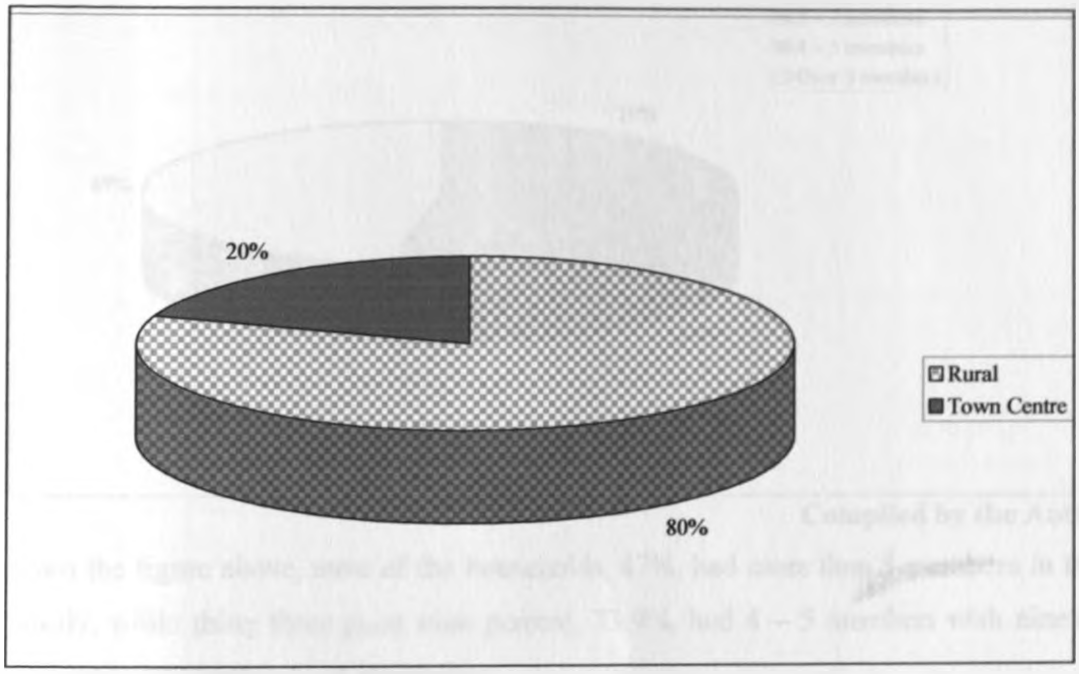
Settings of Households

Setting	Frequency	Percentage (%)
Rural	135	80.4
Town Centre	33	19.6
Total	**168**	**100.0**

Compiled by the Author

From table 4.6 most of the respondents interviewed resided in the rural setting. The percentage was eighty point four percent (80.4%) while those residing in the town centre were only nineteen point six percent (19.6%).

Figure 4.6 Settings of Households



Compiled by the Author

4.2.7 Size of the Households

Table 4.7: Size of the Households

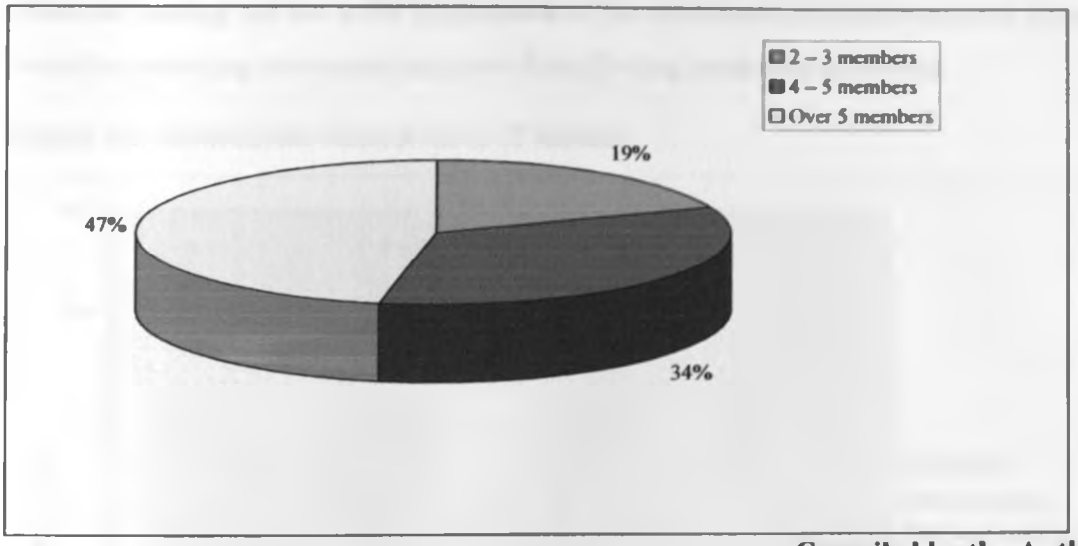
No.	Frequency	Percentage (%)
2 – 3 members	32	19.0
4 – 5 members	57	33.9
Over 5 members	79	47.0
Total	**168**	**100.0**

Compiled by the Author

In the Second World Water Forum and Ministerial Conference for World Water Day held in March, 2000 at the Hague had Vision 21 as one of its main agenda. Vision 21 lays an approach to people-centered development and takes households as the prime catalyst for change and the first level in planning and management of environmental services. It considers a change in household or neighbourhood as capable of leading to ripples of

cooperation and action involving an entire society. This would lead to achieving the World Water Vision (WWV) (World Water Vision Report, 2000).

Figure 4.7: Size of the Households



Compiled by the Author

From the figure above, most of the households, 47%, had more than 5 members in their family, while thirty three point nine percent, 33.9%, had 4 – 5 members with nineteen percent (19%) having 2 – 3 members.

4.2.8 Households Main Source of Income

Table 4.8 Households Main Source of Income

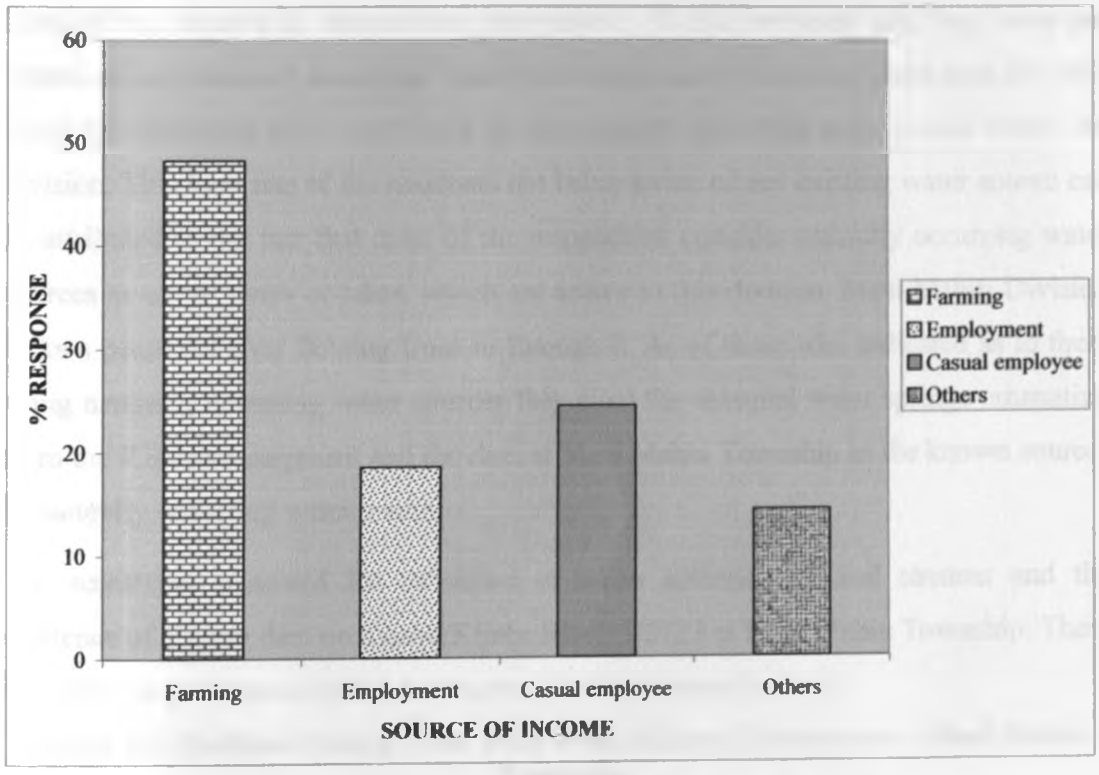
Source of Income	Frequency	Percentage (%)
Farming	81	48.2
Employment	31	18.5
Casual employee	41	24.4
Others	15	14.3
Total	**168**	**100**

Compiled by the Author

From the table above, farming was the main source of income for the households at forty eight point two percent (48.2%), this was followed by casual employment with twenty four point four percent (24.4%) of the household respondents having it as their main source of income. Those in employment were eighteen point five percent (18.5%) and the others category having fourteen point three percent (14.3%) response. In the other

categories there were respondents who were businessmen, a few spoke of being brokers while others depended on charcoal burning as a source of income. Most of these economic activities had a negative impact on the water situation in the study area. Charcoal burning has led to the degradation of the catchments as indigenous tree are cut down thus reducing the vegetation cover thus affecting the fragile ecosystem.

Figure 4.8: Households Main Source of Income



Compiled by the Author

From the table above it is evident that most of the respondents (households) were residing in the area. This is deducible from the fact that most of the households depended on farming for their livelihood. This combined with the number of those who depended on casual or manual within the division gives a high percentage of seventy two point six (72.6%) of the respondents as those who depended on a livelihood within the division.

4.2.9 Presence of Naturally Occurring Water Sources

Table 4.9 Presence of Naturally Occurring Water Sources

Response	Frequency	Percentage (%)
Yes	72	42.9
No	96	57.1
Total	168	100.0

Compiled by the Author

Most of the household respondents interviewed, 57.1%, indicated that they were not aware of any naturally occurring water source with only forty two point nine (42.9%) being the only ones who were aware of any naturally occurring water source within the division. This high rate of the residents not being aware of any existing water source can be attributed to the fact that most of the respondents consider naturally occurring water sources as either rivers or lakes, which are scarce in this division. Maai Mahiu Division lacks a perennial river flowing from or through it. As of those who indicated as to there being naturally occurring water sources they cited the seasonal water springs emanating from the Kikuyu escarpment and the dam at Maai Mahiu Township as the known sources of naturally occurring water points.

The researcher observed the existence of water springs, seasonal streams and the existence of a water dam on Kijabe/Kijabe Block 1/3723 at Maai Mahiu Township. There was also the presence of drilled boreholes. (See the figures below).

