UNIVERSITY OF NAIROBI

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IMPACTS OF A DEGRADED DRYLAND RIVERINE ECOSYSTEM ON LIVELIHOODS: A CASE STUDY OF KAKETA IN KILOME DIVISION OF MAKUENI DISTRICT

BY

MAGAMBO ESTHER KATHURE
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DECLARATION

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

Sign_____ date 9.10.06

Magambo Esther Kathure

(Candidate)

This report has been presented for examination by our approval as university supervisors.

Sign_____ date 11.10.06

Dr. G. H. N. Nyamasyo

(Supervisor)

Sign_____ date 11.10.06

Dr. Francis Mwaura

(Supervisor)

DEDICATION

This work is dedicated to my children ***Carol***, ***Martin*** and ***Mercy***, for their support and understanding during the process

LIST OF ACRONYMS

ASAL- Arid and Semi Arid land

CBD- Convection on Biological Diversity

UNCCD- United Nations Convection to Combat Desertification

KWS- Kenya Wildlife Service

NAP- National Action Plan for Kenya.

PRSP- Poverty Reduction Strategy Paper

UNDP- United Nations Development Programme

WSSD- World Summit on Sustainable Development

NEAP- National Environmental Action Plan

UNFCCC- United Nations Framework Convention on Climate Change

NES- National Environment Secretariat

UNEP- United Nations Environment Programme

ABSTRACT

The study aims at establishing how people's livelihoods in Kaketa Riverine Ecosystem have been impacted on by the degradation of the same. Specific attention has been focused on impacts on food security, fuel wood supply and supply of water for domestic use.

A sample of 60 households was relied on to give an inference to the population consisting of about 200 households within the Kaketa Riverine Ecosystem. Systematic random sampling procedure was employed to select the households to be included in the sample. Both primary and secondary data sources were of use as the study employed the use of SPSS (Statistical Package for Social Scientists) tool in data analysis. Qualitative and quantitative statistics were used in the analysis. The former involved the use of descriptives such as percentages and averages, while the latter involved the use of regression analysis to establish relationship that exists between variables.

The study found out that the degradation of Kaketa Riverine Ecosystem has adversely affected livelihoods of the local people as there is rampant food insecurity, fuel crisis and shortage of water for domestic use.

Consequently, the study recommends that the government through the relevant authorities should ensure full enforcement of the relevant legislation on sustainable utilization and conservation of the natural ecosystem, such as the Water Act, the Agriculture Act and the Forest Act among others. This would prevent further destruction of the ecosystem and allow the already degraded ecosystem to be restored to its original status. For further researchers, the study recommends scientific analysis of the soil status of the area in order to give more accurate and specific recommendations in improving the soil fertility status on a sustainable basis.

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However, take full responsibility for any errors and mistakes that may be contained in this report.

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CHAPTER ONE
INTRODUCTION

1.1 Background

Kenya has a growing population of over 28.7 million people according to the 1999 Population and Housing Census. Though the country is undergoing industrial transformation, agriculture remains the mainstay of the economy. The country has an area of about 587 900 km^2 of which 576 000 km^2 is land surface. 88% of the land surface is classified as arid and semi-arid lands (ASALs) and the remaining 12% forms the medium and high agricultural potential land.

Drylands of Kenya fall into ecological zones V to VII and are characterized by inadequate moisture. Rainfall is generally poor, evapotranspiration is high and soils are shallow. These areas, however, support much of Kenya's wildlife; they host Kenya's terrestrial National Parks and are the principle livestock areas. Evaporation demand in these areas is higher than precipitation. The low amounts of rainfall received have very high spatial and temporal variability and storms are a common occurrence. Temperatures are commonly high during the day and low at night.

Drylands cover about 1/3 of the earth and provide a livelihood for about ¼ of the world population. The ASALs have soils that are generally shallow and poorly endowed with organic matter. The soils are susceptible to both erosion and compaction. They have poor water holding capacity and are subject to sodicity, alkalinity and salinization. The only exceptions are the riverine and the low-lying floodplains which have rich alluvial soils. These areas are experiencing drought, as a result of desertification; the extreme form of land degradation.

The consequences of desertification in general are; loss of productivity of land, reduced animal productivity, ecological disruption, increased frequency of drought, loss of genetic diversity, degradation of water resources and increased atmospheric dust. Likewise, desertification leads to migration of people, social dislocation, social distress and unrest, poor health and quality of life.

Makueni district, in which the study area is located, falls within the dryland areas of Kenya, and is undergoing the same process of desertification as experienced in other dryland parts of the country, with threatening consequences. The soils are degraded leading to reduced agricultural productivity, there exists water problem as its wetlands are no longer functioning properly, and the few forests are substantially cleared, compromising the availability of fuel wood as a source of energy.

The study area, Kaketa Riverine Ecosystem is a wetland within a dryland. Wetlands are among the most productive ecosystems on the earth. They allow interaction between water, soil, vegetation and light all the year round or during a greater part of the year. The depth of the water is such that it allows photosynthesis to occur, making wetlands productive life-supporting ecosystems. It is this association of water, light, soil and plants that typifies various wetlands of Kenya which are famous for their spectacular avifauna and fisheries resources.

According to the Kenya National Environment Action Plan (NEAP), prepared in 1994, a substantial proportion of Kenya's water resources are found in wetlands, which cover 2 to 3% of the country's surface area. These wetlands are diverse in type and distribution. Some of the larger wetlands of Kenya include the shallow lakes Nakuru, Naivasha, Magadi, Kanyaboli, Jipe, Chala, Elmentaita, Baringo, Ol'Bolossat, Amboseli and Kamnarok; the edges of Lake Victoria and Lorian, Saiwa, Yala, Shompole swamps; Lotikipi (Lotagipi) and Kano plains; Kisii valley bottoms and Tana Delta; and coastal wetlands including the mangroves swamps, sandy beaches, sea grass beds and coral reefs. The list also includes various seasonal and temporary wetlands that occur where internal drainage allows water to collect in some seasons or in some years. These are found all over the country, including rock pools and springs in the southern part of Nairobi, west of Ngong' Hills, and at Limuru. Man-made wetlands include the dams, primarily meant for hydropower and water supply, and wetlands created for purposes of wastewater treatment. This list is by no means exhaustive since inventory is still on-going.

The Kenyan wetlands play a fundamental ecological role and have potential as resources of great economic, cultural and scientific value. Among the critical values are:

- Wetlands provide critical habitats for a wide range of flora and fauna. Their biodiversity includes a large number of aquatic plants, fish, herbivores and avifauna of resident and migratory birds;
- Wetlands are important sources of water for human consumption, agriculture and watering of livestock. They recharge wells and springs that are often the only source of water to some rural communities, for livestock watering and for wildlife support systems. The recharging of aquifers raises the water table making groundwater easily accessible. This has been the case in western Kenya, along the Tana River corridor and in the Chyulu hills catchment area for Mzima springs and the Nol-Turesh water supply system.
- Wetlands provide economic benefits through fisheries and generation of products such as fuelwood, building material, medicine, honey and various types of natural foods;
- Wetlands are important grazing areas. They are the only sources of water and pasture/fodder for the pastoral communities during drought in the ASALs;
- Wetlands serve a wide variety of ecosystem functions including flood control, water purification, shoreline stabilization and sequestration of carbon dioxide;
- Wetlands are areas of great scenic beauty. They are a tourist attraction, form important recreation sites for game and birds watching, swimming, photography and sailing;
- Wetlands have great potential for multiple uses (including agricultural) so long as precautionary measures are taken for sustainable development.

The wetland environment is generally most endangered. This is particularly true of those found in drylands. Wetlands are highly fragile and are easily upset by any external disturbances especially associated with human activities. This is the case since they are apparently able to support life, including crops when the surrounding area is very dry. The tendency has been for people to mis-use and over-use these environments leading to their degradation. The Kaketa Riverine Ecosystem is one of these fragile ecosystems in Makueni district which has undergone severe degradation

and no longer carries out the functions of a wetland. The soils are highly degraded, the agricultural productivity is low, the water problem is worse and fuelwood is scarce compromising the livelihoods in the area.

1.2 The Problem Statement

Kenya is a signatory to the Convention on Biological Diversity (CBD), Convention to Combat Desertification (CCD), United Nations Framework Convention on Climate Change (UNFCCC), the Bonn Convention on Migratory Species, and the Ramsar Convention on Wetlands. These conventions guide towards sustainable resource management at both national and international levels. To achieve the desired results the issues raised by these conventions need to be implemented. However, implementation of the same has remained a challenge so far. It is further appreciated that natural resource management has to be effected at local/ household level. There is general lack of baseline data at this level to guide towards development of appropriate guidelines. Households in drylands have been found to basically operate at subsistence level. This means that activities outside normal survival are not possible and/ or feasible. Challenges here include meeting water needs, energy requirements and food security. The big question therefore remains: - ***what interventions are necessary to ensure that household activities contribute towards sustainable resource management?***

The management of sensitive ecosystems such as wetlands and drylands is currently under various institutions, whose mandates and activities are not only sectoral but also uncoordinated and sometimes overlapping. Each of the institutions interacts with these ecosystems in accordance with its interpretation of its mandate. Kenya Wildlife Service (KWS), for instance, being the national focal point for the Bonn Convention on Migratory Species and the Ramsar Convention on Wetlands, has the mandate of conserving Kenya's natural resources (including wetlands) within the gazetted protected areas, which are the national parks and game reserves. This management preference leaves out many other important wetlands unprotected and under threat of degradation. Among these are the wetlands in the fragile dryland ecosystems.

Within the ASALs, most wetlands are traditional water sources and the only available grazing areas during drought. It is therefore suicidal to leave out these important but fragile areas in planning for ecosystem management in the country.

Kaketa River is one of the rivers originating from Kilome-Kilungu Forest block and flows for 30km before joining other streams. The river is the nerve centre for over 25000 people. In the recent past, poor land management including inadequate forest conservation measures have turned the one time permanent river into a seasonal one, thereby threatening the lives of the people and the biodiversity, and consequently contributing to change in the local climate.

In the past colonialists appreciated that this ecosystem was fragile and as a result imposed the 30m clearance between the riverbank and any productive activities. Subsequent 'development' including coffee processing have caused a lot of degradation. There has been excessive, almost unchecked abstraction and diversion of water for use in irrigated crop production e.g. French beans. Planting of Eucalyptus species has also contributed to degradation of this ecosystem. Other unsuitable land use practices like grazing have compounded the problem.

Plate 1: A section of Kaketa River showing direct diversion of water by an individual.

All these factors have contributed to reduced standards of living in the area as most households rely mostly on food from external sources including relief, as water and energy availability remain a big problem to the local community in the Kaketa area.

Plate 2 showing the extent of degradation in Kaketa farms

It is against this background that the present research studies on the impacts of a degraded dryland riverine ecosystem on livelihoods in the Kaketa Riverine Ecosystem were initiated. In carrying out this study, the following research questions have been answered. These include:

- ✓ What is the status of the farms bordering the degraded riverine ecosystem?
- ✓ How do the farm conditions relate to household livelihoods as far as energy and food security are concerned.
- ✓ What impact does the degraded river have on supply of water for domestic purposes?
- ✓ What options are there for policy makers on sustainable utilization, conservation and management of the already degraded ecosystem?
- ✓ How about issues for future research?

Therefore, the overall goal of the project is to come up with how the degradation of this riverine ecosystem has affected the livelihoods of the estimated 25,000 people and subsequently propose guidelines on sustainable land use management.

1.3 Objectives of the Study

1.3.1 General Aim

To study the impacts of the degraded Kaketa riverine ecosystem on livelihoods and suggest appropriate recommendations for policy makers on sustainable utilization, conservation and management of the already degraded ecosystem, and suggest areas for further research

1.3.2 Specific Objectives

i. To assess the status of the farms bordering the degraded riverine ecosystem

ii. To relate the farm conditions to household livelihoods with emphasis on energy and food security.

iii. To evaluate the impact of the degraded river on supply of water for domestic purposes.

1.4 Study Hypotheses

H_o: The crop yield of farms around Kaketa River is **not** below the potential yield for the area.

H_1: Alternative

H_o: The farms around Kaketa River produce adequate food for the households

H_1: Alternative.

H_o: Individual farms in Kaketa Riverine Ecosystem are able to meet the individual household fuelwood requirements.

H_1: Alternative.

H_o: There is no significant linear correlation between the quantity of water used and size of the households of Kaketa Riverine Ecosystem.

H_1: Alternative

H_o: The ecosystem is able to adequately supply the community with water for domestic purposes. H_1: Alternative.

1.5 Justification of the Study

The World Summit on Sustainable Development (WSSD) in September 2002 reaffirmed land degradation as one of the major global environment and sustainable development challenges of the 21st Century, calling for action to "... address causes of desertification and land degradation in order to restore land, and to address poverty resulting from land degradation." The summit also emphasized that "sustainable forest management of both natural and planted forest and for timber and non-timber products is essential to achieving sustainable development and is a critical means to eradicate poverty". Addressing land degradation would, therefore, contribute significantly to the Millennium Development Goals of reducing by half the proportion of people in poverty by 2015 and ensuring environmental sustainability.

Land degradation means damaged soil structure which leads to the loss of soil nutrients through processes such as water or wind erosion; water-logging and salinization; and soil compaction. The main causes of land degradation are inappropriate land use, mainly unsustainable agricultural practices; overgrazing; and deforestation. These practices are most prevalent in places where land, water, and other natural resources are under-priced. In addition, people who do not have land tenure security and/or water rights have little or no incentive to invest in sustainable land management. Instead, they tend to focus on meeting their short-term economic needs, to the detriment of the environment.

Land resources can suffer degradation from human activities, in turn affecting water and biological resources. Often, land degradation weakens the ability of communities to depend on their environment for their livelihoods. This is seen clearly when land resource potential is diminished through desertification and deforestation. Activities that contribute to land degradation include: soil erosion, denudation, pollution, loss of organic matter, fertility and vegetation cover, invasive species, habitat conversion (whether urban or agricultural) and aquifer degradation.

Wetlands were the first ecosystem to receive international attention through the "Convention on Wetlands of International Importance especially as Habitats for Waterfowls", opened for signature at Ramsar, Iran, in February 1971. Kenya ratified this convention in 1990 and has since designated Lakes Nakuru and Naivasha as

Wetlands of international importance (Ramsar Sites) in accordance with the requirements thereof.

The convention definition however, seems to cater only for sectoral interests of conservationists whose concern is water birds. In this respect therefore, Kenya has through the National Wetlands Standing Committee (NWSC) defined Kenyan wetlands as: "areas of land that are permanently, seasonally or occasionally waterlogged with fresh, saline, brackish or marine waters at a depth not exceeding six metres, including both natural and man-made areas that support characteristic biota".

The above national definition has also an inclination towards biodiversity conservation but could allow exploitation of wetlands under the "wise use" principle. However, this has not been the case with most wetlands of Kenya. As has already been mentioned, Kaketa River which was once a permanent source of water is presently degraded and the surrounding community is now water insecure.

The estimated 2500 people who depend on this ecosystem for their livelihood i.e. for water, energy and food, are now threatened. It is evident that massive degradation has taken place and is continuing without tangible efforts to arrest the same. Presently during the dry months of the year no water flows in the once permanent river. There is therefore need to establish the status of the ecosystem's life support and put in place measures to arrest the situation and gradually rehabilitate the ecosystem.

In Kenya, little research has been carried out on small wetlands especially riverine wetlands in arid areas despite the fact that these wetlands are very important especially for domestic supplies of water, vegetables and grazing, and their ecological importance cannot therefore be overlooked. This is against the fact that absence of riverine wetlands in dry areas could contribute to significant water deficit for both humans and livestock.

The present study is therefore justified in comprehensively studying degradation of one of these forgotten, small, fragile but crucial ecosystems in the drylands and relating the same to livelihoods. The study has therefore provided relevant and workable suggestions that if applied would promote harmony between human activities and natural ecological functions in these ecosystems.

1.6 Scope and Limitations of the Study

The study has been based on investigation on the impact of the degraded Kaketa Riverine Ecosystem on the livelihoods of the area. There are various aspects of livelihoods, but this study has emphasized its focus on food, domestic water and energy supply with emphasis on fuelwood

Similarly, the study has restricted itself to its main objectives, assessing the status of farms bordering the degraded Kaketa Riverine ecosystem, relating the farm conditions to household livelihoods with emphasis on energy and food security, and evaluating the impact of the degraded river on supply of water for domestic purposes. This study has involved only selected households in the area (sample). This is to allow in-depth investigation of the problems identified for the study. However, these are expected to give an accurate representation of the ideal situations existing in other households along the Kaketa River.

On the other hand there has been a limitation of time as the study was planned to be completed within a short period of time. In addition, the study lacked funds especially for laboratory analysis of soil conditions. Nevertheless, in spite of these limitations, the study has involved scientific methodology and has been carried out within the specified objectives and laid down framework. Therefore, these limitations have not compromised the findings of the study.

1.7 Operational Concepts

Land Degradation

Land degradation can be defined in many ways. In brief, it is any change in the land that reduces its condition or quality and hence its productivity or productive potential. It occurs whenever the natural balances in the landscape are changed by human activity, through misuse or overuse (Williams 1991; Cocks 1992). Put another way, it is the result of using land and other resources beyond their capability.

Desertification

Desertification is land degradation in arid, semi arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities

(United Nations Convention to Combat Desertification or UNCCD, art.1, pg. 3).

Ecosystem

An ecosystem is the interrelationship of living organisms with each other and with the physical environment.

Environment

According to the "Heritage Illustrated Dictionary of the English Language (1975)", the word "environment" refers to the following:

1. Something that surrounds surroundings.
2. The total of circumstances surrounding an organism or group of organisms, especially;
    a The combination of external or extrinsic physical conditions that affect and influence the growth and development of organisms.
    b The complex of social and cultural conditions affecting the nature of an individual or community.

For this study, the word "environment" refers to the biophysical and socio-economic and cultural factors that surrounds and influence the life of an organism.

Livelihoods

According to "The New Choice English Dictionary", Livelihood is employment; a means of living, while living means providing oneself with what is necessary for life. For the study it is used to refer to how people earn their living through their interaction with the biophysical environment.

Riverine ecosystem

This is an ecosystem found along a river. It mostly consists of aquatic and semi-aquatic flora and fauna.

Household

The term household in this study refers to a family with one head of family. The sampling units were households.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The aim of this literature review is to show the contribution of past research in this area of study, with a view of pointing out strengths, weaknesses and gaps in their contributions and how relevant they are to the present study.

Environmental degradation has been a topic of debate and concern globally. Since the world is changing rapidly, growing population densities leads to scarcity of land and widespread changes in land use. Uncontrolled human activities results in a wide range of environmental problems including deforestation, overgrazing and depletion of land and water resources.

Globally, several studies have been done on environmental degradation most of which are incorporated in published textbooks on environment. These studies have been focused on forests, arable land, wetlands and even on drylands, and how these have affected ecological functions of the planet earth and life of organisms on the planet.

Literature on environmental degradation is broad in scope globally, for both developed countries as well as for developing countries. However, few specific studies have been done that attempts to solve the inherent problems related to environmental management in small wetland ecosystems in drylands, particularly for developing countries. This is because most of studies touching on environmental degradation in the tropics have been focused on the loss of the tropical forest which studies have revealed to be a home of a diversity of flora and fauna.

2.2 Policy and Related Literature

- **The Convention on Biological Diversity** (CBD)

The Convention on Biological Diversity (CBD) that came into force in 1993 provides an international, legally binding framework for conservation and sustainable use of biodiversity. CBD has three main objectives; the conservation of biological diversity,

the sustainable use of its components, and the fair and equitable sharing of the benefits arising from such use.

The CBD has a pivotal role in that among other things it provides the following:

- ✓ It reaffirms national sovereignty over genetic resources and stresses the importance of in-situ conservation
- ✓ It recognizes the central role of indigenous and local communities in biodiversity conservation through their traditional and sustainable practices and knowledge systems
- ✓ It acknowledges intellectual property rights with the understanding that such rights should promote and not compromise the convention's objectives
- ✓ It is expected not only to oversee and monitor but also to stimulate financial and other resources that will support the conservation and sustainable use of biodiversity.

The present study is in agreement with the convention and the convention's role in recognizing the central role of indigenous and local communities in biodiversity conservation which forms the basis of the study.

- **United Nations Convention to combat Desertification (UNCCD)**

Chapter 12 of Agenda 21 deals with "Managing Fragile Ecosystems: Combating Desertification and Drought". It is pointed here that these problems concern one quarter of the earth's soil surface and one sixth of the world's population. Losses to ecosystems through the mechanisms of desertification and drought have important implications for alleviating poverty and avoiding catastrophes. The objective of the convention was to combat desertification and mitigate the effects of drought, especially in African and Latin American countries. Therefore, the convention formulated national and regional action programs which focus on improving productivity of the land and rehabilitation, conservation and sustainable management of land and water resources. This convention provides guidelines for this study.

- **National Action Programme for Kenya (NAP)**

This is a framework for combating desertification in Kenya developed within the context of UNCCD. The document prepared by National Environment Secretariat (NES), in Feb 2002, stresses that among the factors that have made previous efforts by government to fall short of the expectations is the inadequate involvement of the local communities affected. The study in investigating this conclusion in NAP finds out to what extent the local communities are affected by the process of desertification especially in regard to availability of the basic necessities of life, namely food, water and energy, and consequently suggests how they may be involved.

2.3 Livelihoods in a Dryland - Wetland Ecosystem

Dryland ecologies are basically hostile and fragile. The flora and fauna found in these areas are well adapted, and characteristically these areas have low biomass hence low carrying capacity. According to Golany (1978), the dynamics of these areas is slow and the period of most coping cycles is long. Due to this, resources are prone to degradation upon subjection to any slight environmental stress. The study in support of Golany's views, investigates the impacts of human activities on the Kaketa Riverine ecosystem.

Vegetation plays a significant role in the maintainance of balance in these ecologies. In most cases desertification of these areas has been linked to loss of vegetation resource. Robin et al (2003) observed that major challenges facing drylands arise from agriculture, human settlement, desertification, livestock grazing, global warming and mining. The present study builds on Robin et al's views, and goes further to establish the impacts of the degradation on livelihoods. Michael et al (1999) found out that settlement and associated crop production in these areas not only reduce vegetative cover but are also responsible for replacement of more permanent vegetation with temporal soil covers. These may sometimes seal the soils completely. In drylands where vegetation is less abundant it may produce an environmental stress and or activate other destructive processes. Corrective measures in these regions are slow to set in and may quickly be overcome by such processes as wind and water erosion and unpredictable rainfall, prompting poor infiltration, surface run-off etc.

The study in validating this view looks at the impact of degradation on soil conditions in Kaketa with particular reference to ability to support crop production.

The Kaketa Riverine Ecosystem is a wetland within a dryland. The Ramsar Convention on wetlands of International importance especially as waterfowl habitat defines "wetland" in its Article 1 of 1972 as: "Areas of marsh, fen, peat land or water whether natural or artificial, permanent or temporary with water that is static, flowing, fresh, brackish or salty including areas of marine water the depth of which at low tide does not exceed six meters" (Dugan, 1993).

Maltby, (1986) states that for a long time a combination of diseases, flooding and waterlogged soils tended to keep people and development out of wetland areas. This study probably did not consider the dryland wetlands which are the main areas of cultivation and development. The present study, in disagreeing with Maltby, investigates livelihoods of a dryland wetland and how developments within those areas, including agricultural production, which Maltby ignored, have contributed to massive degradation of the ecosystems.

According to Badlock (1984), use and misuse of wetlands have been going on for a long time globally. Prolonged presence of water makes them suitable for farming and grazing especially in drylands. The present study in consideration of these facts as put by Badlock investigates how the use and misuse of these fragile areas have negatively impacted on the livelihoods of the households in those areas.

Thenya (1998) while studying the ecological characteristics of Ewaso Narok Swamp argued that most wetland research in Kenya has concentrated on large lacustrine wetlands of the Rift Valley, Coast and Lake Victoria. He pointed out that little research has been done on riverine wetlands especially those occurring in arid areas as they have been regarded as having minimal use both ecologically and socially. This research in Kaketa riverine ecosystem has tried to fill this gap that was identified by Thenya.

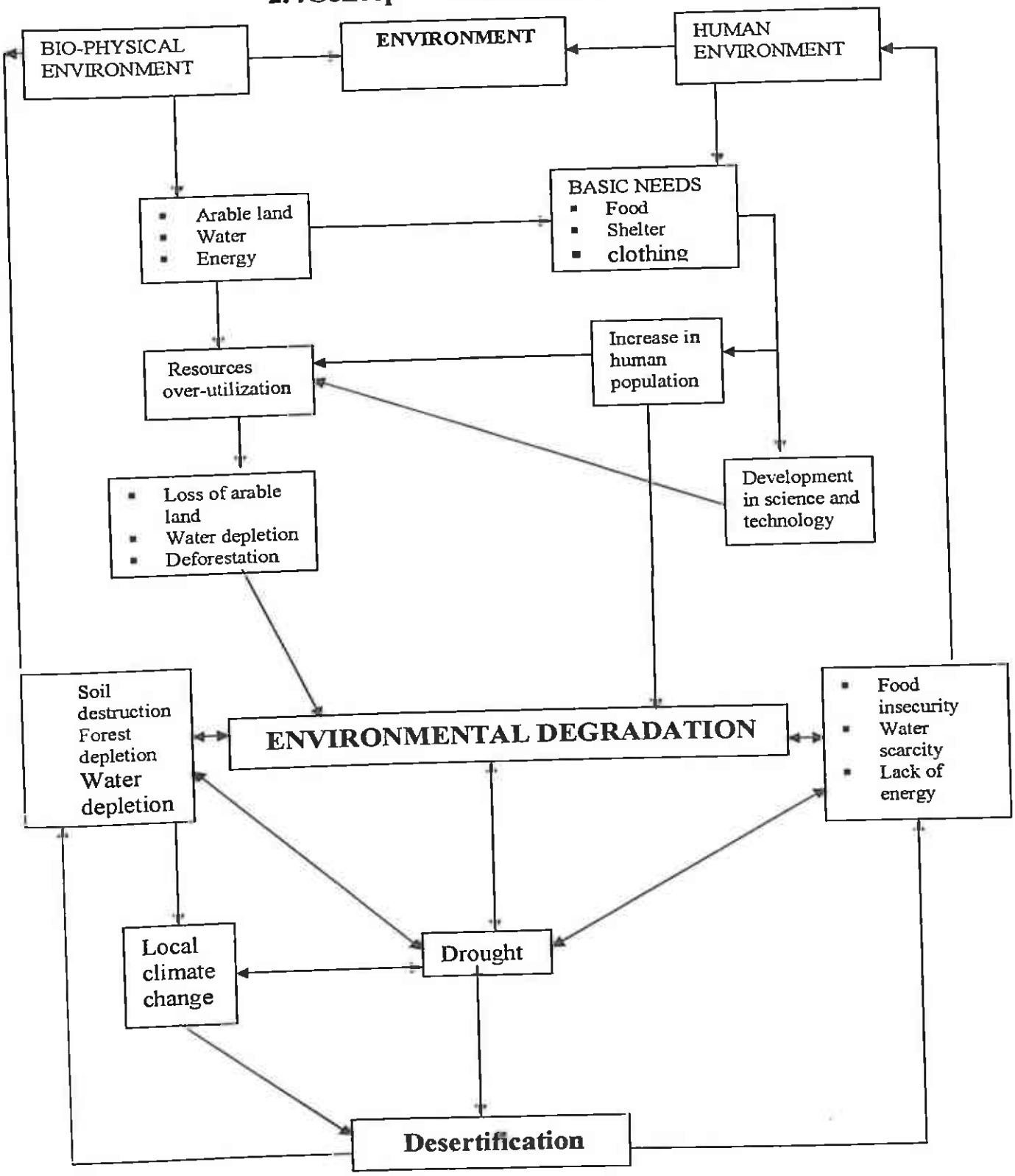
Mwaura (1992) after an empirical study relating rainfall, agriculture, livestock and human density in the marginal lands of Kenya suggested that many densely populated semi-arid districts have populations well above their carrying capacities. He further says that the aftermath of this is almost always environmental degradation particularly in the absence of proper land management. Wetlands in these areas are usually the first ones to show the impacts of degradation. They actually become centers of desertification. In validating this argument, the present study has been based in a dryland wetland and has tried to investigate and establish how vulnerable these areas are and how they impact negatively in the general life of the local community.