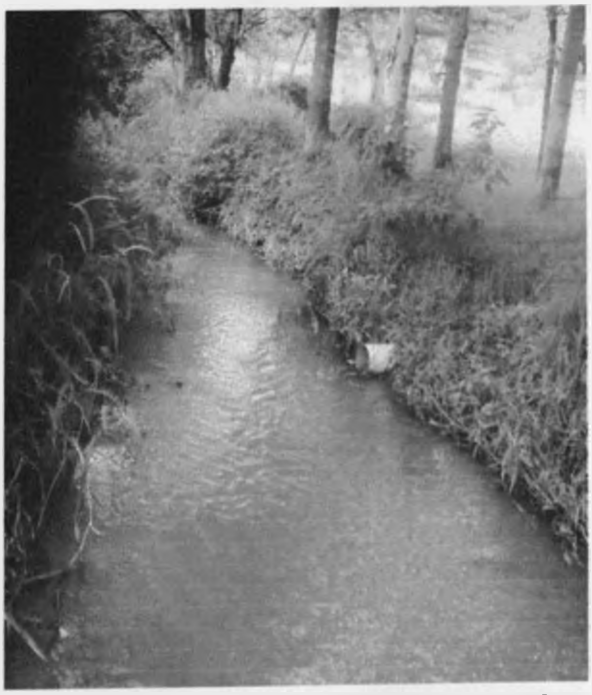
Figure 4.8: Gathima Spring at the Foot of the Kikuyu Escarpment – Maai Mahiu Township

Compiled by the Author

Figure 4.9: A Drilled Borehole at the Jikaze IDP Camp

Compiled by the Author

Figure 4.10: A Seasonal Stream in the Division



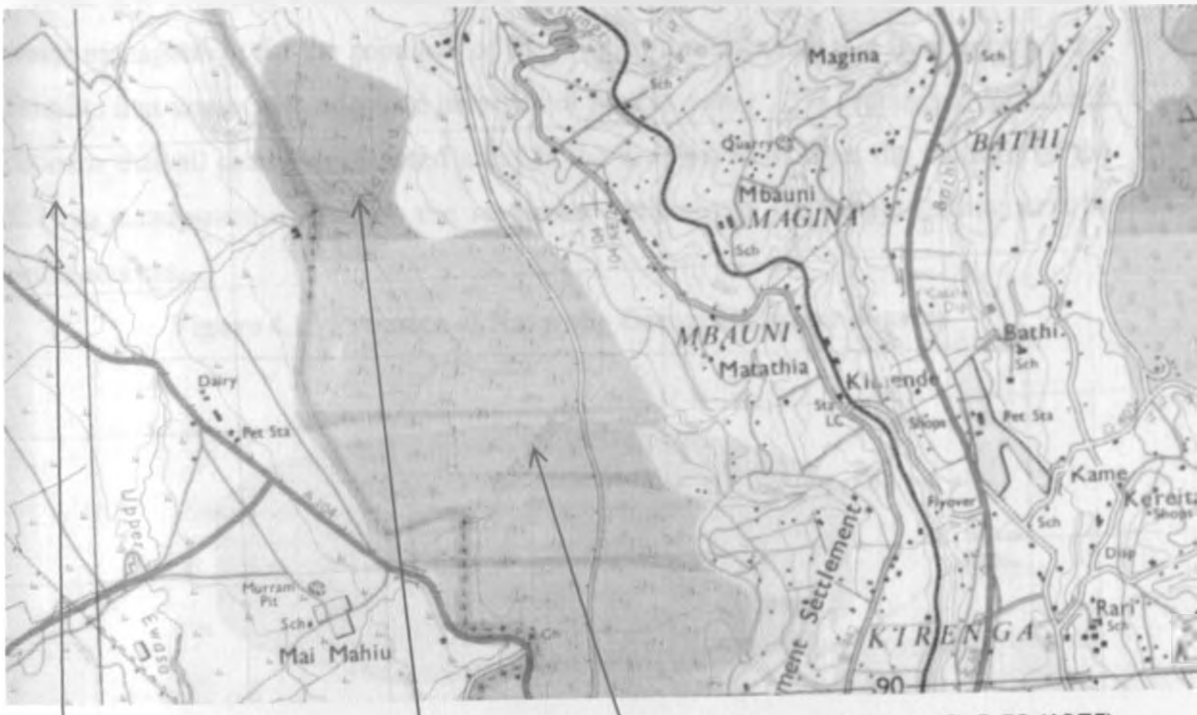
Compiled by the Author

Figure 4.10 indicates a section of a seasonal stream which the researcher was able to know existed in the 1970's as a perennial river (Matathia River) that was a tributary of Ewaso Kedong River, which has also become a seasonal river.

From various interview with key informants, the researcher was able to learn that in the early 1980's there were several perennial rivers flowing through the region. In one of the conversations with an elderly Maasai herdsman, the researcher learnt of the existence of a tributary of the upper Ewaso Kedong River which was called "*Tongi Tongi*" (The Maa pronunciation of Maai Mahiu or Hot water). Within this period there also existed two other perennial tributaries of the Upper Ewaso Kedong namely; Nasaia and Matathia with their source being the Kikuyu escarpment.

The researcher sought to confirm this by going through various document records. In one of the documents, the G.O.K, 1975, Topographic sheet number 134/3 (Kijabe) the government had mapped the above tributaries. Upon visiting the river channels, as shown in the topographic sheet, the researcher found that the rivers had dried up and in their place were dried river beds on the upstream and gulleys downstream as shown in the photographs below.

Figure 4.11: A section of the G.O.K Topographic Sheet of 1975 Indicating the Three Rivers



Source: G.O.K (1975)

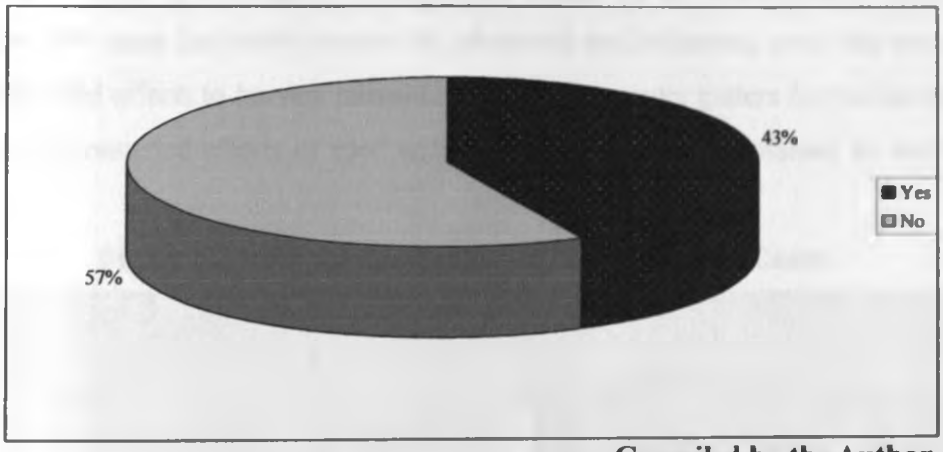
Tongi Tongi River Nasaia River Matathia River

Figure 4.12 Part of the Dry Water Bed of Tongi Tongi

Compiled by the Author

With Maai Mahiu having few naturally occurring water sources it is therefore important that the few available water sources and waterways be conserved to enhance sustainable water management for the populace of the division thus ensuring that they enjoy all the benefits that come with adequate presence of potable water. The researcher noted with concern that all densely populated areas in the division were all at the foothills of the Kikuyu escarpment a situation the researcher attributes to the people settling next to water sources.

Figure 4.13 Presence of Naturally Occurring Water Sources



Compiled by the Author

Old Kijabe that borders the Kijabe Hospital is the oldest Centre. In this Centre it was purported that the Indian community inhabited the area during the colonial days. The Centre has piped water that experiences irregular supply. The inhabitants receive water for approximately two days a week.

Suswa lies in a relatively flat terrain with shrubs that characterizes arid and semi -arid areas. The area's main economic activity is pastoralism and stone quarrying. Farming has greatly reduced due to low rainfall and perennial shortage of water. The area is supplied with water using plastic pipes that are occasionally destroyed by herders in search of water for their animals. This consequently creates water conflict between the neighbouring communities. Lower Longonot has two main IDPs Camps. One of the camps, going by the name *Jikaze*, has a borehole whose water is not fit for human consumption since its water is hot and salty (with a fluoride level of 8.8mg/litre) (Kenya Bureau of Standard Report on the Jikaze Borehole). The area thus depends on piped

water whose source is the underground water from the Kikuyu Escarpment. The water is supplied twice a week.

With the rapid rise of population the IDP camp is facing an acute water scarcity with 47% of the households in the study area having more than five members, each households requires a minimum of 250 litres per day. Considering that the supply from the Kikuyu Escarpment is rationed and supplied twice a week, this therefore means that their social economic activities are disrupted as 41.7% of the households have to go in search of water at a distance of more than two kilometers (Table 4.10). The researcher noted that the entire IDP camp had close to over 80 galvanised roofed houses, only five structures had made solid efforts to harvest rainwater by installing water gutters for the harvesting. The lack of concerted efforts of roof water catchment is easily explained by the figure 4.14.

Figure 4.14: Human Settlement at the Jikaze IDP Camp

Compiled by the Author

4.2.10 Distance to Distribution Point

Table 4.10 below indicates the distance of the water point from the households interviewed. The distance in this case shall be considered as the number of kilometers that the respondents had to cover to get to the nearest water point in their locality.

Table 4.10 Distance to Distribution Point

Distance	Frequency	Percentage (%)
In front of the premise	28	16.7
Less than 100 m	12	7.1
100-1 km	41	24.4
1km-2km	16	9.5
More than 2 km	70	41.7
Total	**168**	**100**

Compiled by the Author

Most of the respondent interviewed indicated that the distance to the nearest water point to their homestead as being more than 2km. as indicated in the table above they were forty one point seven percent (41.7%). The researcher was able to determine this by observing and taking pictures of the mode of transport. The use of motorized and non-motorized transport in the area was rampant. This could be attested by checking at the mode of transport as shown in the figure below.