Likens *et al* (1969) in a study done in the Hubbard Brook watershed in North America revealed that forest clearing had profound effects on both the quality and quantity of water. This study was done in a non-tropical zone. The present study has tried to reaffirm this in a tropical dryland zone set up.

2.4 Theoretical Basis

Few watersheds are natural, because various management practices will usually change the ecological status of land, rivers and lakes (Goodman, 1984) particularly with regard to vegetation, soils and water quality. Agricultural development in many parts of the world has often been followed by substantial scenery changes, and scientists have often pointed out the serious environmental disorders that arise in watersheds as a result of land degradation and the application of agro-chemicals (Haslam, 1978; Roberts and Roberts, 1984). Pratt and Gwynne (1977), while studying environmental problems from a mathematical perspective, concludes that an environmental problem arises whenever there is a change in the quality or quantity of any environmental factor that directly or indirectly affects the health and well being of the biota in an adverse manner. Haslam (1978) discusses the influence of topographic and climatic factors with regard to vegetation structure. It is noteworthy that she stresses the role of human activities in changing natural vegetation patterns.

2.4Conceptual Framework



Source: Researcher, 2005

Fig 1: The Conceptual Framework

2.5.1 Explanation of the Conceptual Framework

1. Biophysical and human factors determines the nature of the environment
2. The human component depends on resources from the biophysical environment e.g. land, water and energy to satisfy its basic needs.
3. Satisfaction of the basic needs contributes to population increase and advancement in science and technology, which again exert negative impacts to the biophysical environment through over-utilization of the available resources.
4. Over-utilization of resources leads to reduced productivity of the arable land, reduction in water availability, and deforestation. These situations contribute to environmental degradation.
5. Environmental degradation manifests itself both in the biophysical environment and in the human environment. In the former it results in soil destruction, forest reduction, and water depletion, which further aggravate the problem of degradation. In the latter it results in food insecurity, water scarcity and energy crisis. Similarly, these conditions also worsen environmental degradation.
6. Environmental degradation contributes to drought, which at the same time results in further degradation of the environment.
7. All the above factors and conditions finally result in desertification, which worsens the problem of environmental degradation.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This section describes the procedures that have been followed in conducting the study. Various techniques that have been used in obtaining and analyzing data are outlined. In deciding the best research method for this study, various factors have been taken into consideration including:

1. The conditions and situations of respondent: The respondents are responsible members of rural households going about the daily chores. In addition, a good number are either illiterate or semi illiterate.
2. Time and Resources available: Time for data collection was short and was further compounded by minimal resources available.
3. The quickest way to obtain data: A direct interview was preferred as the quickest method of questionnaire administration.

3.2 The Study Area

3.2.1 Location, Topography and Soils

The study area is in Mukaa location which is one of the three locations in Kilome Division of Makueni District in Eastern Province of Kenya. Kilome Division covers an area of 359.4Km^2. It borders Machakos District to the west, Kasiken division to the south east and Kilungu division to the north east.

The study area consists of hilly topography with very steep slopes. The soils vary a bit with red sandy loams being the major soil type. Some areas have black cotton soils. These soils are infertile and therefore have low agricultural productivity.

3.2.2 Rainfall and Temperature Characteristics:

Rainfall pattern in the area is bimodal. Long rains are experienced in March, April and May while the short rains fall in November and December. The annual rainfall totals vary highly with some years having as little as less than 250mm, while other years are wet and the rainfall totals hit over 15000mm. Generally, the normal rainfall in the study area is between 800 and 1200mm.

The study area is one of the coolest parts of Makueni District. It experiences very low temperatures especially at the hill tops. This is due to the forest and the windy conditions. Generally, the mean temperature range for Makueni District ranges between 20.2^{0}C to 24.6^{0}C, with an average of 22.1^{0}C.

Fig 3.1 Map of Kenya showing Location of Makueni District

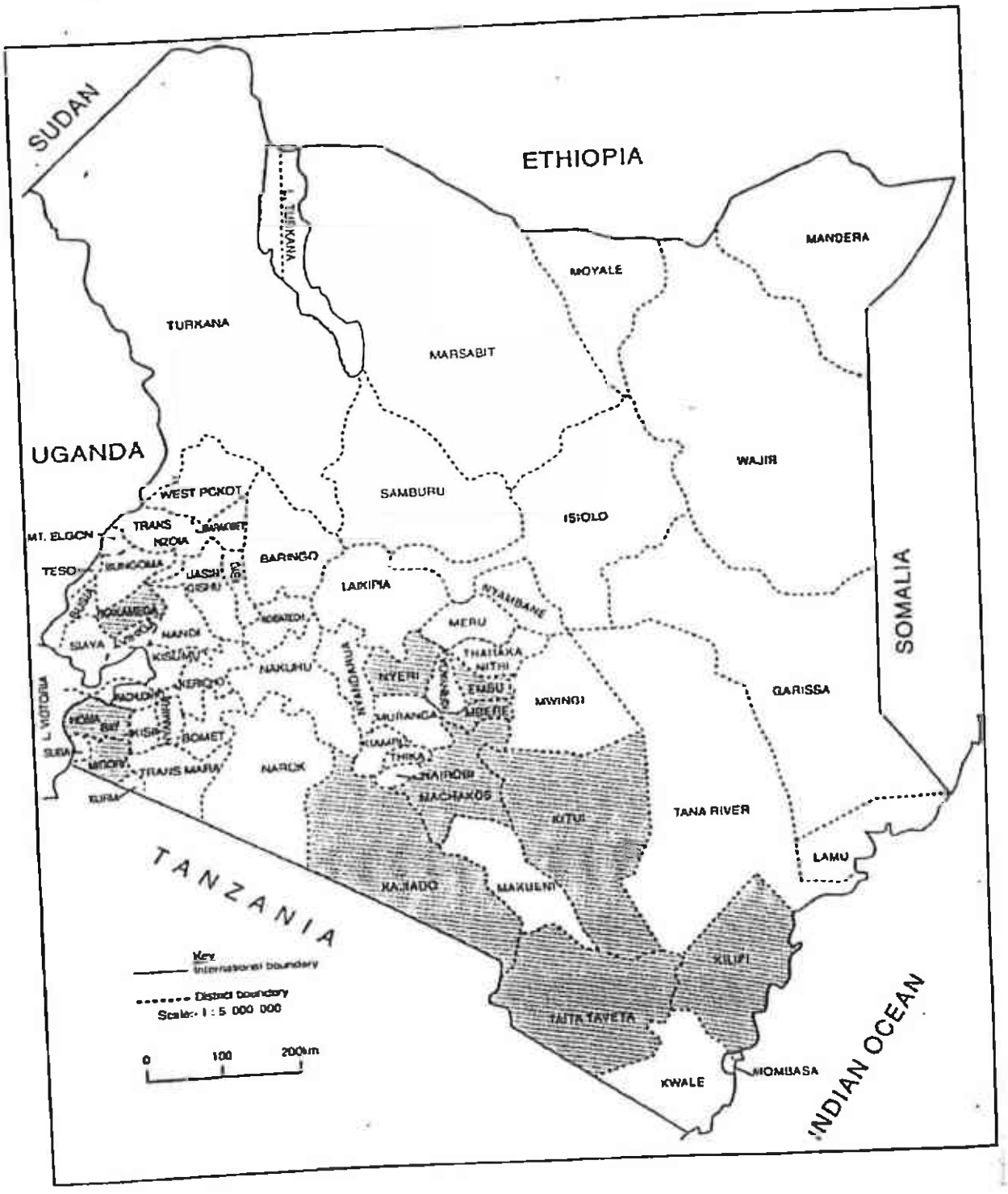
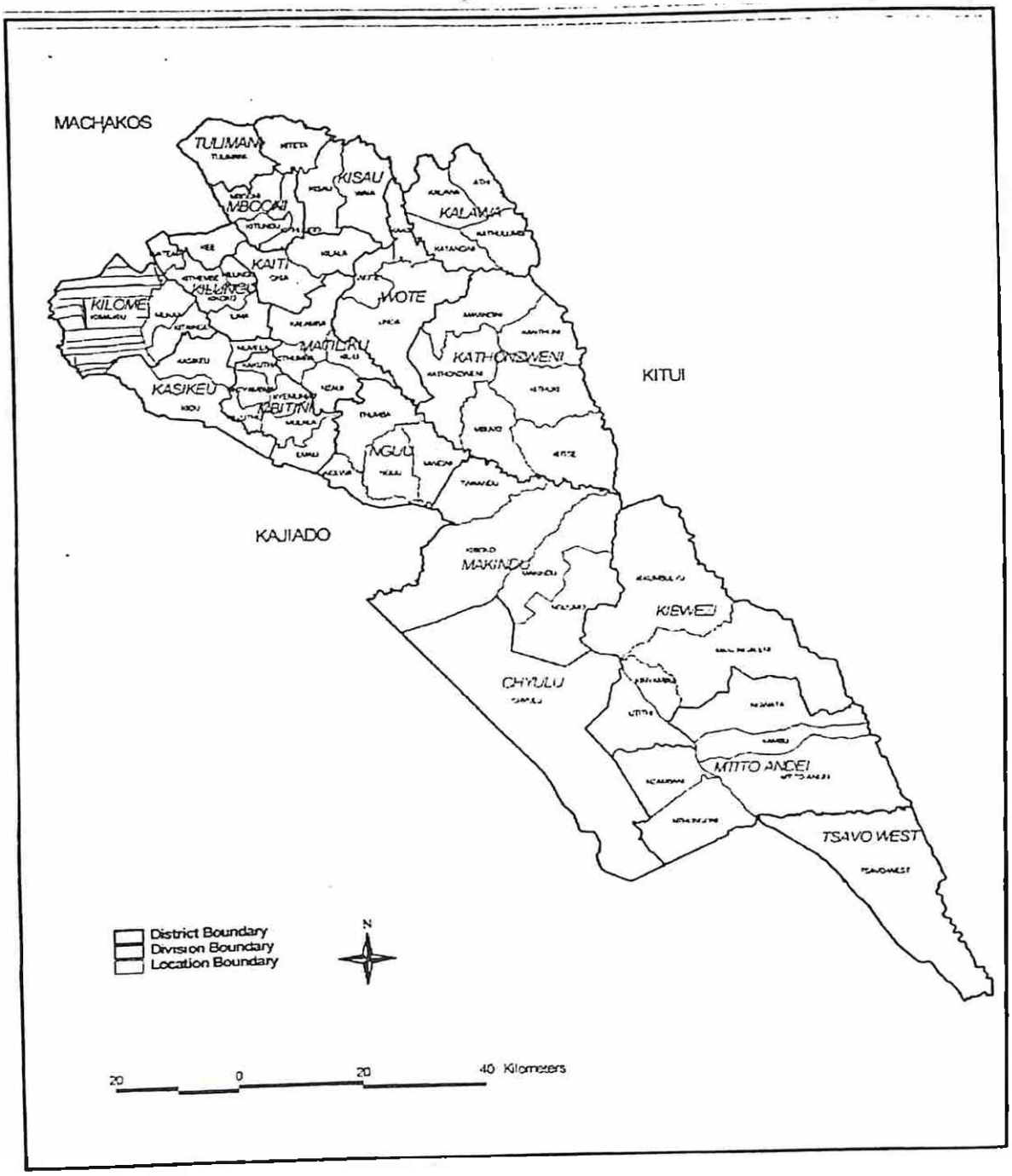


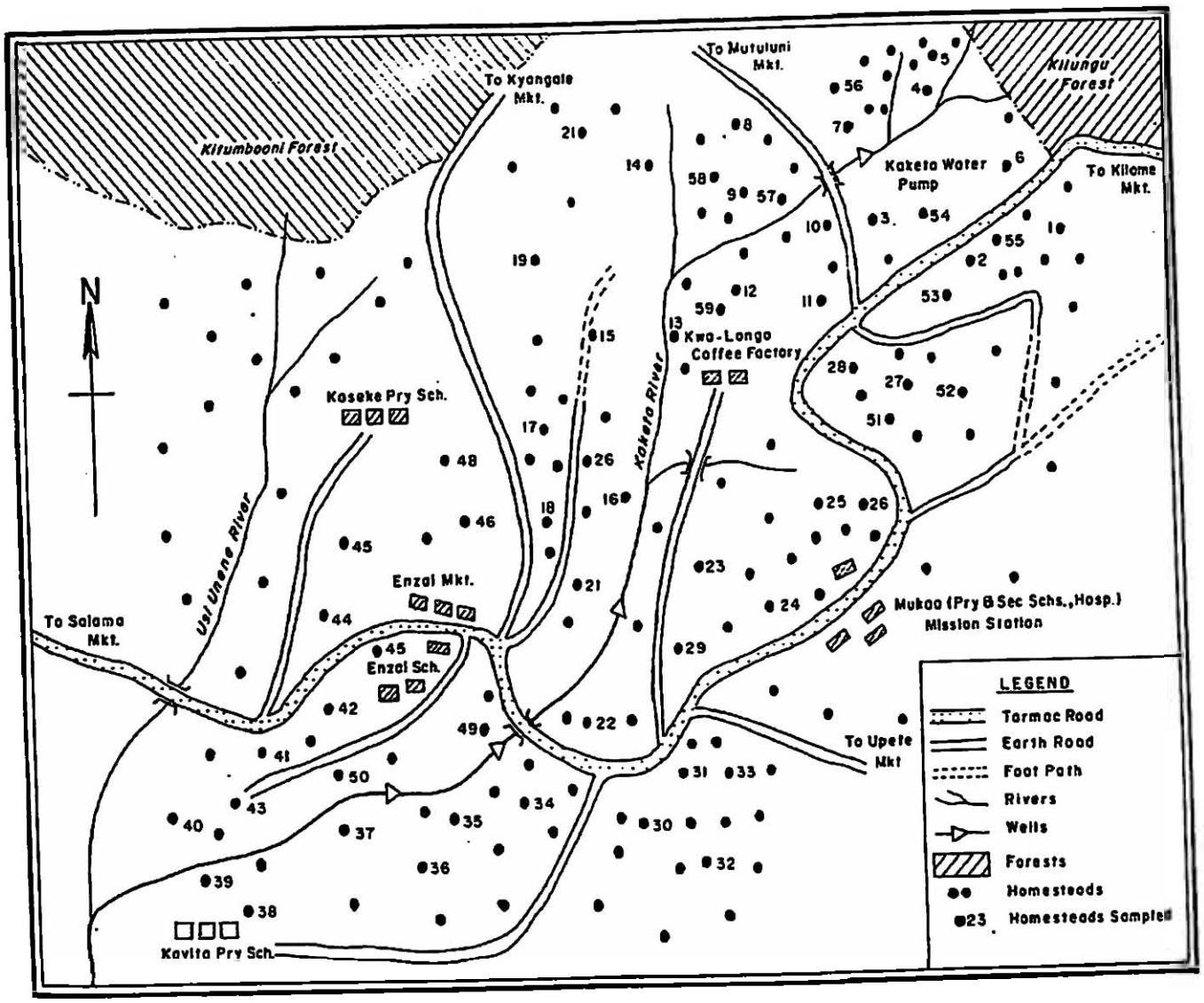
Fig 3.2 Map of Makueni District showing location of Kilome Division



3.2.3 Population and Settlement

According to the 1999 Population and Housing Census, Makueni District registered a total of 771545 people. Kilome division in which the study area falls registered 86,204 people. Settlement in the study area is sparse as the division had a population density of 129 persons per square kilometer with a total of 8,631 households (1999 Census Report, Makueni District).

Fig 3.3 A sketch of Kaketa Riverine Ecosystem



3.2.4 The Kaketa Riverine Ecosystem

The study specifically concentrated on Kaketa Riverine Ecosystem. The Kaketa River is one of the several streams originating from Kilome – Kilungu Forest block, a 148.4 Ha protected area in Makueni district. The river which runs for well over 30Km was a reliable source of water for many years and this probably explains why people settled within its reach.

The Kaketa Riverine Ecosystem was identified as fragile very early by the colonial authorities who prohibited activities such grazing and cultivation within the river bank. The Kilome forest block was gazetted as a protected area partly to ensure proper functioning of the entire ecosystem.

However, over the years, the ecosystem has deteriorated so much that the lives and biodiversity there in are threatened. Among the causes of this deterioration are:

- Excessive water abstraction from the river for irrigation, domestic and industrial use.
- Lack of management plans for the river bank and the subsequent absence of enforcement of the relevant legislation for river bank protection e.g. Agriculture Act (Cap 318) and the Water Act (Cap 372).
- Poor management of the catchment area especially through inadequate forest conservation measures with over 60 Ha backlog afforestation
- Declining productivity of the landscapes, occasional deforestation and soil erosion. This phenomenon generally referred to as "LAND DEGRADATION" eventually leads to food insecurity and to loss of other ecosystem's goods and services such as biodiversity resources and water provision.

3.2.4.1 Indicators of Land Degradation in the Kaketa Riverine Ecosystem:

The following are some of the many land degradation indicators in the Kaketa Riverine Ecosystem:

i. ***Vegetation Indicators***

Most of the shallow rooted vegetation in this ecosystem has been replaced by deep rooted vegetation, which is a clear indication that much of the top fertile soil has been eroded. Varieties of Aloe and Cactus plants which do well in degraded lands are also present.

Plate 3: Vegetation types in Kaketa area, a sign of a degraded ecosystem

ii. Soil Erosion Indicators

Another indicator of land degradation in the ecosystem is the existence of gullies, which cover a substantial land area. During the rainy seasons sediment laden runoff water is seen flowing down the hill slopes.

iii. ***Water Resource Indicators***:

Water resource indicators of land degradation involve runoff intensity, flooding and sediment deposition in the area. Lower parts of the area where all gullies empty their load have a lot of sediment which has reduced the value and use of the agricultural land in the affected area.

Plate 4: Abandoned communal water intake, a consequence of degradation

iv. ***Socioeconomic Indicators:***

The increasing population has led to clearance of land for settlement in the hill tops exposing the land to severe soil erosion through surface runoffs while grazing and cultivation of the hill tops have exposed the ecological system to physical and climatic shocks. Indeed all the community livelihood activities seem to have negative impacts on the environment especially land degradation.

v. ***Fuelwood Indicators***:

Most households in the Kaketa village use fuelwood for cooking purposes and this has threatened the woody trees. Many people in the area have already exhausted their woody vegetation in their land and have now resulted to using charcoal whose manufacture is yet a bigger threat to trees.

3.3 Study Population

A population is defined as a complete set of individuals, cases or objects with some common observable characteristic (Mugenda, and Mugenda 1999). Ngechu (2000) defines population as a well-defined set of people, group of things, households, firms, services, elements, or events, which are being investigated.

The population for this research consists of households whose farms are close to Kaketa River in Kilome Division of Makueni District.

3.4 Sampling

3.4.1 The Sample

This is a subset of individuals in a population selected for study. The sample selected, which consisted of 60 households, was representative enough to give an accurate inference to the entire population characteristics. The sample size was about 30% of the total households in the study area.

3.4.2 Sampling Procedure

As has been mentioned, households from Kaketa River Valley formed the study population. A sketch map of the area under study was made with consultation with local field officers with the Ministry of Agriculture and the local leaders. A list of all the households in the target area was made. This totaled to 200 households.

With the households list, systematic random sampling was then used to select every third household from both sides of the valley to form the sample.

3.4.3 Sampling Technique

Systematic random sampling was used in the study. This is a probability sampling where every $K^{th.}$ case in the population frame is selected for inclusion in the sample. It is also called interval sampling. To obtain a truly random sample using this method, the list of all the households in Kaketa riverine ecosystem was obtained and randomised. The sampling interval was then determined by dividing the total population by the sample size. The first element in the sample was selected randomly. Although this method is quick and simple, and it is the most convenient especially for this kind of study, it has some limitations, for example, it relies on the availability of a complete unbiased population list and the list must not have any cyclical or periodic characteristics. However, these limitations were overcome as the Kaketa Valley household list (population list) could easily be constructed without any difficulty. The construction of the list was made in a preliminary study of the area thus there could not be any periodic or cyclical characteristic in the list.

3.5 Data Collection

The type of data collected included both primary and secondary data.

a) Primary Data

i) **Field Observation:** These included observations that the researcher made as she carried out the study. General status of the farms and the extent of degradation in the study area among other things were observed during the study.

ii) **Responses to the interviews:** These included information got from key informant interviewees such as the village elders in the study area, and the relevant agricultural officers of Kilome Division regarding potential maize yields of the area and the issue of food security among others.

iii) **Responses to the questionnaires:** These included the written answers from the interviewees during the interviews depending on the requirements of specific questions.

iv) Apart from the above-mentioned sources, any of the first hand information relevant to the study topic has been regarded highly.

b) Secondary Data:

Various secondary data sources have been of use including literature review of published and unpublished works relevant to the study problem, study of demographic and health surveys and other relevant reports, review of population census and other government reports such as the National Development Plan and Economic Surveys, Agricultural reports, records etc and relevant baseline map of the study area, figures and photographs.

Various methods were used to collect data during the study, including note taking of observed situations, use of questionnaire, use of key informant interviews and use of photograph among others.

Data collection was by each objective as discussed below.

Objective 1: To assess the status of the farms bordering the degraded riverine ecosystem

To achieve this objective a thorough literature review was done and observation and recording was done on the physical status of the farms in the area. The following parameters were used to achieve this objective: farm sizes, main food crops grown, the main methods used in crop production, management practices employed, and crop yields. Data was also collected on the actual yields of the farms of the area through direct interviews with the farmers, and compared with that from the Ministry of Agriculture on the potential yield of the same area (source: Divisional Agriculture Office, Kilome).

Objective 2: To relate the farm conditions to household livelihoods with emphasis on fuel and food security.

i. Food Security

To achieve this objective, data was collected on estimated production figures for maize from the farms owned by each and every household in the sample. Maize was considered because from the preliminary study, it was found to be the staple food for the area presently. In addition, data on consumption of maize for the same households was also collected and subtracted from the production to find out whether the households are food secure or not.

ii. Fuel

For this objective data was collected on the most commonly used type of fuel in the households for domestic purposes, its source, that is, whether from within the farms belonging to the same households or from outside sources e.g. other neighbouring farms, the forest or bought from the market.

Objective 3: To evaluate the impact of the degraded river on supply of water for domestic purposes.

To achieve this objective, data was collected on water utilization in the households. Specifically, the research collected data on the quantity of water used in every household vis-à-vis the size of the household. This was to get the average water use

per person in each of the households to compare with the estimated quantity per person from the Ministry of Water.

3.6 Data Processing and Analysis

Various methods of data analysis and presentation were used to facilitate interpretation of data. Both qualitative and quantitative data analysis techniques were used. In addition, other cartographic methods were employed.

Preliminary data operations entailed processing of data, cleaning and data reduction. Data was coded for easy capturing using computer-based technique, namely; the Statistical Package for Social Scientists (SPSS).

Data analysis was objective based. Both the quantitative and qualitative techniques were applied to all the objectives, i, ii, and iii. Quantitative analysis entailed use of descriptive statistics; summary counts (frequencies), means and variances. Cartographic presentation such the use of graphs, pie carts and creation tables have been used to achieve set objectives and afford data greater meaning. This is largely based on what Bailey calls the theoretical principle; driven by the researchers goals and theory (Bailey 1981). Further data analysis entailed subjecting data to statistical tests with the aim of making inference on relationship between data sets or variables. Regression analysis was used to assess relationships between independent and dependent variables.

A regression function is a mathematical function that describes how the mean of values of a dependant variable changes according to the values of an independent variable. Taking the dependant variable to be y and the independent variable to be x, then for each fixed value of x there is a conditional distribution of y values around the mean (μ) with some standard deviation which is a measure of variability of the y observations that have the same x value.

Linear regression uses a method of Ordinary Least Squares (OLS). This is a method for estimating the linear function that provides the best approximate of the relationship between the interval variables based on observations from a random

sample. Alpha(α), betta (β), and the population standard deviation (δ) are treated as unknown parameters and must be estimated in order to estimate the regression equation $(E(Y) = \alpha + \beta x$ for the population. The estimated regression equation can then be used to make predictions about the dependent variable Y and its mean at specific values for the independent variable X.

The following assumptions are made in a regression model:

a) The specification error, that is, the relationship between Xi and Yi is linear and the dependant and the independent variables are clearly identified.
b) No measurement error: the Xi and Yi are accurately measured at an interval scale.
c) For the error term:
    - The mean of the error term is zero.
    - The variance of the error component is constant for all values of Xi (homoscedasticity or equal variance)
    - There is no autocorrelation for the error terms for any two observations of X. Correlations suggest that there is additional information in the data that has been erroneously omitted.

Correlation Coefficient (R)

In determining the association between Y and X, correlation Coefficient (R) and coefficient of determination (R^2) is calculated. The slope b of the prediction equation $\ddot{y} = a + bx$ indicates the direction of the association between Y and X. When b is positive then there is a positive or upward association meaning that Y increases as X increases. When b is negative the association is otherwise and Y decreases as X increases. However b does not appropriately measure the strength of the association, and thus the need for calculation of correlation coefficient (R), which can be described as a standardised slope whose value does not depend on the units of measurement.

Properties of R

a) $-1 \leq R \geq 1$
b) The larger the absolute value of R, the stronger the degree of linear association.

c) It is appropriate for use only when a straight line is a reasonable model for the relationship. When there is no linear relationship between Y and X , then b = 0 and R = 0

The formula for calculating R is as follows:

$$R = \frac{\sum_{i=1}^{n} xiyi - \sum_{i=1}^{n} (xi)\left(\sum_{i=1}^{n} yi\right)/n}{\sqrt{\left[\sum_{n=1}^{n} x^2 - \left(\sum_{i=1}^{n} xi\right)^2 / n\right]\left[\sum_{i=1}^{n} yi^2 - \left(\sum_{i=1}^{n} yi\right)^2 / n\right]}}$$

3.6 Hypothesis Testing

Hypothesis is a starting point of investigation. It is a proposition formulated for the purpose of a statistical test to a problem under investigation. Once a hypothesis has been formulated, it has to be tested. There are two types of hypothesis; the null and the alternative hypotheses. The null is negative proposition formulated to be rejected, while the alternative hypothesis is a positive proposition.

The statistical theory of probability allows us to prove the hypothesis within a margin of error. In this study, descriptive and inferential statistics have been used in determining the relationships that exist between the variables under investigation. In this study percentages have been used in determining the relationship and even the strength of the purported relationship.

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1 Overview

This chapter presents the results as obtained from the field. The chapter is organized under two sections. The first entails an analysis of the questionnaire return rate. The second section presents the research findings and discussions on food security, fuel consumption and water supply in Kaketa area.

4.2 Questionnaire Return Rate

During the administration of the questionnaires, there was high level of co-operation as the researcher explained to the interviewees the purpose and the importance of the study. This way a high return rate was ensured as shown in the table 4.1 below

Table 4.1 Questionnaire return rate

Target	Sample size	No. Responded	Percentage
Households	60	57	95

The questionnaire return rate was considered adequate.