Figure 4.15 Several Modes of Transport in the Area

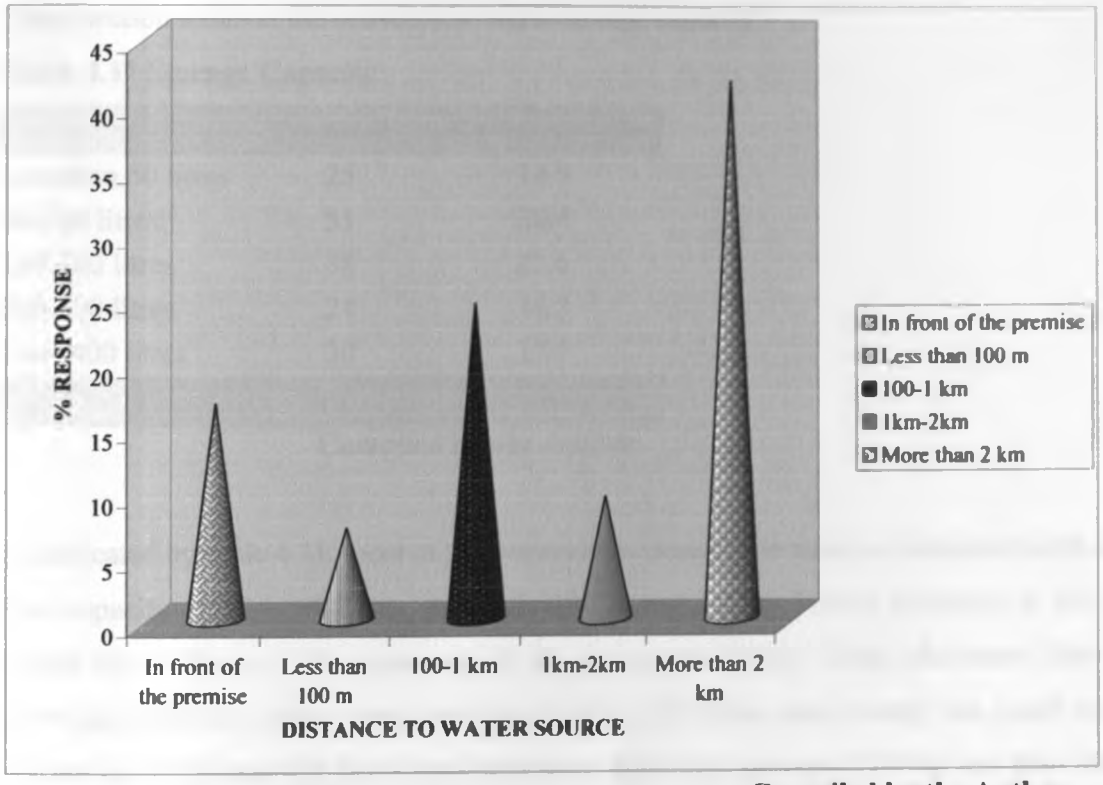
a): Donkeys as a mode of non motorized transport for water

b): Water Vendors fetching water

Compiled by the Author

100 – 1 kilometres had the next highest response at twenty four point four (24.4%) followed by those who had water at their homestead or just in front of their homesteads at sixteen point seven percent (16.7%), then nine point five percent (9.5%) for those who had to cover distances between 1km – 2km. Less than 100m had the least response at seven point one (7.1%)

Figure 4.16 Distance to Distribution Point



Compiled by the Author

In Maai Mahiu, the area most affected by water scarcity is the Lower side of the division towards Suswa. Efforts to have water supplied to this area from the Kikuyu Escarpment have been met with a prohibitive cost as charges to have pipelines cross below the railway line. The researcher noted that in the recent past a group of locals who tried to have pipes cross from the Kikuyu Escarpment to the lower side of the Escarpment were charged 200,000 Kenya shillings for the government to allow them proceed with having the pipes cross below the railway line. They never ventured into it as they considered the cost prohibitive. This was aggravated by the constant destruction of water infrastructure by flash floods that cut out supply to these areas.

4.2.11 Capacity of Water Storage Containers

These section looks at the households' water storage capacity.

Table 4.11 Storage Capacity

Capacity	Frequency	Percentage (%)
Less than 50 litres	25	14.9
50-100 litres	51	30.4
100-200 litres	38	22.6
200-400 litres	24	14.3
Over 400 litres	30	17.9
Total	**168**	**100**

Compiled by the Author

As indicated by table 4.11, most of the respondents stored their water in containers with a total capacity of 50 – 100 litres. An equivalent of two twenty Jelican containers to five twenty litres jelicans. The percentage in this group was 30.4%. Those who stored their water in containers with a total capacity of 100 – 200 litres were twenty two point six percent (22.6%), over 400 litres were seventeen point nine percent (17.9%), less than 50 litres were 14.9% while those with 200 – 400 litres of storage capacity were 14.3%.

4.2.12 Means of Fetching Water

Table 4.12 Means of Fetching

Means	Frequency	Percentage (%)
People	68	40.5
Donkeys	49	29.2
Carts	6	3.6
Bicycles	13	7.7
Water is delivered	32	19.0
Total	**168**	**100.0**

Compiled by the Author

The most common mode of fetching water in Maai Mahiu Division was by human back. This is mainly done by the women and children. From the table above, human means of fetching had 40.5% of the respondents considering it as their means of fetching water. The population that fetched water by use of donkeys was 29.2%, while those who

depended on water vendors were 19%. Carts and bicycles had 3.6% and 7.7% respectively.

Figure 4.17: Donkey as Means of Transporting Water for Domestic Use

Figure 4.18: Water Abstraction for Agricultural use by use of Water Pumps

Compiled by the Author

The researcher observed that during the dry season most farmers near the water dam abstracted water by use of diesel water pumps for agricultural purposes. The farmers practised furrow farming and depended on abstraction from the water dam for their agricultrual uses. Despite the farmers not being licenced to abstracte water the researcher found out there was no authority that was curtailing this kind of activity in the region.

4.2.13 Rating Quality of Water

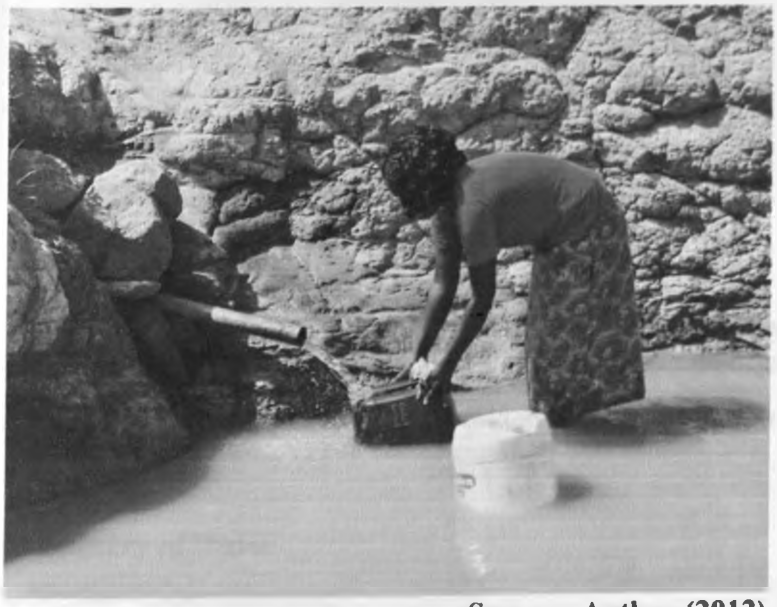
Table 4.13 Rating of Water Quality

Rating	Frequency	Percentage (%)
Very good	42	25
Good	78	46.4
Poor	42	25.0
Very poor	6	3.6
Total	**168**	**100**

Compiled by the Author

When the respondents were asked to rate the quality of water most of them, 46.4%, stated that the quality of water was good with twenty five cent (25%) indicating it as very good while a similar percentage indicated it is being poor. Only a partly three point six percent, 3.6%, rated the water as being very poor.

Figure 4.19: One of the Springs that act as a Source of Piped Water

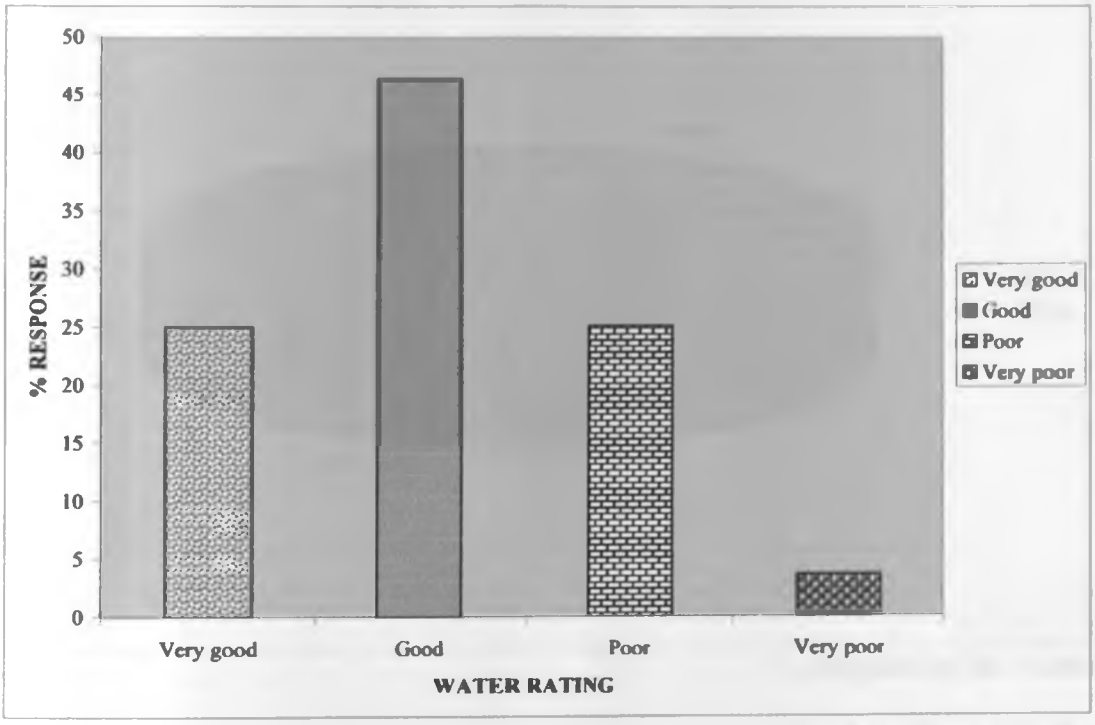


Source: Author (2012)

The researcher noted that most of the springs that acted as the source of piped water for the division were not protected and in most cases water users end up contaminating the water through poor water handling methods. Figure 4.19 show some of the ways in which water at the springs was being contaminated and thus affecting its quality especially for the users downstream. The researcher sought to find out about this discrepancy where though the researcher had noted from personal observations that the quality of water was

wanting, most of the respondents (71.4%) had rated it as being good. The findings indicated that the respondents were more concerned about the water supplied from the Kikuyu Escarpment which was their main source of drinking water (potable water) and judged the quality of water in terms of how clear the water was.

Figure 4.20: Rating of Water Quality



Compiled by the Author

The entire Maai Mahiu Division has seven drilled boreholes whose water quality is saline and hot. Of those seven drilled boreholes one was drilled for over 300 meters and yielded no positive results.