4.3 Research Findings and Analysis

The section presents the research findings and analysis as per each objective. It is therefore divided into four sub sections as follows:

4.3.1 Status of Farms in Kaketa Riverine Ecosystem

In assessing the status of farms in the Kaketa area, the following factors were considered:

- Farm sizes
- Major enterprises and crops grown in the farms
- The main methods used in food crop production in the farms
- Management practices employed in the farms
- Yields of crops grown in the farms

a) Farm Sizes

The farms in the study area were found to be small in size and in most cases not more than one hectare as shown in the table below:

Table 4.2 Farm sizes in Kaketa

Farm sizes	Frequency (No.)	Percentage
Up to 1 Ha.	31	54.39
1 to 2 Ha.	17	29.82
Over 2 Ha	9	15.79
Total	57	100

Most farmers own very small land parcels which are inadequate for subsistence food production. As such most of the households rely on food from the market and in some instances relief food from the government, Non- Governmental Organizations and other well wishers including international organizations.

b) Farm Enterprises and Major Food Crops

The farms in Kaketa area are used mainly for subsistence food production. The major food crops of the area are maize and beans. These are the staple crops in the area. Other food cops also grown in the area include millet, bananas, kales, potatoes, tomatoes, and other varieties of vegetables.

Other than subsistence food production, the farms are also used for other enterprises such as livestock production (e.g. dairy cattle, goats, sheep and local cattle breeds.), poultry, fruits and woodlots. These however, are just supplementary uses of the farms and their existence in the farms depend on whether the farm size is big enough to adequately accommodate maize and beans and to allow extra space.

c) The Main Methods of Food Crop Production

The farmers rely on rain for crop production. Irrigation is hardly practiced in the area. Of the 57 households interviewed only 3 practice irrigation in their farms. These are farms which border the Kaketa River, and abstract the river water for use in their

farms. They only account for 5.26% of the households. Therefore crop production in the area is highly affected by rainfall availability and variability.

d) Farm Management Practices

To realize gains from the small farms in Kaketa, farmers in the area use inputs such as manure and inorganic fertilizers. However, the use of inorganic fertilizers is not very significant as most farmers prefer to use manure in their farms as demonstrated in the table below:

Table 4.3 Use of manure and fertilizers in Kaketa

Input applied	No of households	Percentage
Organic manure alone	41	72
Both manure & Inorganic fertilizers	16	28

The low use of inorganic fertilizers (about 28%) as shown in the table above can be attributed to the high level of poverty, ignorance and the low gains expected from the crops among other factors not investigated in the present research.

Apart from the use of manure and inorganic fertilizers, there are also cultural agronomic practices used widely in the farms. These include terracing, contour farming, crop rotation, and use of trash lines. Few farms practice crop rotation in the area due to small farm sizes (refer to table 4.2)

e) Maize Yields

The study confirmed the potential maize yields for the area to be 2700 Kg per hectare (Kilome Divisional Agriculture Office). The study also investigated the yields of the same from individual farms in the sample as shown in the table below.

Table 4.4 Maize yields in Kaketa

Crop yields in Kg/Ha/Year	No. of farms	Percentage
Less than 100	1	1.75
100 to 500	18	31.58
500 to 1000	21	36.84
1000 to 1500	11	19.30
1500 to 2000	2	3.51
Over 2000	4	7.02
Total	**57**	**100**

Note: Complete table of yields of individual farms in the sample is appended in this report.

Maize has been considered for the assessment because it is the staple food in the study area. From the above table maize yields from individual farms are far much below the potential yield for the division.

f) First Hypothesis Testing

H_o: The crop yield of farms around Kaketa River is above the potential yield for the area.

H_1: Alternative

As has been mentioned earlier, maize being the staple crop for the area has been considered for this analysis. This analysis entails the use of descriptive statistics to compare the potential yields of the area for maize crop against the yields of the same from individual farms in the sample. Using SPSS it was shown that the mean maize yields from individual farms (about 882) is far much below the potential maize yield of the same area (2700). This implies that only 33% of the potential yield is realised. Therefore the H_o is rejected and the H_1 adopted that "the crop yield of farms around Kaketa River is below the potential yield for the area" (refer to table 4.5 below)

Table 4.5 Average maize yields in Kaketa

No. of households	Minimum Yield	Maximum yield	Mean yield	Std. Deviation
57	75.00	3600.00	881.5877	646.8688

Note: Crude data in annex 1.

4.3.2 Food Security

Food and Agriculture Organization (FAO) defines food security as a state of affairs where all people at all times have access to safe and nutritious food, to maintain a healthy and active life. This food must be culturally acceptable.

a) Second Hypothesis Testing

H_o: The farms produce adequate food for the households

H_1: Alternative.

In investigating food security of the area, the research considered the quantity of maize grain consumed in every household per year and compared it to the amount of the same produced in the farms. This was to find out whether the farms were actually able to sustain the consumption of the households. The analysis was aided by the use of SPSS and the results are as shown in the table 4.6 below:

Table 4.6 Food production and consumption in Kaketa

	N	Minimum in Kgs	Maximum in Kgs	Mean in Kgs	Std. Deviation
Production	57	22	15300	691	2007.36
Consumption	57	90	3650	1149	816.54

Note: Raw data on consumption and production is in Annex 1

b) Interpretation

From the table above the mean production is far much below the mean consumption of the households in the area. This means that the farms in Kaketa Riverine Ecosystem do not produce adequate food for the households, and therefore the **Ho** is rejected while the H_1 adopted. Even though maximum production is higher than maximum consumption, the standard deviation is quite large, and therefore this high figure cannot be used to infer to the normal population characteristics.

c) Discussion on Farm Conditions and Food Security

The impacts of farm conditions on the livelihood of households in Kaketa Riverine ecosystem have been investigated with emphasis on food security and household fuel supply.

As discussed earlier in the chapter, food production (maize) is below the area's potential. Several reasons can be attributed to this, including the following among others:

- **Soil infertility**: This has been caused by various factors including cultivation on steep slopes, monoculture (maize and beans are the main crops), and minimal crop rotation among others

- **Use of poor quality of seed**: The study revealed that the farmers in Kaketa mainly use seed from previous crop and therefore do not buy recommended seeds from the stockists

- **Unfavourable climatic factors**: As has been discussed, the study area falls within a dryland. It therefore experiences harsh climatic conditions that are not conducive for production of crops such as maize.

- **Inadequate knowledge on various suitable agronomical practices and crop choices**: The study revealed that farmers are limited in knowledge on various agronomical practices that are suited to the area. In addition, farmers have persistently planted crop varieties not suited for this kind of environment.

In addition, during the field research more households admitted that their farms were not producing enough food for their subsistence use and have to buy more from the market and of course depend heavily on the very unpredictable relief food. This is shown in table 4.7 below:

Table 4.7 food security in Kaketa

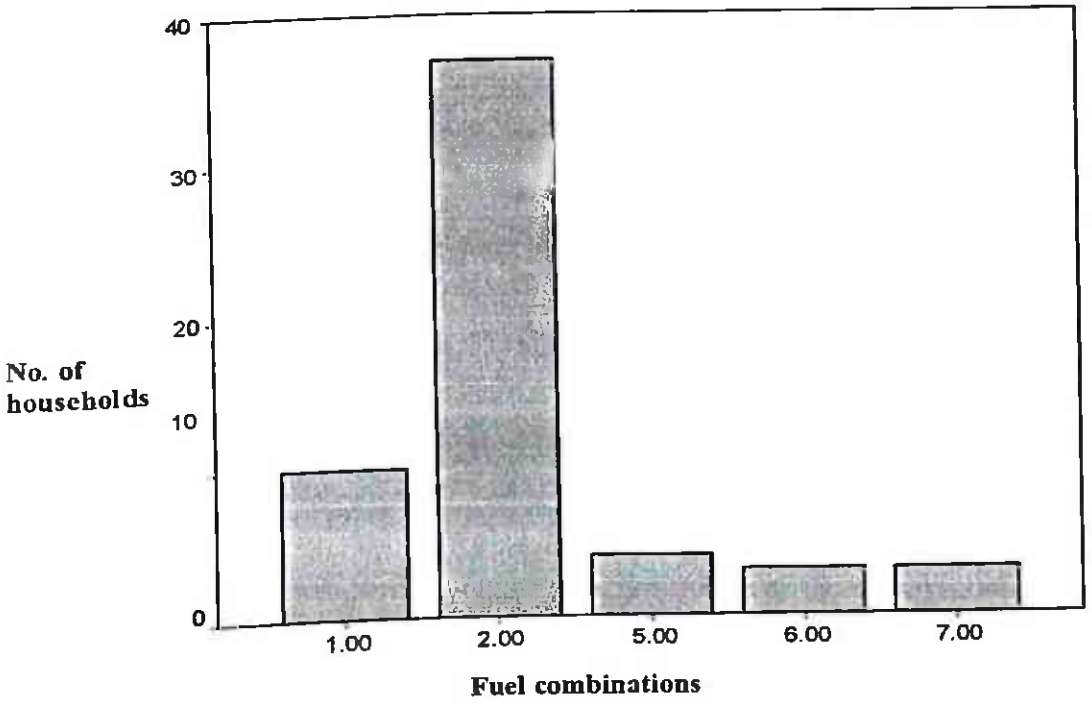
Households	Number	Percentage
Food secure	9	16
Food insecure	48	84
Total	**57**	**100.00**

In conclusion, the degradation of the ecosystem is severe to the extent that farms produce far below their potential, and consequently, the area is generally food insecure.

4.3.3 Household Fuel Supply

Another factor that affects livelihood in the study area is the supply of fuel. The types of fuel used in the area include fuel wood, charcoal, kerosene, gas, and solar.

The use of the above named fuel types is as shown in the graph below:



Graph 4.1Household energy supply in Kaketa

Key

1 – Use of fuel wood and kerosene
2 – Use of fuel wood, kerosene and charcoal
5 – Use of fuel wood, charcoal, kerosene, gas and solar
6 - Use of fuel wood, charcoal, kerosene, and gas
7 - Use of fuel wood, charcoal, kerosene, and solar

It is obvious from the graph above that fuel wood and kerosene are used in almost every homestead in the study area. Likewise, there is also wide use of charcoal. Kerosene is mainly used for lighting. The use of gas and solar is very rare. There is however, a lot of potential for solar in the area given the environmental conditions. The only limiting factor would be the investment costs given the high poverty levels in the area.

In the households of Kaketa Riverine Ecosystem, fuel is used for the following purposes:

- Cooking food
- Lighting houses
- Source of warmth during cold seasons (charcoal and firewood)

a) Testing of Hypothesis 3

H_o: Individual farms in Kaketa Riverine Ecosystem are able to meet the individual household fuel requirements.

H_1: Alternative.

In carrying out this investigation, self sufficiency of households as far as the supply of fuel wood as a source of energy is concerned, has been considered. This is because fuelwood is used in every household in the study area, and its supply directly affects livelihoods in addition to affecting the physical environment.

In asking the households whether they are self sufficient in fuel supply, the following result was obtained.

Table 4.8 Fuel wood supply status in Kaketa

Households	No. of households	Percentage
Self sufficient	21	37
Not self sufficient	36	63
Total	**57**	**100.00**

b) Interpretation

It is evident from the table above that most of the households in the area are not self sufficient in supply of fuel wood for their domestic use. The H_0 above is thus rejected and the H_1 adopted. This implies that the 63% of households source fuelwood from elsewhere such as buying from the neighbouring farms, or the market or getting from the forest.

c) Discussion on Fuel Supply in Kaketa

The inability of farms in Kaketa Riverine Ecosystem to adequately supply the households with adequate fuel wood is an indication of the extent of degradation in the ecosystem. A few farmers have realised the situation and have embarked on planting of trees specifically as a source of fuel wood, though at long last the trees tend to have a multiplicity of functions both economic and ecological. The tree species that have widely been adopted for planting in the area include *Croton megolocapus, Grevillia robusta*, the Wattle tree, Blue gum, Cypress, Pine, Eucalyptus and a few species of Acacia in addition to the indigenous naturally occurring tree species. Generally, the supply of wood fuel is affected by seasonality. The supply is good during dry season while it is down in the wet and cold season.

Planting of trees for fuel supply and for other uses is greatly affected by climatic conditions as the farmers experience a lot of problems in carrying out the same. It is evident that the unavailability of piped water in the area makes the farmers to be at the mercy of natural factors. This to a great deal negatively affects their livelihoods

4.3.4 Domestic Water Supply

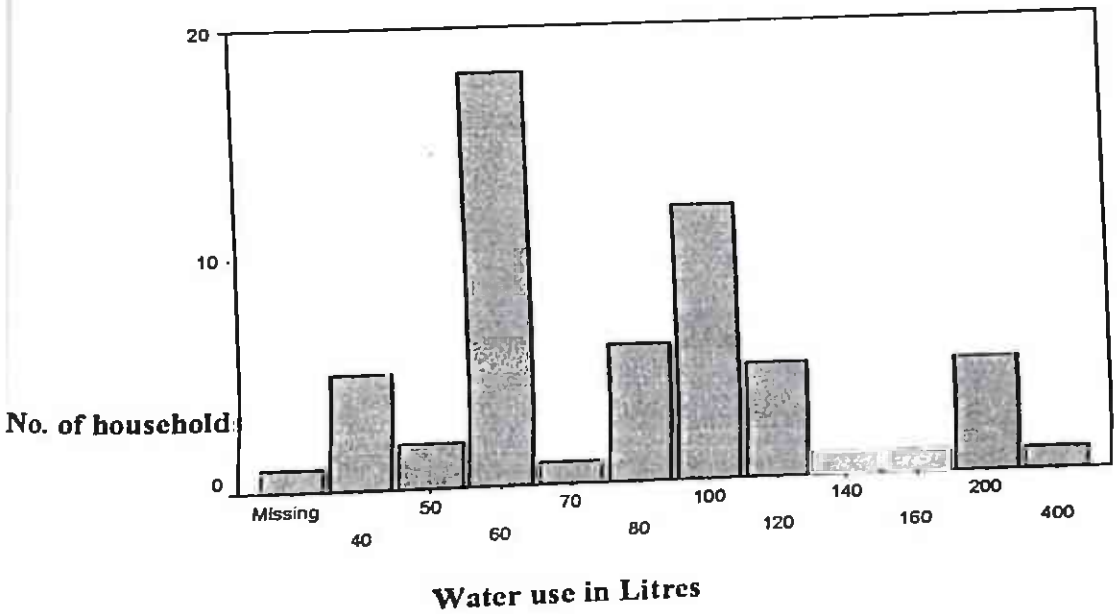
Water supply is an important factor that affects livelihoods in Kaketa Riverine Ecosystem and even elsewhere on the globe. Water is life and without it there is no life. It is a fundamental component accounting for 70% of the planet earth. It is therefore an important determining factor in quality of life.

The main source of water in the ecosystem is the Kaketa River. Other sources of water include wells, boreholes, stored rain water, and piped water from Mt. Kilimanjaro. The main uses of water include cooking, washing, and watering domestic animals.

Since the river is the main source of water for the households, people sometimes have to walk for long distances especially during dry seasons to fetch water. Fetching of water for use in the household is done by female members of the household. The male members assist occasionally.

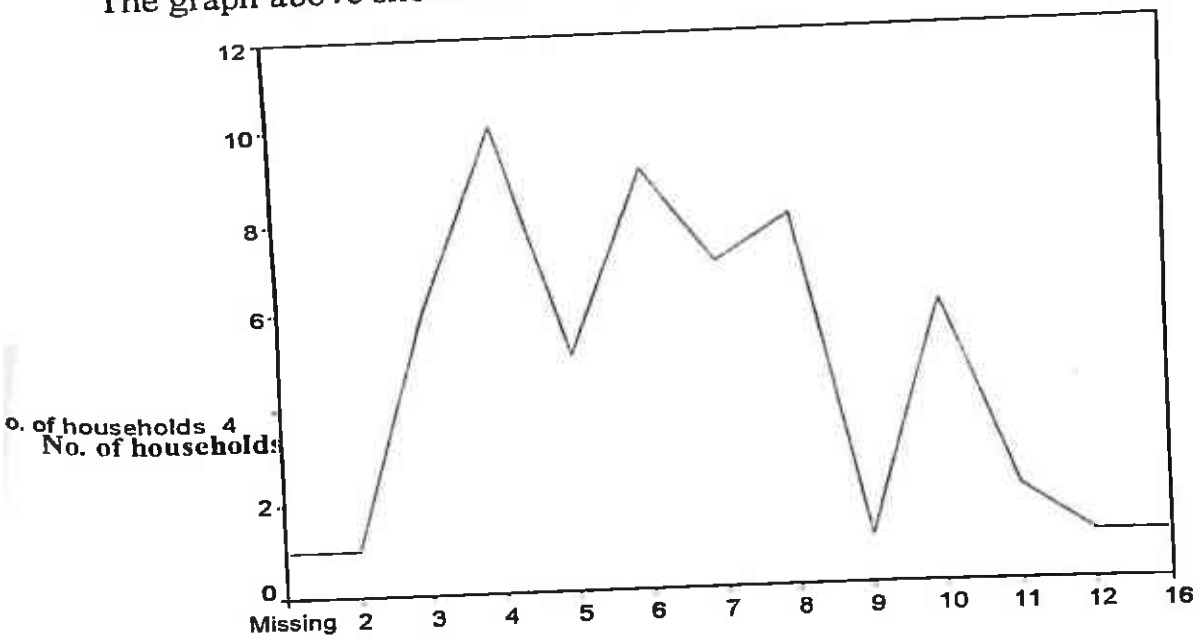
The time spent in fetching water varies a lot depending on the distance of the water source from the homestead. This also depends on the season of the year, as sometimes during dry periods some streams dry up. Households are forced to look for water far away. This could be as far as 10 km. The households spend between 30 minutes to 10 hours a day in fetching water for domestic use. On average the households of Kaketa area spend 3 hours a day in fetching water (Annex 2).

The study investigated the quantity of water used per household and related it to the household size as shown in the graphs below.



Graph 4.2 Distribution of water use by households in litres

The graph above shows the family size of households of Kaketa area



Graph 4.3 Household size in Kaketa

Having found out the family sizes of the households of the area and the quantity of water consumed in the same, the study carried out a regression analysis to find out the actual relationship between the two variables.

a) Regression Analysis

In finding out whether there is any linear association between the quantity of water used in individual households and the family size, the correlation coefficient was calculated. The dependant variable **Y** is the quantity of water used, while the independent variable **X** is the household size. The calculation has been aided by SPSS and the result is as shown below:

Model Summary

R	R^2	Std. Error of the Estimate
0.345	0.119	56.75

b) Interpretation

From the results above the conclusions can be made as far as the association between the water use and household size in Kaketa area is concerned:

- The association between the two variables water use (Y) and household size (X) is positive because R is positive. This means that the quantity of water use increases as the household size increases.

- The correlation between the two variables is not very strong as the value of R^2 is less than 0.5. This suggests that there could be other factors affecting water usage in the households other than the household size. These may include the distance to the water source, presence of domestic animals among others.

Significance of the Correlation Coefficient

To determine whether the correlation coefficient in a particular situation is significantly different from zero, that is, whether there is a significant degree of linear correlation between the variables X and Y.

d) Hypothesis 4 Testing

H_o: There is no significant linear correlation between the quantity of water used in and the family sizes of the households of Kaketa Riverine Ecosystem.

H_1: Alternative

As has been mentioned the significance of the correlation coefficient is determined and the t statistics is used in testing this hypothesis, such that:

$$t = r\sqrt{\frac{n-2}{1-r^2}} \qquad df = n - 2$$

The calculation is aided by SPSS and the result is as shown below:

df = 55, significance level = 0.05

t	Value
Calculated	2.73
Critical	2.01

In the analysis above, the calculated value is greater than the critical value, therefore, the H_o is rejected, while the H_1 is adopted that there is a significant linear correlation between the quantity of water used in and the family sizes of the households of Kaketa Riverine Ecosystem.

e) Domestic Water Use per Person per Day

The study also investigated the quantity of water use per person per day. This is because the association between the quantity of water use per day and the household size is not perfectly linear. This is emphasized by the big standard error in the calculation for the same. It is therefore prudent to acknowledge the variations in the quantity of water use per person per day and try to explain its existence in the households in the study area (the full list of the quantity of water used per person per day is appended in this report – annex 2).

e) Hypothesis 5 Testing

Ho: The ecosystem is able to adequately supply the community with water for domestic purposes.

H1: Alternative.

In validating this assumption the average water use per person per day in the study area is compared with the quantity of water per person per day as per water planning guidelines by the Ministry of Water and Irrigation for the Medium Potential Rural Areas which is 15 litres.

The analysis aided by SPSS gives the following results:

N	Minimum	Maximum	Mean	Std. Deviation
55	5.00	33.34	14.8751	7.3480

f) Interpretation

From the table above, the minimum water use per person per day for Kaketa Riverine Ecosystem is far much below the minimum quantity estimated by the relevant Ministry. However, the average quantity of water use per person per day is slightly below the established quantity by the Ministry of Water and Irrigation. As such, the research assumption of the ecosystem being able to adequately supply the community with water is rejected. However, it is wise to investigate the same assumption having in mind that the farmers keep domestic livestock, and the quantity of water used for watering the livestock would also add to the high average quantity realized in the present study. Therefore, the conclusion of this study is that the study area is not water secure.

4.4 General Discussions on Land Degradation in Kaketa

4.4.1 An Overview

Land degradation can be defined in many ways. It may be broadly defined as any form of deterioration of the natural potential of land that affects ecosystem integrity either in terms of reducing its sustainable ecological productivity or in terms of its native biological richness and maintenance of resilience. In brief, it is any change in the land that reduces its condition or quality and hence its productivity or productive potential. It occurs whenever the natural balances in the landscape are changed by human activity, through misuse or overuse (Williams 1991; Cocks 1992). Put another way, it is the result of using land and other resources beyond their capability. It is a worldwide phenomenon substantially affecting productivity in many countries on all continents, except Antarctica. Land degradation is especially serious in Africa where a number of countries face dryland degradation or desertification. There are obviously many causes and land degradation takes many forms.

In Kaketa Riverine Ecosystem land degradation is evident and the following can be identified as the various forms of land degradation in the ecosystem:

- Wind erosion
- Water erosion including gullying, rill and sheet erosion, and to some extent mass movements of hill slopes.
- Soil fertility decline and nutrient loss.
- Loss of flora and fauna and hence of biodiversity.

4.4.2 Land Degradation in Kaketa Riverine Ecosystem

Most forms of land degradation experienced in Kaketa are natural processes accelerated by human activities. Land degradation is an insidious disease in the area and it is threatening to kill the ecosystem.

The quantity and availability of water in Kaketa River is a real litmus test on how well the land within the water catchment has been and is being managed. Soil, water, vegetation and animal/human activity are inextricably linked and their interaction dictates whether the management of the land is ecologically sustainable.

The causes of land degradation in Kaketa Riverine Ecosystem include the following:

a) Land fragmentation:

Land fragmentation is the sub division of land into very small sizes. The households in the Kaketa ecosystem own very small farms. This has resulted from subdivision as a result of the rapid population growth experienced in the area. This situation has resulted in reduced production as it discourages implementation of any meaningful activity in the farms.

b) Over-cultivation of land:

Over cultivation involves cultivating the same piece of land repeatedly for a long time without allowing it to remain fallow for nutrients regeneration. Farms in Kaketa Riverine Ecosystem are poor, the crops are sickly and yield very low compared with the potential yield for the area (as has been stated elsewhere in the report). The area has two growing seasons for crops and the same piece of land is used throughout the year. This to a greater extent has caused and encouraged degradation of the ecosystem.

c) Cultivation of very steep hill sides (slopes)

The available land for cultivation is very small. This has resulted to cultivation of hill sides which consist of very steep slopes. Cultivation of the steep slopes accelerates soil erosion in the area with its devastating consequences, which in the long run turns the hill sides and farm lands to be wastelands. This has adverse environmental and socio-economic impacts.

Plate 5: Steep hill sides in Kaketa under cultivation

d) Cultivation and planting of crops along river banks and within the river valleys:

In the Kaketa Ecosystem the farmers whose farms border Kaketa River have invaded the river bank and planted crops even right at the river bed in some instances. This has enormously accelerated river bank erosion and water depletion in the Kaketa River. In addition, there are many diversions of water along the river which has also led to the depletion of water resources making the resource unavailable for other users downstream.

Plate 6: Cultivation of vegetables, along the river bank including the riparian area.

Plate 7: A section of Kaketa River completely under sugarcane

e) Clearing of trees for timber, fuel and other uses:

The once green and biodiversity rich ecosystem is presently a degraded land as trees have over the years been cleared to give room for farm lands and settlement for the growing population. The ecosystem is currently lacking in natural vegetation with its

rich biodiversity. The only vegetation in site is unhealthy crops and few planted trees which are purposely planted for fire wood provision.

This degradation as discussed above, has translated into the process of desertification as discussed below.

4.4.3 DISCUSSION

Desertification is land degradation in arid, semi arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities (United Nations Convention to Combat Desertification or UNCCD, art.1, pg. 3).

Desertification is a problem of global dimension and a serious obstacle to sustainable development in the world's drylands. Drylands cover about 54 million sq. km or 40% of the world's land area, and are home to over 1 Billion people, the large majority of whom live in developing countries. Kenya for instance has about 88% of its land area being categorized as drylands, and a good portion of this is either a desert or at present undergoing the process of desertification (NAP- Kenya 2002). The impacts of desertification and drought on human life in dryland regions are very severe as almost all of the poor depend directly on land, what they grow, breed livestock, and gather or catch as is the case with study area.

4.4.3.1 Causes and Consequences of Desertification

The causes of desertification in Kaketa Riverine Ecosystem are diverse, ranging from natural conditions such as vulnerable soils, vegetation and climatic variations to human activities. Man-made causes include expansion of agriculture, over-cultivation and deforestation. Other causes include the under-valuation of traditional know-how, inappropriate government policies, weak institutions, increasing population pressure and poverty.

4.4.3.2 Environmental Consequences of Desertification:

The degradation of the Kaketa Ecosystem and the on-going desertification in the area has had negative environmental consequences. These include:

- Reduction of land's resilience to climatic variations;
- Loss of top soil and fertility through water and wind erosion;
- Loss of biodiversity. This is because dryland species are highly adaptable to environmental stress, they are a vital source for drought and disease resistant crop varieties;
- Local and regional climatic changes due to rising temperatures and reduced moisture levels, inducing changes in climate and atmospheric circulation.

4.4.3.3 Social and Economic Impacts of Desertification:

In addition to the negative consequences on the physical environment, desertification has also been associated with socio-economic aspects in Kaketa area. These include:

- Loss of income: Globally it is estimated that desertification results in lost income of more than $US 42 billion per year (UNEP 2003). In Kaketa residents hardly get any income.
- Aggravation of poverty as the community lose their assets and sources of income;
- Migration of the work force in search of income. This is evident as most of the active population in the area migrates to live and carry out business in the local market centre and other neighbouring towns such as Salama, Kilome, Machakos and Kitui among others. Others also seek employment in Nairobi and other big towns in Kenya;
- Limited access to firewood, drinking water, agricultural land etc., and placing heavy burdens particularly on women. This has already been seen especially with the long hours spent in fetching water.

4.4.3.4 Remedial Measures

Land degradation has both poverty and global environment dimensions. Sustainable solutions require financial support for interventions that address both dimensions. Therefore, countries should seek to integrate sustainable land management practices into their priority national sustainable development frameworks such as National Development Plans, Poverty Reduction Strategy Papers (PRSPs), and comprehensive development framework. Such integration would facilitate coordinated mobilization of funding for successful implementation of cost-effective and sustainable programs especially in the vulnerable drylands.

Many land degradation prevention and control programs were largely based on a Sector-by-sector approach and this had the unintended effect of fragmenting policies, institutions, and on-the-ground measures. Successful land degradation prevention and control, therefore, require scientifically sound and cross-sectoral approaches to land management. This would integrate the ecological, economic, and social dimensions of land degradation issues in program design.

Development and implementation of programs and projects to address land degradation are most successful when effective participation of stakeholders, including women, occurs at all stages. Early intervention in areas vulnerable to land degradation such as ecologically sensitive marginal lands like the Kaketa Riverine Ecosystem is essential in preventing and controlling land degradation. An appropriate enabling environment, including policies, regulations, and economic incentives to support sustainable land management is necessary for effective local, national, and international response in solving the problem of land degradation.