4.2.14 Rating Adequacy of Water

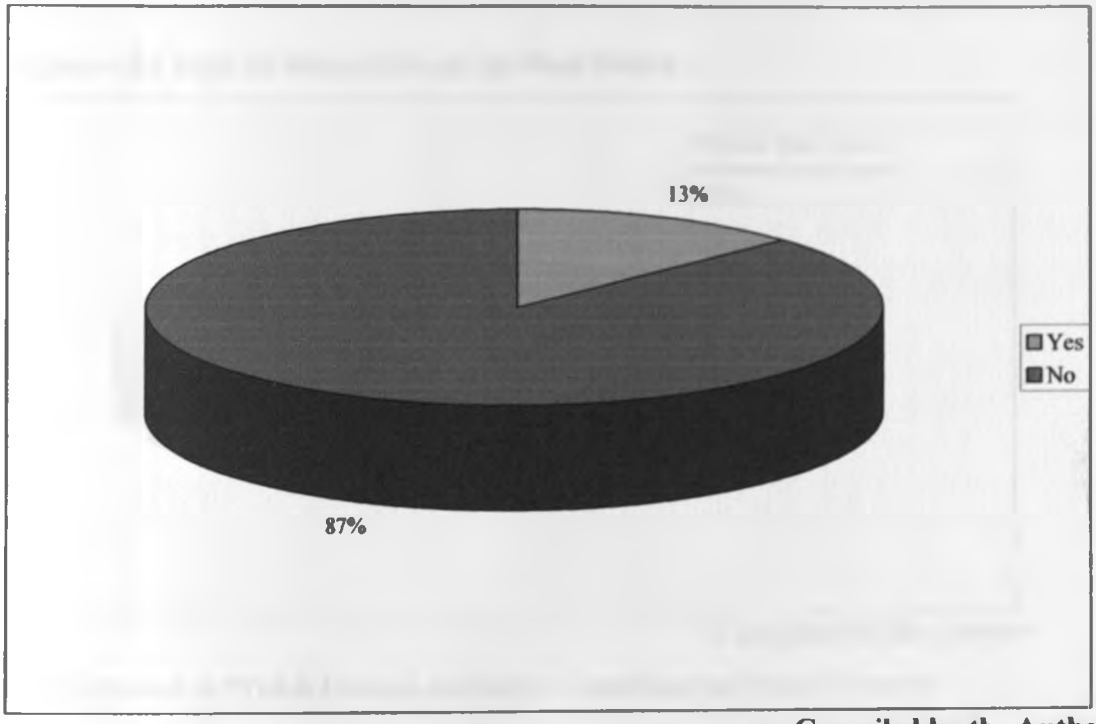
Table 4.14 Rating the Water Adequacy

Response	Frequency	Percentage (%)
Yes	22	13.1
No	146	86.9
Total	**168**	**100**

Compiled by the Author

From the table above, the highest number of respondents rated the water availability as not being adequate. Eighty six point nine percent of the respondents were of the view that the water was not adequate in the location.

Figure 4.21 Rating the Water Adequacy



Compiled by the Author

The researcher found that the main source of surface water was available during the rainy season and at the Dam within the Maai Mahiu Township. Ground water was the main source of water for the residents of Maai Mahiu opting for dug up wells.

4.2.15 Type of Water Scarcity

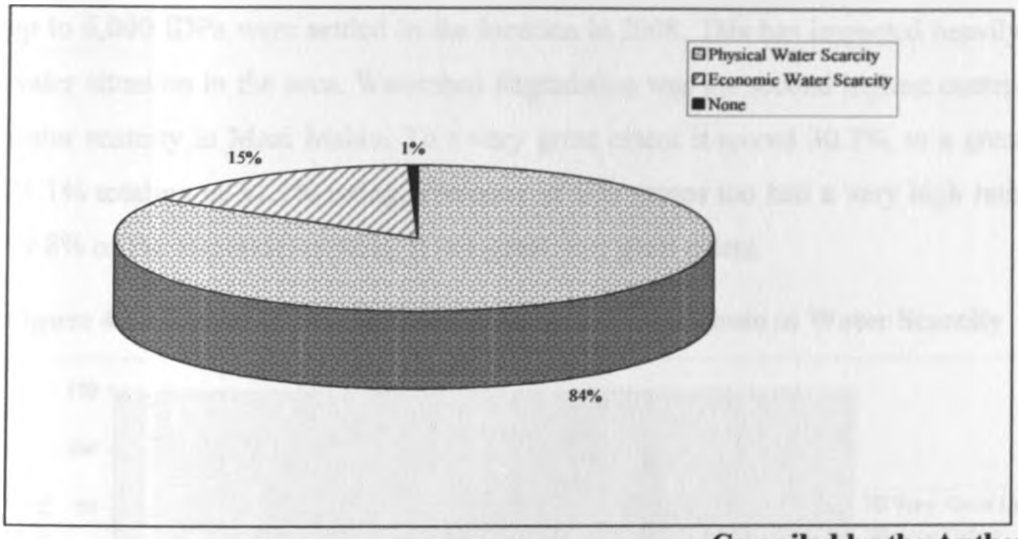
Table 4.15 Type of Water Scarcity in Maai Mahiu

Scarcity	Frequency	Percentage (%)
Physical Water Scarcity	141	83.9
Economic Water Scarcity	26	15.5
None	1	0.6
Total	**168**	**100**

Compiled by the Author

Most of the respondents, 83.9% were of the view that physical water scarcity – where the demand outruns the supply was the most rampant in Maai Mahiu. As for economic water scarcity there were 15.5% respondents who touted it as the type of water scarcity which was prevalent in the division.

Figure 4.22 Type of Water Scarcity in Maai Mahiu



Compiled by the Author

4.2.16 Extent to Which Human Activities Contribute to Water Scarcity

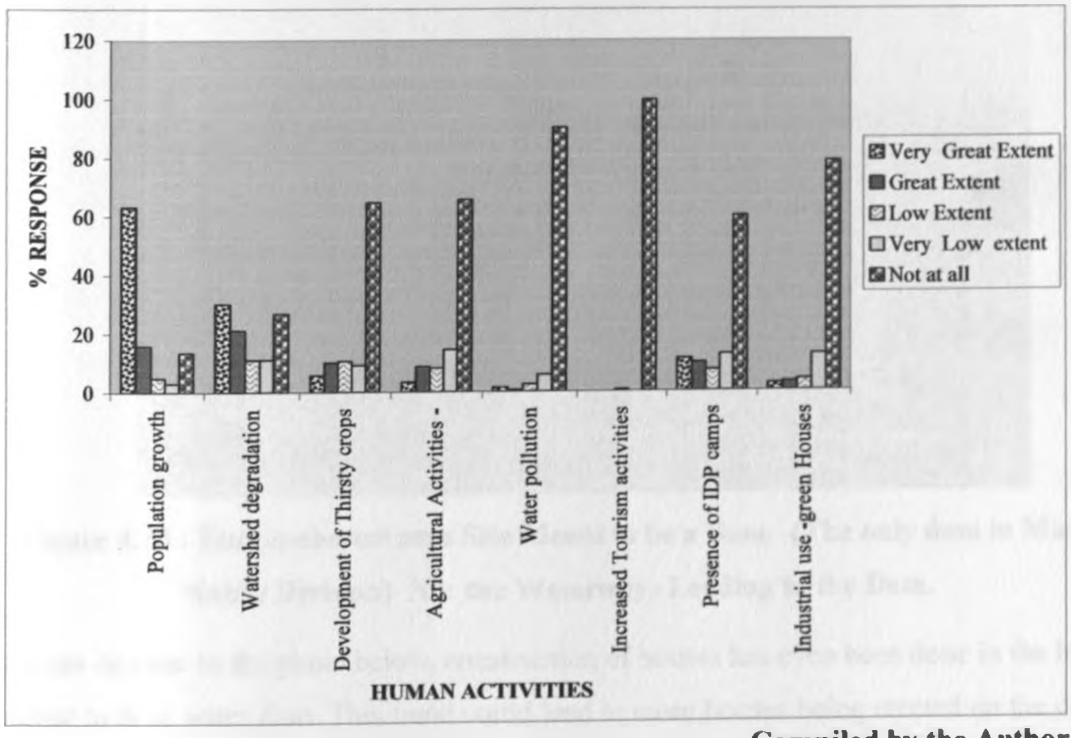
Table 4.16 Extent to which human activities contribute to Water Scarcity

Factor		Very Great Extent	Great Extent	Low Extent	Very Low extent	Not at all	Total
Population growth	Frequency	132	33	10	6	28	209
	%	63.2	15.8	4.8	2.9	13.4	100
Watershed degradation	Frequency	63	44	23	23	56	209
	%	30.1	21.1	11.0	11.0	26.8	100
Development of Thirsty crops	Frequency	12	21	22	19	135	209
	%	5.7	10.0	10.5	9.1	64.6	100
Agricultural Activities -	Frequency	7	18	17	30	137	209
	%	3.3	8.6	8.1	14.4	65.6	100
Water pollution	Frequency	3	1	5	12	188	209
	%	1.4	0.5	2.4	5.7	90.0	100
Increased Tourism activities	Frequency	0	0	1	0	208	209
	%	0.0	0.0	0.5	0.0	99.5	100
Presence of IDP camps	Frequency	125	20	15	26	23	209
	%	59.8	9.6	7.2	12.4	11.0	100
Industrial use - green Houses	Frequency	5	6	8	26	164	209
	%	2.4	2.9	3.8	12.4	78.5	100

Compiled by the Author

From table 4.16 above, population growth had the highest rating as the factor that contributes to water scarcity to a very great extent. With a very great extent of contributing to water scarcity it was ranked at 63.2% and great extent of 15.8%. Cumulatively this two total up to 76.8% thus population growth was rated as the major factor that contributed to water scarcity in the division. This population growth is easily traceable to the PEV where IDPs were settled in the area. It is approximated that a total of up to 6,000 IDPs were settled in the location in 2008. This has impacted heavily on the water situation in the area. Watershed degradation was the second highest contributor to water scarcity in Maai Mahiu. To a very great extent it scored 30.1%, to a great extent 21.1% totaling to 51.1% rating. Presence of IDP camps too had a very high rating with 59.8% of the respondents rating it to a great very great extent.

Figure 4.23 Extent to Which Human Activities Contribute to Water Scarcity



Compiled by the Author

Increased tourism was one of those factors which least contributed to water scarcity in Maai Mahiu. Water pollution was also considered as not being a contributor to water scarcity in the area. Though water pollution affects water scarcity, the case was different in Maai Mahiu as most people had not come across naturally occurring water sources therefore the respondents would not have felt their water sources being contaminated or

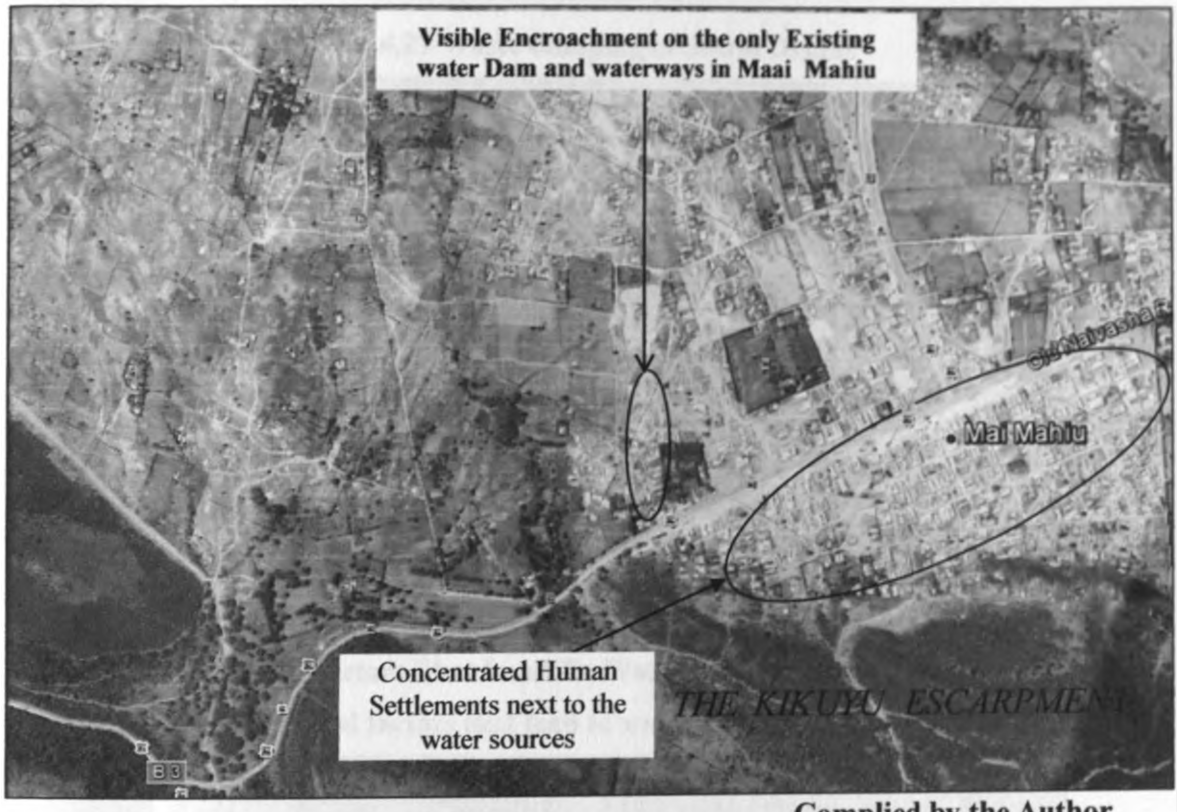
destroyed by pollution. Being an Asal it is expected that the development of water thirsty crops would not be a contributing factor. Most of the civic education on environmental conservation has been on planting of trees an example being the Mau Reforestation efforts. Thus most respondents do not consider planting of thirsty water crops as being a contributor to water scarcity in the region rather as an effort that should be applauded.