In Kaketa area the farmers make efforts to manage the degraded ecosystem. They do reforestation especially for water catchment and for fuel, terracing, use trash lines, contour farming, practice crop rotation and use of organic manures.

To ensure success of these efforts to manage life in the degraded environment, the community needs support, both technical and financial, from the government, Non Governmental Organizations and other relevant groups. It is therefore, necessary for

the government to consider Kaketa Riverine Ecosystem in particular and the fragile dryland ecosystem in general as environments which require urgent attention as far as rehabilitation of degraded ecosystems is concerned.

Specifically, the relevant government ministry should get in touch with the community in the line of practicing sustainable agriculture. This would ensure continuity of life as well as reducing threat to the environment. Sustainable agricultural practices can help to improve and sustain the productivity of rain - fed agriculture. This may involve crop diversification to reduce the risk of failure; introduction of high-yielding and drought tolerant crop varieties; adoption of mixed cropping systems; crop rotation to recycle soil nutrients; water harvesting; and improved access to credit, extension, and marketing services.

These interventions would have additional benefits related to the conservation of biological diversity; sequestration of soil carbon; and reduction in carbon dioxide emissions.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Findings

- The mean production of maize in Kaketa area is far much below the mean consumption of the same. The farms in Kaketa Riverine Ecosystem do not produce adequate food for the households. Only 16% of the households are food secure. The rest, 84 % are food insecure and thus have to depend heavily on local markets, and the very unpredictable and inadequate relief food supply from the government or other support agencies.

- Generally, the farms in Kaketa Riverine Ecosystem are not self - sufficient in fuel supply. Only 37% of the households are self sufficient in woodfuel supply. 63% of the households source woodfuel from elsewhere including buying from the neighbouring farms or the market, or getting from the nearby gazetted forest.

- About 50% of the residents do not adequate water for domestic use. Kaketa River is the major source of water used by the households. Sometimes people have to walk for as long as 10km, especially during dry season, to fetch water. Fetching of water for use in the household is done by female members of the family. The male members assist in very rare occasions.

- Most forms of land degradation experienced in Kaketa area are natural processes accelerated by human activities, which include; land fragmentation, river bank and river bed cultivation, over-cultivation of the available land, cultivation of along steep slopes, monoculture, and clearing of trees for settlement, timber and fuel

- Local efforts by farmers in Kaketa area to manage their degraded ecosystem include practices like reforestation, contour ploughing, terracing, trash lines, and use of organic manure to improve fertility of the land.

5.2 Conclusion

Land degradation adversely affects the ecological integrity and productivity of about 2 Billon Ha or 23% of landscapes under human use. Agricultural lands in both dryland and forest areas have been most severely affected by land degradation. They cover about one-fourth of the world's total land area and account for 95% of all animal and plant protein and 99% of calories consumed by people. About two-thirds of agricultural land has been degraded to some extent during the last 50 years (UNDP, 2003).

The negative impacts of land degradation are both ecological and socioeconomic. Land degradation undermines the structure and functions of ecological systems such as the biogeochemical cycles (i.e. carbon, hydrological, and nutrient cycles) that are critical for the survival of human beings. This impact has already put at risk the livelihoods and economic wellbeing, and the nutritional status of more than 1 billion people in developing countries. The socioeconomic impacts of land degradation include; loss of income, aggravation of poverty as the community loses their assets and sources of income, migration of the work force in search of income, and limited access to firewood, drinking water, agricultural land etc., placing heavy burdens particularly on women.

Early intervention in areas vulnerable to land degradation such as ecologically sensitive marginal lands like the Kaketa Riverine Ecosystem is essential in preventing and controlling land degradation. An appropriate enabling environment, including policies, regulations, and economic incentives to support sustainable land management is necessary for effective local, national, and international response in solving the problem of land degradation.

Development and implementation of programs and projects to address land degradation are most successful when effective participation of stakeholders, including women, occurs at all stages. It is therefore clear that it is community action that will bring about real change more than what the government can do.

5.3 Recommendations:

5.3.1 for Policy Makers

- The Government through the Ministry of Agriculture should fully enforce the Agriculture Act, Cap 318 of 1965 to ensure conservation and protection of water courses. The Act states in part that "*any person who, except with written permission of an authorized officer, cultivates or destroys the soil, or cuts down any vegetation or depastures by any livestock, on any land lying within 2 metres of water course more than two metres wide, within a distance equal to the width of that water course to a maximum of 30 metres, shall be guilty of an offence*".

- The Government through the Ministry of Water and Irrigation should enforce the Water Act, Cap 372 to address the many diversions and intakes present in Kaketa River. This would ensure that the resource is also available to the downstream users. Efforts should be made to revive the stalled / abandoned water project. Individual water abstractions and diversions need to be reviewed visa vis providing water to the people through the project.

- Indiscriminate cutting down of trees for timber, charcoal, firewood and other purposes should be checked by the relevant government authority to ensure sustainable use of the resource. Efforts should be made to promote establishment of more suited trees for fuel wood supply such as *Cassia Siamea*, *Cassia Siamea* and *Acacia Albida*.

- The Agricultural Extension Officers in the Kaketa area and in other fragile ecosystems in the country should liaise with the local farmers and equip them with the necessary knowledge on sustainable agricultural practices relevant to their local conditions.

- There is need to promote production of dryland crops in the area. The food insecurity is compounded by the fact that the residents depend so much on maize as their staple food. The potential for maize in the area is low, and is made worse by the fact that farmers plant varieties that are not suited for the

area. Efforts to promote production and consumption of better suited crops like sorghums, millets and pigeon peas should be put in place to improve general food supply in the area. The specific varieties suited for these areas should be promoted.

- The Government should come up with a long lasting solution to the food problems in Kaketa area and other areas which experience food insecurity within the country. Relief food should be discouraged except in emergencies. Investments in sustainable approaches and technologies, such as harvesting of rain water for crop production need be emphasized.

5.3.2 For Future Researchers

- There is need for future researchers to carry out relevant scientific and laboratory tests on soil to establish soil fertility status in order to give accurate guidelines that would help increase soil productivity and yields.
- There is need to assess the status of water supply in the area taking into account other uses within the households such as watering of domestic animals.

BIBLIOGRAPHY

AACM International (1995): *Social and Economic Feasibility of Ameliorating Soil Acidification*: A national review. Land and Water Resources Research and Development Corporation, Canberra.

ABS (1996): *Australians and the Environment. Catalogue No. 4601.0.* Australian Bureau of Statistics, Canberra.

Adera B A, (1996): *The occurrence of agricultural drought and its impact on maize production in Kisumu District*

ANCA (1995): *Environmental Weeds in Australia.* Australian Nature Conservation Agency, Canberra.

Anon. (1996): *Managing Australia's Vegetation*: A community perspective. Greening Australia, Canberra.

Anon. (1997): *Natural Heritage Trust*: A better environment for Australia in the 21st Century. Environment Australia, Canberra.

Bailey, N. T. (1981): *Statistical Methods in Biology.* Hodder and Stongton, London

Barson, M. *et al.* (1993): *Opportunities for Regional Rural Adjustment.* Bureau of Resource Sciences, Canberra.

Bonyhady, T. (1995): *"Cracks in the canvas".* Sydney Morning Herald, September 23.

CALM (1995): *Conservation or Degradation of Land*: what is the cost? Department of Conservation and Land Management, Sydney.

Cocks, D. (1992): *Use With Care*: managing Australia's natural resources in the twenty first century. New South Wales University Press, Sydney.

Dalziell, I. & Poulter, D. (1992): *The economics of land degradation*: the case of acid soils. 36th Conference of the Australian Economics Society, ANU, Canberra.

Dugan, P. (1993): *Wetlands in Danger: A world Conservation Atlas.* London: Mitchell Beazley.

Edwards, P.D. & Joyce, R.B. (Editors) (1967): *Anthony Trollope's Australia.* University of Queensland Press, St. Lucia. First published 1873 in Australia and New Zealand by Chapman & Hall, London.

Francis, J. (1997): "*Understorey helps to halt dieback*". Australian Farm Journal Sustainable Agriculture, September, 14-15.

Francis, P. (1995): "*Grazing Strategy Combines Profit and Sustainability*". Australian Farm Journal Wool, November, 19-21.

Gideon, G. (1978): *Planning Urban sites in Arid Regions; The basic consideration in Urban Planning for Arid Zones, Americas Experience & Direction.* New York; John Wiley & Sons

Gikonyo, J M, (2004): *The Effects of Biomass Energy Use by Rural Households in a Dryland Environment.* A Case Study of Mwingi District. MA thesis, University Of Nairobi.

Glanznig, A. *et al.* (1995): *Native Vegetation Clearance, Habitat Loss and Biodiversity Decline.* Biodiversity Series Paper No. 6. Department of Environment, Sport and Territories, Canberra.

Goodman, A.S. (1984): *Principles of Water Resource Planning.* Prentice Hall.

Graetz, R.D. *et al.* (1995): *Landcover Disturbance Over the Australian Continent*: a contemporary assessment. Biodiversity Series Paper No. 7. Department of Environment, Sport and Territories, Canberra.

Graham, O.P. *et al.* (1989): *Land Degradation Survey, New South Wales 1987-1988.* Soil Conservation Service of New South Wales, Sydney.

Hamblin, A. & Kyneur, G. (1993): *Trends in Wheat Yields and Soil Fertility in Australia.* Bureau of Resource Sciences / Australian Government Publishing Service, Canberra.

Haslam, S. M. (1978): *River Plants. The Macrophytic Vegetation of Water Courses.* Cambridge University Press

Jacobs, S. (1988): *A Graziers Guide to the Saltbush Plains Country of Western New South Wales*. Soil Conservation Service of NSW, Sydney.

Karssies, L. & East, J. (1997): "*Australia's Cereal Producing Lands*: the state of the resource base". Agricultural Science, 10(2), 33-39.

LWRRDC (1995): *Data Sheets on Natural Resource Issues*. Occasional Paper No. 06/95. Land and Water Resources Research and Development Corporation, Canberra,

LMTF (1995): *Managing for the Future: report of the Land Management Task Force.* Rural Division, Commonwealth Department of Primary Industries and Energy, Canberra.

Mavuti, K. M (1981): *Wetlands and Shallow bodies in Kenya: Characteristic and general status of Knowledge*. Msc thesis, University of Nairobi

MDBMC (1987): *Murray-Darling Basin Environmental Resources Study*. Murray-Darling Basin Ministerial Council, Canberra.

Michael J. Stephen P, and Marc S: *The Systematic Reconnaissance Flight (SRF) as a tool in Assessing Ecological Impacts of Rural Development Programme in an Extensive area of the Lawveld of South Africa.* Source African Journal of Ecology bvol. 37, issue 4 pg 449-56 Dec 1999.

Ministry of Agriculture, *Kilome division annual reports for 1999, 2000, 2001 and 2004.*

Mugenda O.M and Mugenda, AG (1999): *Research Methods: Quantitative and Qualitative Approaches.* Acts Press, Nairobi

Mwaura F, (1992): *Some Aspects of Hydrochemistry, Lake Level and Vegetation Dynamics in the Lake Elementaita Basin, Rift Valley.* Msc thesis, University of Nairobi

Haslam, S. M. (1978): *River Plants. The Macrophytic Vegetation of Water Courses.* Cambridge University Press

Jacobs, S. (1988): *A Graziers Guide to the Saltbush Plains Country of Western New South Wales*. Soil Conservation Service of NSW, Sydney.

Karssies, L. & East, J. (1997): "*Australia's Cereal Producing Lands*: the state of the resource base". Agricultural Science, 10(2), 33-39.

LWRRDC (1995): *Data Sheets on Natural Resource Issues*. Occasional Paper No. 06/95. Land and Water Resources Research and Development Corporation, Canberra,

LMTF (1995): *Managing for the Future: report of the Land Management Task Force.* Rural Division, Commonwealth Department of Primary Industries and Energy, Canberra.

Mavuti, K. M (1981): *Wetlands and Shallow bodies in Kenya: Characteristic and general status of Knowledge*. Msc thesis, University of Nairobi

MDBMC (1987): *Murray-Darling Basin Environmental Resources Study*. Murray-Darling Basin Ministerial Council, Canberra.

Michael J. Stephen P, and Marc S: *The Systematic Reconnaissance Flight (SRF) as a tool in Assessing Ecological Impacts of Rural Development Programme in an Extensive area of the Lawveld of South Africa.* Source African Journal of Ecology bvol. 37, issue 4 pg 449-56 Dec 1999.

Ministry of Agriculture, *Kilome division annual reports for 1999, 2000, 2001 and 2004.*

Mugenda O.M and Mugenda, AG (1999): *Research Methods: Quantitative and Qualitative Approaches.* Acts Press, Nairobi

Mwaura F, (1992): *Some Aspects of Hydrochemistry, Lake Level and Vegetation Dynamics in the Lake Elementaita Basin, Rift Valley*. Msc thesis, University of Nairobi

Nyamasyo G.H.N, (2003): *A new vision in working with communities in sustainable Dry land Biodiversity Management for income generation, food security and reduced vulnerability to drought.* Paper presented during the Regional Workshop on Sustainable Biodiversity Management for Reduced Community Vulnerability to drought, at Lake Bogoria Hotel, Kenya 1st-3rd October, 2003

Ngechu, M. (2000): Understanding the Research Process and Methods – An Introduction (First Edition).

Noble, J.C. (1997): *The Delicate and Noxious Scrub*: CSIRO studies on native tree and shrub proliferation in the semi-arid woodlands of Eastern Australia. CSIRO Division of Wildlife and Ecology, Canberra.

Nyangaga J M, *Effects of agricultural practices on water quality in RIANA River Catchment.* Msc thesis, University of Nairobi

Omukoba, Winston Ouma, (1999), *Effects of damming on the Sosian River Ecosystem: an environmental impact Assessment.* Msc thesis University of Nairobi

Powell, J.M. (1993): *The Emergence of Bioregionalism in the Murray-Darling Basin.* Murray-Darling Basin Commission, Canberra.

Pratt, D.I. and Gwynne, M. D. (1977): *Rangeland Management and Ecology in East Africa.* Robert Kriegen Publishing Company London.

Republic of Kenya, (1994), *National Environment Action Plan (NEAP).*

Republic of Kenya, (2002), *National Action Programme (NAP – A Framework for Combating Desertification in Kenya. Government Press, Nairobi.*

Roberts, R. D. and Roberts, T. M. (1984): *Planning and Ecology.* Chapman and Hall Publishers, London.

Robin, P. White and Janet Nickoney (2003): *Drylands, People & Ecosystem Goods & Services: A wed Based Geospatial Analysis.*

Spouncer, L.R. . (1996): *Allocation of Acidity Profile Classes to Atlas of Australian Soils Mapping Units*. CSIRO Division of Soils Technical Report 20/1996. Land Assessment and Policy Unit, CRC for Soil and Land Management, Adelaide.

Thenya T, (1998): *Some ecological aspects, Bio-economic values and Human impact on a tropical papyrus wetland, Ewaso Narok Swamp, Laikipia District, Kenya*. Msc thesis University of Nairobi

UNGA, (1994), *Convention to Combat Desertification*

United Nations, (1992), *Agenda 21: Programme of Action for Sustainable Development*.

United Nations (1992): *Convention on Biological Diversity*.

Williams, J. (1991): *"Search for Sustainability: Agriculture and its Place in the Natural Ecosystem"*. Agricultural Science, 4(2), 32-39.

Annex 1

MAIZE PRODUCTION AND CONSUMPTION IN KAKETA

Serial no.	No. of persons	Yield/ Ha	Size of farm in Ha.	Area under maize in Ha	Total production in Kgs	Consumption in Kgs.
1	7	450	1.0	0.8	360	1825
2	5	1125	2.0	0.2	225	1632
3	4	450	1.6	1.6	720	810
4	7	450	2.0	1.6	720	1464
5	8	2500	12.0	6.1	15300	990
6	6	540	1.2	0.6	324	2920
7	7	1080	0.8	0.6	648	1098
8	8	900	0.2	0.02	22	1825
9	5	1000	2.0	0.1	100	910
10	5	675	1.2	0.4	270	480
11	2	720	0.3	0.1	90	432
12	10	1080	0.6	0.4	432	1350
13	4	990	0.6	0.4	396	500
14	7	900	1.2	0.6	540	780
15	4	312.5	2.0	0.1	374	730
16	8	225	0.8	0.4	90	1456
17	3	225	0.8	0.4	90	744
18	4	75	0.1	0.4	30	816
19	8	900	0.1	0.1	90	988
20	3	720	0.75	0.2	360	450
21	5	300	0.1	0.1	30	730
22	8	900	3.0	1.0	900	364
23	10	900	3.0	0.1	90	1350
24	6	240	1.0	0.16	135	390
25	6	900	2.5	1.0	900	900
26	7	1080	3.2	2.0	2160	3010
27	4	1350	0.4	0.1	270	365

28	6	675	0.8	0.4	270	665
29	3	133	0.8	0.6	80	730
30	8	1125	3.2	0.8	900	1095
31	4	1800	0.2	0.1	180	895
32	10	450	1.2	0.8	360	3650
33	9	450	0.1	0.1	45	1095
34	11	900	2.0	0.5	180	2160
35	4	1800	0.8	0.6	1080	360
36	4	2250	0.8	0.4	900	-
37	10	1200	2.0	0.6	720	730
38	4	1200	1.2	0.6	720	730
39	10	675	0.8	0.4	270	-
40	12	135	1.2	1.0	135	1825
41	3	1080	2.5	1.0	1080	360
42	6	675	2.8	1.6	1080	1825
43	7	275	0.4	0.2	55	720
44	6	900	1.6	0.8	720	1460
45	11	900	1.2	0.6	540	2190
46	6	900	0.8	0.4	360	1460
47	10	450	0.8	0.2	90	2190
48	3	1350	0.8	0.4	540	90
49	6	300	0.8	1.2	360	1460
50	7	1350	0.4	0.5	540	780
51	8	720	0.8	0.6	432	2190
52	16	2250	1.2	0.4	900	3650
53	5	270	2.0	2.0	540	180
54	3	3600	0.2	0.1	360	520
55	4	300	0.4	0.2	60	312
56	6	450	0.2	0.2	90	1095
57	6	700	0.2	0.2	140	900

Annex 2

WATER CONSUMPTION IN KAKETA HOUSEHOLDS

Serial No.	No. of Persons in the Households	Total water consumed in Litres	Consumption per Person per Day in Litres.	Time taken to fetch water in Hours
1	7	40	5.71	1.33
2	5	100	20	5
3	4	200	50	10
4	7	120	17.14	1.5
5	8	120	15	3
6	6	60	10	2
7	7	60	8.57	1
8	8	60	7.5	1
9	5	80	16	1.33
10	5	60	12	3
11	2	40	20	0.5
12	10	100	10	1.5
13	4	60	15	1
14	7	70	10	5
15	4	80	20	4
16	8	40	5	0.33
17	3	100	33.34	0.83
18	4	60	15	1.5
19	8	80	10	2
20	3	60	20	1
21	5	60	12	1.5
22	8	120	15	3
23	10	200	20	5
24	6	160	26.67	4
25	8	100	12.5	2.5
26	7	120	17.14	3

27	4	40	10	2
28	6	60	10	3
29	3	40	13.33	1
30	8	60	7.5	1
31	4	60	15	4.5
32	10	100	10	2
33	9	60	6.67	1.5
34	11	100	9.09	3.75
35	4	120	30	2
36	4	50	12.5	4
37	10	50	5	1.5
38	4	60	15	1.5
39	10	80	8	4
40	12	400	33.33	10
41	3	100	33.33	2
42	6	200	33.33	5
43	7	60	8.57	0.5
44	6	80	13.33	3.5
45	11	100	9.09	3.5
46	6	100	16.67	2.5
47	10	200	20	5
48	3	200	66.67	4
49	6	80	13.33	2
50	7	60	8.57	1.5
51	8	100	12.5	1.25
52	16	140	8.75	7
53	5	100	20	2.5
54	3	60	20	1
55	4	60	15	2
56	6	100	16.67	5
57	6	60	10	3

Annex 3

QUESTIONNAIRE TO HOUSEHOLDS

UNIVERSITY OF NAIROBI

DEPARTMENT OF GEOFRAPHY AND ENVIRONMENTAL MANAGEMENT

MA ENVIRONMENTAL PLANNING AND MANAGEMENT

Kaketa Riverine Ecosystem, Kilome Division of Makueni District

Questionnaire to Households

Preliminary information

Environmental degradation and related impacts have become subjects of interest in the recent past. This questionnaire is part of a research aimed at evaluating the impacts of degradation on Kaketa Riverine Ecosystem on people's livelihoods. The researcher is a post-graduate student at the University of Nairobi. Your accurate responses to the questions below will enable the researcher to complete the study. Note that the information you give will be treated in confidence and will only be used for the purpose of this study.

Instructions on completing the questionnaire

Put a cross (×) in the box against the response(s). In cases where there is more than one response to a question, mark all the appropriate responses. *Where the response falls under other remember to specify in each case*

PART 1: PERSONAL INFORMATION

1.1. Name _____

1.2. Sex [ ] Male [ ] Female

1.3. Age (years) _____

1.4. Position in the household

(i) [ ] Husband/ father (ii) [ ] Wife/ mother (iii) [ ] Son

(iv) [ ] Daughter (v) [ ] Relative (vi) [ ] Employee (vii) [ ] Other

1.5. No. in the household _____

1.6. Age composition of the family

i. Below 10 years_____ ii. 10 to 18 years _____

iii. Over 18 years _____

1.7. Religion (i) [ ] Christian (ii) [ ] Muslim (iii) [ ] None

(iv) [ ] ATR (African Traditional Religion (v) [ ] Other

1.8. Occupation (i) [ ] Faming (ii) [ ] Trading (iii) [ ] Employed in farms

(iv) [ ] Employed off farm (v) [ ] other

PART 2: FOOD PRODUCTION AND SUPPLY WITHIN THE HOUSEHOLD

The purpose of this section is to get information related to food supply, production, and related production factors. It also looks at the main food sources, and how farm produce is utilized and / or disposed.

2.1. Size of the land parcel in Ha _____

2.2. List the main enterprises in the farm in order of importance (starting with the most important) and indicate their sizes in Ha

Enterprise	Area in Ha	Enterprise	Area in Ha
1.		5.	
2.		6.	
3.		7.	
4.		8.	

2.3. In the table below list the ***main food crops*** consumed in the household in order of importance in the first column. Indicate approximate quantities of each that are consumed in the household per year in kg (kilogrammes) in the small brackets. Use the other columns provided to indicate the source(s) of each food item

Food item and approximate quantity Consumed per year in kg ( )	Own farm	Rented farm	Market	Relief	Relatives	Other (specify)	Remarks
1. ( )							
2. ( )							
3. ( )							
4. ( )							
5. ( )							
6. ( )							
7. ( )							

2.4. In the table below list the main crops grown in the farm in order of importance. Indicate the area under each in Ha and yields in kg/Ha in 2nd and 3rd columns respectively. Use the last column for any relevant remarks

Crop enterprise	Area in Ha	Yield in kg/Ha	Remarks
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			

2.5. What method(s) of crop production is/ are used in the farm?
(i) [ ] Irrigation (ii) [ ] Rain fed (iii) [ ]
Other_____

2.6. Are there farm inputs are used in the farm to improve soil fertility?
(i) [ ] Yes (ii) [ ] No (ii) I don't know

2.7. If Yes to 2.4. above indicate which ones
(i) [ ] Inorganic fertilizers (ii) [ ] Manures
(iii) [ ] Other_____

2.8. What other cultural soil management practices are employed in the farm
(i) [ ] terracing (ii) [ ] Trash lines (iii) Crop rotation
(iv) contour farming (v) [ ]
Other_____

2.9. How is the produce from the farm used / disposed following harvest
(i) [ ] Stored for future use (ii) [ ] Sold (iii) [ ] Processed at farm
(iv) [ ] Exchanged with other items
(v) [ ]
Other_____

2.10. If any storage in the farm indicate whether the stored produce is preserved in any way (i) [ ] Yes (ii) [ ] No (iii) [ ] I don't know

2.11. If Yes to above, indicate in which way _____

_____

2.12. Is the farm able to produce enough food to meet the household's requirement?
(i) [ ] Yes (ii) [ ] No (ii) [ ] I don't know

2.13. If answer to 2.9. is No, indicate how the deficit is met
(i) [ ] Market sources (ii) [ ] From relatives
(iii) [ ] Relief (iv) [ ] Other

_____

2.14. What do you consider to be the main limiting factors to food production in this farm? (i) [ ] Soil fertility (ii) [ ] Seed quality/ supply
(iii) [ ] Rainfall reliability (iv) [ ] Knowledge on various agronomical practices
(v) [ ] Other

_____

PART 3: HOUSEHOLD FUEL SUPPLY

This is section seeks to get information on types and sources of fuels used by the households, status of their supply and related limiting factors.

3.1. What types of fuels are used in the household?
(i) [ ] Fuel wood (ii) [ ] Charcoal (iii) [ ] Gas (iv) [ ] Kerosene
(v) [ ] Electricity (vi) [ ] Solar (vii) [ ] Other

_____

3.2. Rank the fuels used by the household in order of importance
(i) (v)
(iii) (vi)
(iii) (vii)
(iv)
(iv)

3.3. How much fuel wood is consumed by the household per year in tons (approx)

_____

3.4. What is the source of this fuel wood?
(i) [ ] Own farm (ii) [ ] Bought from other farms
(iii) [ ] Neighbouring forest (iv) [ ] Other _____

3.5. Is the supply of fuel wood affected by seasonality?
(i) [ ] Yes (ii) [ ] No (iii) [ ] I don't know

3.6. If response to 3.5. is yes, indicate how

_____

_____

3.7. Does the farm have any trees specifically for fuel supply?
(i) [ ] Yes (ii) [ ] No (iii) [ ] I don't know

3.8. If the answer to 3.7. is yes. Indicate the types of trees and their respective numbers

Type of tree	Number	Remarks

3.9. Does the farm have an established routine for planting trees for fuel supply?
(i) [ ] Yes (ii) [ ] No (iii) [ ] I don't know

3.10. Does the farm experience any problems with supply of fuel?
(i) [ ] Yes (ii) [ ] No (iii) [ ] I don't know

3.11. How do you think these problems could be solved?
(i) _____

(ii) _____

(iii)_____

(iv) _____

PART 4: DOMESTIC WATER SUPPLY

The purpose of this section is to get information on domestic water. This includes the sources, uses, constraints and any efforts to address the constraints.

4.1. What are the sources of water consumed in the household?
(i) [ ] River water (ii) [ ] Piped supply (iii) [ ] Stored rainwater
(iv) [ ] Well/ Borehole (v) [ ] Other
_____

4.2. What are the main uses of water within the household?
(i) [ ] cooking (ii) [ ] Washing (iii) [ ] Watering domestic animals
(iv) [ ] Gardening (v) [ ] Other
_____

4.3. What is the average consumption of water by the household per day in litres?
_____Litres

4.4. If water is fetched from outside the farm, indicate who does it
(i) [ ] Husband/ father (ii) [ ] Wife/ mother (iii) [ ] Son (s)
(iv) [ ] Daughter(s) (v) [ ] Workers (vi) [ ] Relative (s)
(vii) [ ] Other _____

4.5. Estimate how much time is spent in total in fetching water for the household's daily requirement per day in hours. _____hrs

4.6. Is the water supply to the household affected by seasonality?
i) [ ] Yes (ii) [ ] No (iii) [ ] I don't know

4.7. If yes to 4.6., how? _____

4.8. How does the household manage periods of water shortage?
_____

4.9. Are there any efforts to tap rainwater or conserve water through other ways by the household?
(i) [ ] Yes (ii) [ ] No

4.10. If the response to 4.9. above is yes, indicate what ways
(i) _____
(ii) _____
(iii)_____
(iv)_____