Population growth being one of the major factors leading to water scarcity in Maai Mahiu is leading to the increased demand for land for settlement. In the Maai Mahiu township, where the only naturally existing water dam (in Maai Mahiu Division) stands, the Dam and the area surrounding the dam has been encroached.

Figure 4.24 : Encroachment on a Site Meant to be a Dam. (The only dam in Maai Mahiu Division) Nb: the Waterways Leading to the Dam.

As can be seen in the photo below, construction of houses has even been done in the land meant to be a water dam. This trend could lead to more houses being erected on the dam and this could inevitably lead to the extinction of the dam leading to greater water scarcity for the livestock and people who depend on it during the dry season.

Figure 4.25: An aerial View showing the Extent of Encroachment on Water Catchemnet Areas, Water Sources and Waterways



Complied by the Author

Figure 4.26 Waste Damping on a Road Leading to Water Stagnation and Water Pollution

Even though the respondents noted that water pollution does not contributed to water pollution in the area, the researcher was able to capture water pollution and pollution of

water ways or the storm drains a situation that the researcher believes affects people downstream. This is shown in the figures 4.26 and 4.27.

Figure 4.27 Waste damping in Storm Drains

4.2.20 Environmental Factors That Lead To Water Scarcity

Table 4.17 Environmental factors that lead to water scarcity

		Very Great Extent	Great Extent	Low Extent	Very Low extent	Not at all	Total
Low Rainfall	Frequency	177	17	5	4	6	209
	%	84.7	8.1	2.4	1.9	2.9	100
Low ground water supplies	Frequency	95	26	26	28	34	209
	%	45.5	12.4	12.4	13.4	16.3	100
Few Lakes and Rivers	Frequency	106	32	15	6	50	209
	%	50.7	15.3	7.2	2.9	23.9	100
General Aridity	Frequency	117	32	12	17	31	209
	%	56.0	15.3	5.7	8.1	14.8	100
Location of the Area	Frequency	79	10	9	14	97	209
	%	37.8	4.8	4.3	6.7	46.4	100

Compiled by the Author

Low rainfall was the most rated factor as being the environmental factor contributing to water scarcity in Maai Mahiu Division. As shown in the table above, it had an overall rating of 92.8% i.e. 84.7% to a very great extent and 8.1% to a great extent. General aridity of the area followed with an overall effect of 71.3% (56.0% to a very great extent and 15.3% to a great extent). The presence of few lakes and rivers was also considered as an environmental factor that has led to the existence of water scarcity in the area. It had a

cumulative ranking of 66% and low ground water supplies had 57.9% cumulative rating as a contributor to water scarcity. The general location was the leas ranked as being a contributor to water scarcity with only 37.8% of the respondents rating it to a great extent and 4.8% rating it to a great extent.

4.2.21 Climate Change Contribution to Water Scarcity

Table 4.18 Climate Change Contribution to water Scarcity

Factor		Strongly agree	Agree	Uncertain	Disagree	Strongly Disagree	Tota
Water shortages due to changes in precipitation patterns	Frequency	27	3	6	1	4	41
	%	65.9	7.3	14.6	2.4	9.8	100
Decreased natural water storage capacity from glacier	Frequency	7	10	6	1	17	41
	%	17.1	24.4	14.6	2.4	41.5	100
Increase vulnerability of ecosystems	Frequency	4	9	17	5	6	41
	%	9.8	22.0	41.5	12.2	14.6	100
Increase water temperatures	Frequency	9	5	15	2	10	41
	%	22.0	12.2	36.6	4.9	24.4	100

Compiled by the Author

From the findings the water shortage due to precipitation had the highest ranking as one of the effects of climate change with a rating of 65.9% strongly agreeing while decreased natural water storage capacity from glacier had the least ranking with a majority of the respondents (41.5%) strongly disagreeing. Increase in vulnerability of ecosytems had the highest ranking with the most number of uncertain respondents at 41.5% followed by increase in water temperatures as an effect of climate change.

According to the Nema Report of 2002, 'Kenya's Climate Change Technology Needs and Needs Assessment' stated that, indicators of climate change include weather variability, floods, droughts, increased greenhouse gas emissions, temperature changes, etc. It went further to state that extreme climate events are associated with disasters and increase in incidences of diseases. Incidences of vector and waterborne diseases increase during periods of heavy rains and flooding, while droughts and high temperatures cause famine and malnutrition thereby weakening resistance to diseases.

In the case of Maai Mahiu, the researcher observed that all the perennial rivers that existed in the area in the past few decades had dried and in their place were gulleys and dry river beds. With the climate variations, this brought some serious losses to the tourism sector and other areas when a section of the Maai Mahiu – Narok Road got washed away by the recent floods in the district. As reported by Kirui in The Star Daily, , Chairman of Narok Central Business Association said that traders had lost over Sh150 million since the road was closed. Businesspeople had incurred losses amounting to over Sh100 million while livestock traders who ferried their stock to Nairobi had run into losses of over Sh50 million because they had been forced to take longer routes.

The researcher made an effort to visit the scene where the Maai Mahiu – Narok had shown cracks forcing the closure of the road on the 17th of May, 2012 and noted that the area lied on an extinct river. Due to the heavy downpour the water had found its way to the river bed and this led to the washing away of the section of the road. As shown in the image below, figure 4.21, the section of the road lied directly on an extinct waterway.

Figure 4.27: Section of the Maai Mahiu – Narok that was Washed away by Floods

Nb: The Dry River-Bed Marked in Red

The google map image (Figure4.27), clearly shows the dried up river bed and the point it intersects with the road. For the planners and contractors of the road, this intersection should have been designated as a bridge and this goes to show the importance of looking at the past so as to clearly see the future. This is an essential aspect of planners.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY OF FINDINGS

5.2.1 Water Sources

While surface water allocations are generally correlated with inflows so that a reduction in rainfall and inflows results in a reduction in surface water allocations, groundwater allocations are usually not affected to the same extent. As such, when surface water becomes scarce and the price of water rises, irrigation is more likely to substitute toward groundwater usage, where this is possible. While groundwater is usually more expensive to access because it involves extra pumping costs, these costs may be worth bearing as water becomes scarce and its value increases.

In Maai Mahiu Division, most of the water used in the division is tapped ground water from the Kikuyu escarpment which is to the North of the division. Sourcing of water from the escarpment is done by financially able individuals who abstract water and supply it downstream to various vending point in the service centres where only 19.6% of the respondents reside. The presence of dug wells was minimal and the few that occurred were only in existence during and immediately after heavy rainfall. There is no public water supply and distribution system in Maai Mahiu. This makes the water supply and distribution a venture of those economically endowed individuals who monopolise the commercialization of the social good thus creating an economic water scarcity in the division.

The researcher noted that despite the area lying in the ASALs the Maai Mahiu community did not lay any deep emphasis on supplementing their water sources. This noted and captured in photos where the greatest percentage of homesteads had not invested in meaningful water harvesting mechanisms. In the entire period of the research, the researcher was only able to come across five homes that had a working water harvesting system. Two of them were in Maai Mahiu Township, two in Longonot township and one in Kijabe. Below is a picture of the house at Longonot that had invested in rain water harvesting.

Figure 5.1: Homestead with a Water catchment System - Longonot Township

From focus group discussion the researcher was able to note that prohibitive measures from the government were affecting water supply to the Suswa part of Maai Mahiu Division. One of the respondents who happened to have spent his entire life in this area lamented that their efforts to supply water to this area had been hampered by punitive cost of getting or obtaining way-leave permits across the the railway line. To have pipes pass below the railway lines the residents were required raise up to 200,000 shillings. A sum that majority of the residents could not afford.

5.2.2 Human Activities

A change in the rate of the amount of storm water runoff reaching streams and rivers is one of the most serious problems associated with increased land development. Both urbanization and agricultural development affect an increase in overland flow, resulting in greater magnitude and frequencies of peak flows on our water bodies (Marsh, 1991)'. In the urban centres in Maai Mahiu this increase has been due to the impervious surfaces. This impact has been serious both financially and environmentally; properties being damaged by increase in flooding, water quality has been reduced, channel erosion has

been accelerated and habitat degradation has occurred. Lives have been also been lost as a result. A case in mind was the recent deaths of students at the Hells Gate Gouge as result of storm water run-off from the Longonot Mountain to the gouge.

From the findings, it is clear that poor farming methods have also contributed to water scarcity. Some of the respondents indicated that though they had tried to plant trees on their farms in various occasions, these trees were destroyed by the pastoralists' livestock during the dry season as they searched for pasture. This is because most farms in the Division were not fenced and thus livestock control was hampered.

Conflict between the pastoralist community and the farmers had also hindered meaningful development in various parts of the Division. This has resulted in most of parts of the area not to be under any meaningful form of agriculture especially farming and this, in a big way, is hampering on any possible afforestation.

The pictures below indicate two scenarios on the situation in Maai Mahiu during the long rains. In the first picture, an entire internal road has been turned into a waterway due to the lack of a proper road and drainage system which can be attributed to poor planning. The second shows a section of the Longonot Township, along the Nairobi-Maai Mahiu-Naivasha Road during the same period. This is a clear indication of plenty of water going down the drain. Can it be enhanced sustainably?

Figure 5.2: Flooded road at the Longonot Town centre

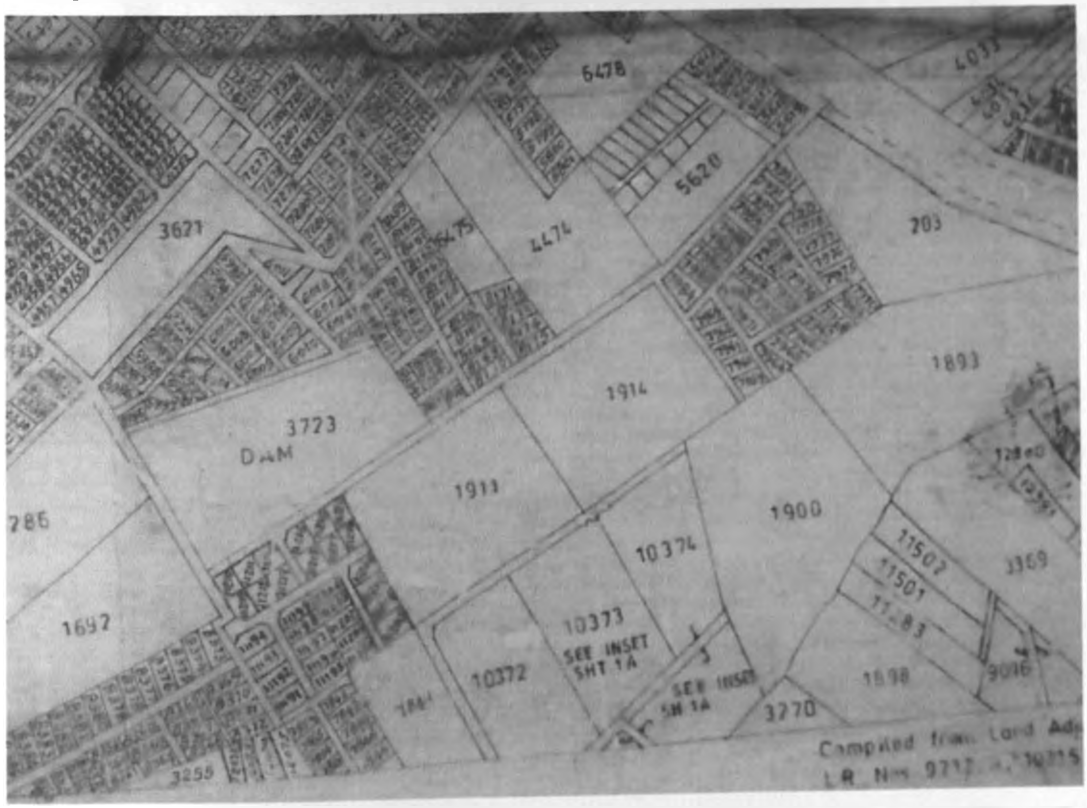
Figure 5.3: A section of the Maai Mahiu-Naivasha Highway

Whilst climate change and increased intensity of rainfall may be blamed for the recent rampant flooding, the fundamental problem is that water courses are being blocked as a result of human activities such as building houses across water ways, the lack of adequate and the right drainage infrastructure and the siltation of the only dam in the division.

Figure 5.4 below is a Registry Index map, Kijabe/Kijabe Block Sheet 4, showing the uncoordinated subdivisions in one of the settlements in Kijabe Location in which Maai Mahiu Township falls. As clearly indicated the parcel number 3723 is a designated Dam. Nevertheless, as the findings indicated and as discussed earlier this land has been encroached.

The dam does not have an intake or a spill way since the land suitable for these facilities have been encroached and the land subdivided and the parcels developed. The researcher observed that an abattoir lies about 400 metres upstream and discharged its liquid wastes into the dam.

Figure 5.4: A section of Registry Index Map for Kijabe/Kijabe Block I (Sheet 4)



Source: Provincial Survey Office (2012)

From the findings the researcher notes that, though currently in Maai Mahiu farming is not considered as a key factor in contributing to water scarcity, if the current water abstraction rate is not checked and regulated in the near future it will be a major contributing factor. The figure 5.5 shows part of land in Maai Mahiu under pastoralist activities. The next figure 5.6 shows some upcoming farming activities that are leading to high abstraction of water.

Figure 5.5: Pastoralism Activity

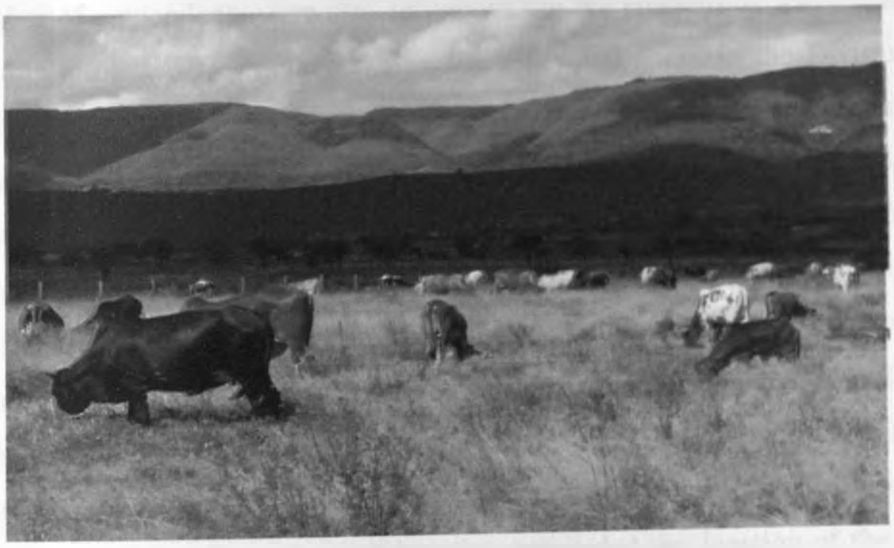


Figure 5.6 Water abstraction for Furrow Irrigation

5.1.3 Environmental Factors

From the findings of the research, low rainfall was rated highest as one of the environmental factors that affected water scarcity to a very great extent. The respondent's view of Maai Mahiu was that of an area that experiences a low annual rainfall. The fact that Maai Mahiu lies on an Arid and Semi-Arid Land was also noted as a contributing factor to water scarcity. This was noted by the presence of many respondents who rated general aridity as affecting water scarcity to a very great extent and to a great extent. A good number of respondents were also convinced that the problem of water scarcity in the area was attributed to the presence of few lakes and rivers in the Division. The Division has no existing lake or large water mass. A low ground water supply was also a factor that was rated by a majority of the respondents as having a contribution to water scarcity in Maai Mahiu. During the dry seasons most of the water was lost from the soils through rapid evaporation as the temperature within this period would rise to very high degrees. These high temperatures lead to rapid depletion of water from the unconfined shallow aquifers during the dry seasons. Location of the area received the least rating as a contributing factor to water scarcity. Most of the respondents in this section felt that location of the area had no effect to water scarcity. Low rainfall, aridity, presence of few lake and rivers and low ground water supplies superseded the location of the area as contributing factor to water scarcity.

5.2 CONCLUSION

From the findings it is clear that human activity, environmental factors and climate change have a considerable effect on water scarcity. As population pressures in the region increase, the demand for water resources rises. Increase in population growth creates a strain on existing water resources; while industrial use goes further to compete for the same. Human degradation of watersheds and catchment areas through forest fires, burning of charcoal, deforestation and farming has a negative impact on water sources. Where low rainfall are experienced and there exists low ground water supplies coupled with few lakes and rivers, the existence of a water crisis becomes real and the general aridity of an area does not make it any better. While the natural factors such as intermittent droughts and limited freshwater reserves are causing water scarcity, high population growth is imposing additional pressures.

Despite all these, the researcher chooses to present a paradigm shift on the case of water scarcity in Maai Mahiu. With the recent long rains catapulting Maai Mahiu into the local and international limelight the researcher is convinced that water scarcity in Maai Mahiu is more of a myth than a reality. An area considered to be an ASAL with a problem of water scarcity has appeared in the local and international news with issues relating to heavy rainfall emanating from the area sweeping away several people away at the Hells Gate National Park several weeks later a part of the main road that links Nairobi to the Narok, a tourist destination is washed away by floods as a result of heavy rainfall. This creates a contrast in itself. "All this water, yet in a few months from now the area will be facing a water crisis. A problem of scarcity and not of abundance". The researcher concludes that the water problem facing Maai Mahiu is one of lack of proper planning and management and not that of water scarcity. With few illustrations the researcher is convinced that water scarcity in Maai Mahiu is a myth and not a reality. It is a myth that the inhabitants of this area are living with and have not made ample efforts to tackle and overcome.

Most governments have traditionally focused on increasing access to fresh water by locating, developing, and managing new sources, despite the high costs often involved (PRB, 2002). However, in Maai Mahiu the case is different. The local authority, which is the government presentation at the local level, is not at the fore front in focusing on increasing access to fresh water. On the ground, there is no government effort is visible in locating, developing and managing existing and new water sources. The encroachment of land meant for a water dam is one clear indication. Lack of a proper physical plan on water supply and distribution is another.

The researcher believes that if proper water management and planning strategies are laid in place the issue of water scarcity would be a thing of the past in Maai Mahiu. In the recommendations the researcher goes further to discuss and highlight areas and issues that if addressed both at the local and national level would lead to addressing the problem of water scarcity in the Maai Mahiu Division which is bordering a water rich District, Kiambu District.

5.3 RECOMMENDATIONS

5.3.1 Water Sources

As indicated from the findings, the major supply of water for the Maai Mahiu Division originates from the Kikuyu Escarpment lying in Kiambu District and such any activities that affect the Escarpment affect the entire Maai Mahiu Division. It is therefore vital that all issues of planning as pertaining to the Kikuyu Escarpment also take Maai Mahiu into consideration and work towards preserving and conserving the Kikuyu Escarpment. As human settlements have a negative effect on water sources, the government and all agencies mandated with conservation of natural resources should prohibit all forms of human settlements within the water catchment areas.

The competition for water among domestic use, agriculture, industry, and nature is leading to scarcity even in areas that seemed water-abundant. Two ways of dealing with scarcity are to increase supply and limit demand. Much of the rainfall and river flows are highly seasonal, economic measures such as pricing and water markets should be given more attention in demand management. Water pricing should be promoted as a means to recover the costs of building and operating water control structures. Though water measuring and billing are often technically difficult and costly, charging users depending on how much they use will work as incentive for the residents to conserve water. Even though water markets will create economic incentives to conserve water, the necessary infrastructure and institutions to transfer water from one user to another must be in put in place. This calls for the proper physical planning of the entre division so as to provide for the infrastructure and institutions to transfer water from one user to another.

Rationing is a prevalent demand-management measure and can be an equitable way of meeting basic needs because it does not depend on ability to pay, but it may be unpopular and difficult to administer. Rotational irrigation deliveries, limited hours of domestic water supply, or limits on water volumes for industry are examples of rationing. Other forms of regulation can help reduce demand.

Education, social marketing, and public awareness campaigns to change behavior deserve much greater attention in water demand management. Awareness of water problems can motivate water conservation, while education can lead to effective changes in water-use

practices. Such campaigns can also make pricing, rationing, or regulatory measures more acceptable to the public and more effective. Finally, measures to reduce water pollution such as regulations on waste management, reductions in agrochemical release into the soil should be regulated.

As far as the water dam in Maai Mahiu Township is concerned, measures should be put in place to recover all the land belonging to it and thereafter rehabilitate it plus all its water-channels. The abutting roads should be maintained in good state in order to facilitate surface runoffs. The abattoir situate on the upstream should be relocated away from the water catchment area in order to avoid direct disposal of waste into the dam.

From the figure 5.7, the area marked in blue represents the abattoir while the one in purple represents subdivisions and human settlement on land that acts as a waterway to the dam. The green line represents the service road to the dam which should be cleared to allow for servicing of the dam while the area marked in orange indicated grabbed land meant for the water dam and which should be reclaimed.

Figure 5.7: Hot Spots

Compiled by the Author

5.3.2 Human Activities

Various developments and the emergence of urban centres within Maai Mahiu Division have led a change in the dynamics of the water cycle in the area. As has been shown in previous discussions, there is a lot of water being allowed to run off the ground while others are left to stagnate on the roadsides. The researcher recommends that proper storm water drainage be developed that will allow for the collection and preservation of water in designated and earmarked sites. Storm water conveyance systems should be designed to prevent flooding, a situation that becomes a reality during a heavy downpour. The design should emphasize on sensitive planning in the development of a storm water runoff system which maximizes the use of natural elements and one that minimizes on cost. The storm water runoff system design should also be correlated with the existing design and layout of the Division with an aim of creating a coordination with existing drainage design thus conserving on costs and avoiding conflicts that may arise with the locals.

Figure 5.8 Stagnated water due to lack of storm Drains on part of the Maai Mahiu – Naivasha Rd.

Figure 5.9: Storm drains on part of the Maai Mahiu – Narok Road

At the same time rain water harvesting and water management systems should be sensitized among the locals. This will help provide access to a sustainable water supply. Some of the water harvesting mechanisms that should be encouraged includes:

a) Roof catchment systems

This effort should begin with all government and public institutions. This will require buildings to have a guttering system, a simple foul-flash component to trap the first flush of dirty water before it enters into a storage tank.

b) Farm ponds

The creation of farm ponds should be encouraged for purposes of conserving water for agricultural purposes.

c) Rock catchments

Rock catchments sites should be demarcated and proper systems put in place to allow for the tapping of water from the hillsides that surround the Maai Mahiu area. These include Mt. Margaret, Kijabe Hill, Nyakinyua Farm as well the Longonot Centre.

d) Sand and sub-surface dams, and shallow wells

Sand and sub-surface dams should be constructed in sandy river beds where the trapped sand will acts as a storage reservoir. Water abstraction from the shallow wells located upstream of the dam wall and the water can then be used for livestock, domestic, and agricultural uses.

It is important that a viable Development Plan is put in place by the local authority that puts priority in preserving and enhancing water provision for the residents of Maai Mahiu for many years to come. This is possible if the current dam at Maai Mahiu is reclaimed and set aside for a large water structure with a filter and separate watering points for livestock and domestic use. It should also be fenced.

Players from various fields e.g. architects, surveyors, land valuers, social workers and representatives from the local communities should be brought on board to come up with a sustainable local physical development plan for the entire Maai Mahiu Division. In this plan, provisions for auxiliary structures such as community water points, a water piping plan and water troughs should be in put in place.

Changes to farm management practices and irrigation technology provide a large range of options in adapting to a more variable or reduced water supply, usually by improving the technical efficiency of water use at the farm level. These can be short-term options ranging from relatively low cost methods such as the adoption of night irrigation to conserve water evaporation losses to more expensive options such as buying in feed to supplement on-farm feed supplies (for dairy and other livestock). More extensive and longer term adaptation options consist of upgrading irrigation technology such as moving

from furrow and overhead sprinkler to drip irrigation (perennial horticulture) or implementing water recovery and reuse systems.

5.3.3 Environmental Factors

Whereas the annual rainfall in Maai Mahiu may be considered to be low, it is important that measures are put in place to make use of the water that is available during the rainy seasons. Adoption of better farming methods would in the long run help in changing in the climatic condition of the area. An increase in forest cover would have a positive effect on improving the climate of the region by acting as a windbreaker and thus reducing water evaporation.

From the findings of the research, low rainfall was rated highest as one of the environmental factors that affected water scarcity to a very great extent. The respondent's view of Maai Mahiu was that of an area that experiences a low annual rainfall. The fact that Maai Mahiu lies on an Arid and Semi-Arid Land was also noted as a contributing factor to water scarcity. This was noted by the presence of many respondents who rated general aridity as affecting water scarcity to a very great extent and to a great extent. A good number of respondents were also convinced that the problem of water scarcity in the area was attributed to the presence of few lakes and rivers in the Division. The Division has no existing lake or large water mass. A low ground water supply was also a factor that was rated by a majority of the respondents as having a contribution to water scarcity in Maai Mahiu. During the dry seasons most of the water was lost from the soils through rapid evaporation as the temperature within this period would rise to very high degrees. These high temperatures lead to rapid depletion of water from the unconfined shallow aquifers during the dry seasons. Location of the area received the least rating as a contributing factor to water scarcity. Most of the respondents in this section felt that location of the area had no effect to water scarcity. Low rainfall, aridity, presence of few lake and rivers and low ground water supplies superseded the location of the area as contributing factor to water scarcity.

In general, the options available for lessening the effects of a reduced and more variable supply of irrigation water all work toward increasing the allocative or technical efficiency of water use across the Basin and within the farm unit. Allocative efficiency refers to

whether water is allocated to those activities for which it generates the most value. Changes to the distribution of water across activities or users to those which value it most, for example by trading temporary water, will improve allocative efficiency. Technical efficiency refers to the efficiency with which water is used in the production process of a certain good. Options that decrease the amount of water needed to produce a particular output, such as improvements in technology, increase technical efficiency.

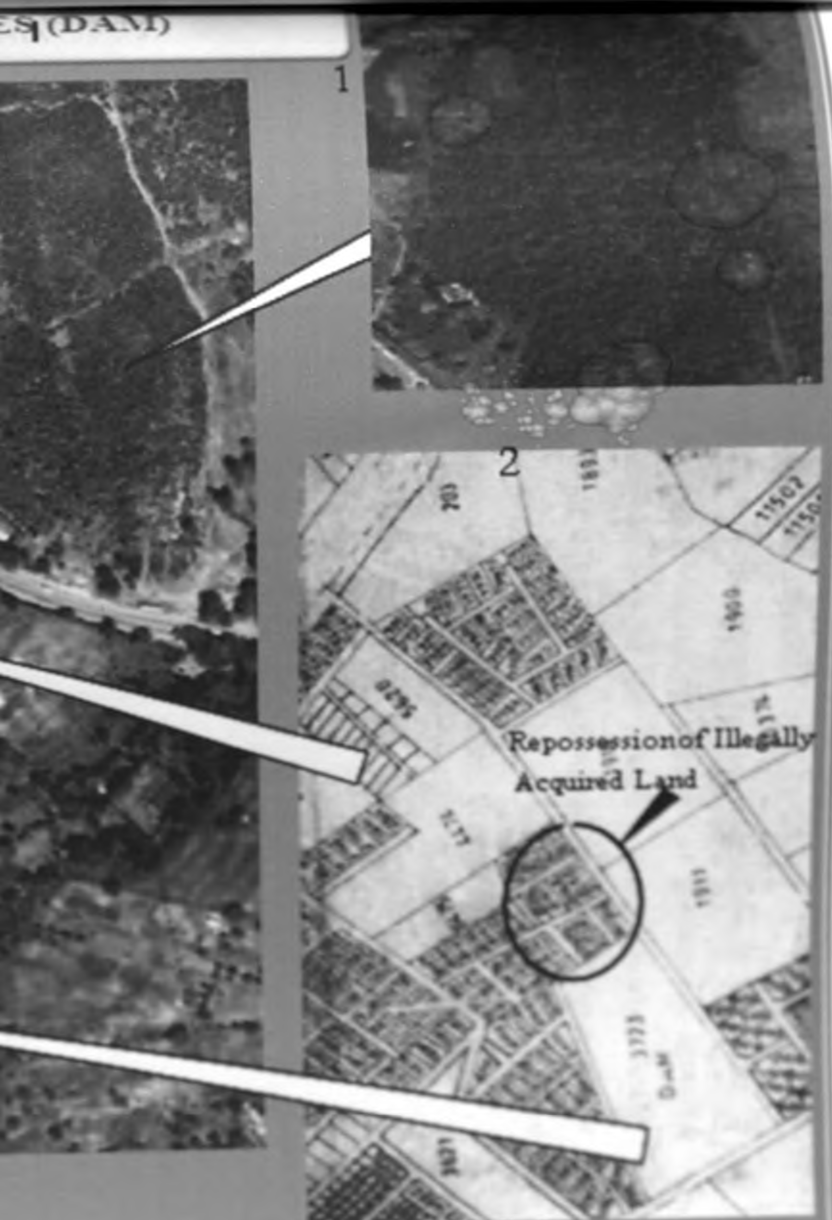
The researcher also recommends that the following be undertaken so as to appropriately manage conserve and distribute water to the residents of Maai Mahiu Division.

1) A riparian reserve along all water courses should be determined and all land in it reclaimed and restored.
2) The wetlands in the study region should be identified, repossessed and be gazetted as westlands.
3) In order to manage point and non-pollution of water sources appropriate solid and waste management technologies should be applied.
4) A feasibility study should be conducted to identify the appropriate location of a dam for the purposes of flood mitigation during the heavy rainy seasons and for water provisions during the drought.
5) A strategic plan for water supply should be formulated and implemented.

However, the researcher tentatively proposes the physical sites for the stated functions.


Restoration and Conservation of the riparian reserve along all the river courses
The entire wetland should be zoned out as a fragile ecosystem preserved and conserved
Proposed site for a dam to serve lower community
Google e

cont'd – INTERVENTION MEASURE


ES|(DAM)
1
2
11507
Repossession of Illegally
Acquired Land

5.4 SUGGESTIONS FOR FURTHER STUDY

The researcher recommends that further researcher be undertaken to determine a legislation mechanism for harmonization and coordination of government agencies involvement in sustainable development of the ASALs The researcher further recommends that a study be undertaken to come up with a mechanism for equitable distribution of scarce resources in ASAL by communities with different social cultural backgrounds e.g. the farming communities and the nomadic communities.

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APPENDICES

APPENDIX I

LETTER OF AUTHORIZATION

University of Nairobi
Department of Urban and Regional Planning
School of The Built Environment
P.O. Box 30197, 00100 GPO Nairobi, Kenya
Tel: 2718548 Fax: 2718548
e-mail:durp@uonbi.ac.ke

Re: UON/CAE/DURP/2/5 **Date**: 1st March, 2012

TO WHOM IT MAY CONCERN

Dear Sir/madam

RE: MWANGI ELIJAH MAINA – B63/71956/2008

This is to confirm that the above named is a Master of Arts (Planning) student in the Department of Urban & Regional Planning.

The purpose of this letter is to ask you to assist him in obtaining data for purposes of his research.

Your assistance will be highly appreciated.

Yours faithfully,

University Of Nairobi
Department Of Urban and Regional Planning.
Faculty Of Architecture, Design and Development
P.O. Box 30197 - 00100

Mrs. Helen Nzainga
Ag. Chairman
Department of Urban & Regional Planning

HKN/eao

APPENDIX II

HOUSEHOLDS QUESTIONNAIRES

The questionnaire is aimed at collecting information about causes of water scarcity in Maai Mahiu, Division. The information you provide is intended for academic purposes only and please answer the questions with utmost sincerity.
Respond to each item by putting a tick (√) on the appropriate response and explaining/ specifying where space is provided.

Section A: Personal Information

1) Name of Respondent: .....
2) Contact Address: .....
3) Area of Residence?
   a) Location.....
   b) Sub-location.....
   c) Village.....
4) Gender of the respondent
   a). Male ☐ b). Female ☐
5) Age of the respondent..... .....years.
6) Who is the head of your Household?
7) Who is the head of your household? .....
8) Marital Status.
   a) Married ☐ b) Single ☐ c) Separated ☐ d) Widowed ☐
9) Respondent's highest level of education
   a) None, nursery/kindergarten ☐
   b) Primary ☐
   c) Secondary, A-level ☐
   d) College ☐
   e) University ☐
10) i) What is your family's main source of income?
   a) Farming ☐
   b) Employment ☐
   c) Daytime/ Casual employees ☐
   d) Seasonal/Contract ☐
   e) Others, specify? .....

ii) If your answer to 8 (i) above is farming, please indicate the type of farming.
   a) Arable farming ☐
   b) Livestock farming ☐
   c) Mixed farming ☐

11) i) Do you engage in any other economic activities?

a) Yes ☐ b) No ☐

ii) If yes above, which other economic activity do you engage in?

.....

12) How many persons live in your household?.....

13) What type of setting is your household located?

a) Rural Setting ☐

b) Town centre Setting ☐

c) Institution/Industrial ☐

Section B: Water Source

14) Which is your main source of water?

a) Spring/River ☐

b) Well/Borehole ☐

c) Dam ☐

d) Water Vendors ☐

e) Rain Catchment ☐

f) Piped Water in the home ☐

15) i) Are you aware of any naturally occurring sources of water in your area?

a) Yes ☐ b) No ☐

ii) If Yes, Which ones? . .....

.....

.....

16) How frequent do you fetch water? .....

17) What is the distance from the house to communal container or discharge point?

i) In front of the premises ☐

ii) Less than 100 m ☐

iii) 100 m to 1 km ☐

iv) 1 km to 2 km ☐

v) More than 2 km ☐

18) Where do store your water?

a) Into containers with leads in the house ☐

b) Into containers without leads in the house ☐

c) Drums or containers outside the house ☐

d) Into water holes ☐

e) Others (please specify):

.....

19) Approximately what capacity do such containers hold?

a) Less than 50lts ☐
b) 50 lts to 100lts ☐
c) 100 lts to 200 lts ☐
d) 200 lts to 400 lts ☐
e) More than 400 lts ☐

20) How do your fetch on your water?

a) People (back and heads) ☐
b) Donkeys and other animals ☐
c) Carts/Vans ☐
d) Bicycles/wheelbarrows ☐
e) Water is delivered ☐

21) How would you rate the quality of water you receive?

a) Excellent ☐ b) Very Good ☐ c) Good ☐ d) Poor ☐ e) Very Poor ☐

22) i) Do you think that the water sources or water supply is enough for all your household needs?

a) Yes ☐ b) No ☐

ii) If No, Why? .....

23) Are the existing water distribution channels in your area adequate and effect?

a) Yes ☐ b) No ☐

ii) If No, Why? .....

24) Which type of water scarcity is rampant in your area?

a) Physical Water scarcity (Demand outruns supply) ☐
b) Economic Water Scarcity (Water is available, but people can't afford it) ☐
c) None ☐

Section C: Human Activities

25) What human activities do you think contribute to water scarcity in your area?

.....

26) How have they contributed to water scarcity?

.....

.....

27) To what extent have the following human activities contributed to water scarcity? Please react by ticking number only to indicate the extent.

Key: 1----Very Great Extent, 2---Great Extent 3----Low Extent 4---Very Low 5---Not at All

Human Activity	**1**	**2**	**3**	**4**	**5**
Increased in population growth					
Industrial use e.g. Green houses					
Degradation of watersheds and catchment areas.					
Development of thirsty crops e.g. eucalyptus trees.					
Over abstraction of water due to agricultural activities					
Presence of IDP camps and other institutions e.g. health centres & schools					
Water pollution e.g. washing of heavy machineries in water sheds					
Increased tourism activity					

28) Which impacts of water scarcity have you ever experienced?

.....

.....

29) What measures can be taken to reduce or eliminate wholly the situation of waters scarcity in your area?

.....

.....

Section D: Environmental Factors

30) What environmental factors do you think contribute to water scarcity in your area?

.....

.....

31) How have they contributed to water scarcity?

.....

.....

32) To what extent have the following environmental factors contributed to water scarcity?

Please react by ticking number only to indicate the extent.

Key: 1----Very Great Extent, 2---Great Extent 3----Low Extent 4---Very Low 5---Not at All

Environmental factors	1	2	3	4	5
Low rainfall					
Low groundwater supplies					
Few lakes or rivers					
General Aridity of the area					
Location of the Division					

33) What can be done to tackle this factors hence reducing water scarcity?

.....

.....

Section E: Climatic Change

34) What can you say about climate change and water scarcity?

.....

.....

35) How does climate change lead to water scarcity?

.....

.....

36) Below are various ways in which climate change contributes to water scarcity. Please tick your level of agreement to the statements.

Key: 1---Strongly Agree, 2---Agree, 3---Uncertain, 4---- Disagree, 5----Strongly Disagree

Statement	1	2	3	4	5
Increase water shortages due to changes in precipitation patterns and intensity.					
Decrease natural water storage capacity from glacier/snowcap melting.					
Increase the vulnerability of ecosystems due to temperature increases.					
Affect the capacity and reliability of water supply infrastructure due to flooding, extreme weather, and sea level rise.					
Increase water temperatures, leading to more algal and bacterial blooms that further contaminate water supplies.					
Increase quantities of water needed for industrial cooling due to increased atmospheric and water temperatures.					

APPENDIX III

WATER VENDORS QUESTIONNAIRES

The questionnaire is aimed at collecting information about causes of water scarcity in Maai Mahiu, Division. The information you provide is intended for academic purposes only and please answer the questions with utmost sincerity.

Respond to each item by putting a tick (√) on the appropriate response and explaining/ specifying where space is provided.

Section A: Personal Information

1) Location of Vending point
   a) Location.....
   b) Sub-location.....
   c) Village.....
2) Gender of respondent
   a) Male ☐ b) Female ☐
3) Age of the respondent.....years.
4) How long have you been in operation?
   a) Less than year ☐
   b) 1 to 3 yrs ☐
   c) 3 – 5 yrs ☐
   d) Over 5 yrs ☐
5) i) Are you a licensed vendor?
   a) Yes ☐ b) No ☐

ii) If yes, which is the licensing authority?.....

iii) If No, why have you not been licenses?.....

6) Water type of premises do you vend water from?
   a) Water Kiosk ☐
   b) Hand cart/Van ☐
   c) Bicycles/wheel barrows ☐
   d) Others, specify?.....

7) What are your charges for the water?.....

8) i) Who are your main clients?.....

ii) What do they use the water for?.....

9) How is the demand for water?

a) Very High ☐

b) High ☐

c) Low ☐

d) Very Low ☐

10) Are you able to meet the water demand of your clients?

a) Yes ☐ b) No ☐

ii) If No, why?. .....

11) Approximately how many litres of water do you sell in a day?

.....

12) About how many clients do you supply with water on a daily basis?.....

Section B: Water Source

13) Which is your main source of water?

a) Spring/River ☐

b) Well/Borehole ☐

c) Dam ☐

d) Water Vendors ☐

e) Rain Catchment ☐

f) Piped Water in the home ☐

14) How do you get the water from the source?

a) Pumped to the vending point ☐

b) Flows by gravity to the vending point. ☐

c) Fetched with containers from the source. ☐

d) Others, specify .....

15) Are you able to maintain a constant water supply throughout the year?

a) Yes ☐ b) No ☐

ii) If No, Why? .....

.....

.....

16) What modes of fetching water are usually employed by your clients?

.....

.....

17) i) Is there anyone who is mandated to oversee the sourcing and water distribution in your area?

a) Yes ☐ b) No ☐

ii) if yes, who is it?.....

18) What methods of water conservation do you use in your business?

.....

.....

19) Are your customers concerned with quality of water they get?

a) Yes ☐ b) No ☐

20) Is there any government official who analyses the water you supply?

a) Yes ☐ b) No ☐

If yes, which one? .....

21) How would you rate the quality of water you supply?

a) Excellent ☐ b) Very Good ☐ c) Good ☐ d) Poor ☐ e) Very Poor ☐

22) What can you say of water distribution channels employed in your area?

a) Excellent ☐

b) Good ☐

c) Bad ☐

d) Pathetic ☐

23) Which type of water scarcity is rampant in your area?

a) Physical Water scarcity (Demand outruns supply) ☐

b) Economic Water Scarcity (Water is available, but people can't afford it) ☐

c) None ☐

Section C: Human Activities

24) What human activities do you think contribute to water scarcity in your area?

.....

.....

25) How have they contributed to water scarcity?

.....

.....

.....

26) To what extent have the following human activities contributed to water scarcity?

Please react by ticking number only to indicate the extent.

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Human Activity	**1**	**2**	**3**	**4**	**5**
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Industrial use e.g. Green houses					
Degradation of watersheds and catchment areas.					
Development of thirsty crops e.g. eucalyptus trees.					
Over abstraction of water due to agricultural activities					
Presence of IDP camps and other institutions e.g. health centres & schools					
Water pollution e.g. washing of heavy machineries in water sheds					
Increased tourism activity					

27) Which impacts of water scarcity have you ever experienced?

.....

.....

.....

28) What measures can be taken to reduce or eliminate wholly the situation of waters scarcity in your area?

.....

.....

.....

Section D: Environmental Factors

29) What environmental factors do you think contribute to water scarcity in your area?

.....

.....

30) How have they contributed to water scarcity?

.....

.....

.....

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32) What can be done to tackle this factors hence reducing water scarcity?

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33) What can you say about climate change and water scarcity?

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35) Below are various ways in which climate change contributes to water scarcity. Please tick your level of agreement to the statements.

Key: 1---Strongly Agree, 2---Agree, 3---Uncertain, 4---- Disagree, 5----Strongly Disagree

Statement	1	2	3	4	5
Increase water shortages due to changes in precipitation patterns and intensity.					
Decrease natural water storage capacity from glacier/snowcap melting.					
Increase the vulnerability of ecosystems due to temperature increases.					
Affect the capacity and reliability of water supply infrastructure due to flooding, extreme weather, and sea level rise.					
Increase water temperatures, leading to more algal and bacterial blooms that further contaminate water supplies.					
Increase quantities of water needed for industrial cooling due to increased atmospheric and water temperatures.					

APPENDIX IV

INTERVIEW SCHEDULE FOR KEY INFORMANTS

1. How long have you lived in Maai Mahiu?
2. What can you say about water scarcity in Maai Mahiu?
3. What are the Environmental factors that lead to water scarcity?
4. How do you consider climate change?
5. What measures can be adopted to address the issue of Climate Change?
6. What intervention measures need to be adopted to address the issue of water scarcity in Maai Mahiu Division?