AN ASSESSMENT OF CLIMATE CHANGE COPING STRATEGIES THAT INFLUENCE VEGETATION DISTRIBUTION WITHIN COMMUNITIES IN KALOLENI SUB-COUNTY, KENYA

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DECLARATION AND APPROVAL

DECLARATION

This thesis is my original work and has not, wholly or in part, been presented for an award of a degree in any other university.

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APPROVAL

This thesis has been submitted to graduate school with our approval as the University supervisors.

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DEDICATION

This project is dedicated in memory of the departed souls, my late Dad Benson, Mum Helen and brothers Jeremiah, Kefas and Abner. Many thanks go to my family members, spouse Paul, son Mordecai and daughter Christine for their constant prayers and support during my years of study. May God bless you all.

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ABSTRACT

Climate change coping strategies play a major role in curbing the effects of climatic shocks especially amongst communities living in Arid and Semi-Arid Lands (ASALS. The study revealed that there are various coping mechanisms applied by smallholder farmers in Kaloleni Sub County. These include marrying off daughters in order to get money for food purchase, stealing food from farm, water vending getting women to work outside home against traditions among others. Preferred coping methods include; use of waste water, livestock sales, wood and charcoal trade. In order to cope with change in biodiversity, use of old mosquito nets to protect free ranged chicken from the emergent black Indian crow was used and commercial tree planting adopted. To cope with rainfall variability, use of zai pits, fertility pits and water pan establishment is on the increase. Purposive sampling was employed in the selection of community and stakeholder representatives who participated in Focus Group Discussions (FGDs) and In-depth key informants' interviews. Arc-Gis v 9.1 and Erdas software were used to analyze Landsat Thematic Mapper ™ imageries of Kaya Forests: Kambe, Bomu and Fungo for years 1991, 2003 and 2011. Quantitative and qualitative data were obtained using various methods: descriptive statistics (mean median) inferential statistics (cross tabulations) and correlations. Shifting forward of the start of the rainy season from March to May was the major climatic factor that led to late planting in June. The main coping strategy adopted to curb food insecurity was wood fuel harvesting and charcoal burning for sale. It was recommended that use of alternative source of energy and sale of Aloe and Neem products would be appropriate for livelihood diversification. Food processing plants and food banks to be established within an appropriate buffer zone for accessibility. The research findings herein would help Researchers, small holder farmers, Agriculture and Forest extension providers in decision making with regard to factors influencing the choice of coping strategies on the vagaries of climate change.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADB	Agricultural Development Board.
ADC	Agricultural Development Co-operation.
CBOs	Community based Organizations
CFA	Community Forest Association.
DDP	District Development Plan.
DFO	District Forest Officer.
ECF	East Coast Fever.
FAO	Food and Agricultural Organization.
GHGs	Green House Gases.
GIS	Geographical Information Systems.
GPS	Geographical Positioning Systems**.**
GDP	Gross Domestic Product
GEC	Global and Environmental Change
IPCCC	Intergovernmental Panel Committee on Climate Change
KFS	Kenya Forest Service.
MDGs	Millennium Development Goals
NGOs	Non Governmental Organizations
NEMA	National Environmental Monitoring Authority
PRA	Participatory Rural Appraisal.
SEA	Strategic Environmental Assessment.
SSA	Sub-Saharan Africa.
UNDP	United Nations Development Programme.
UNEP	United Nations Environmental Programme.
UNFCCC	United Nations Framework Convention on Climate Change
KNBS	Kenya National Bureau of Statistics

CHAPTER ONE

INTRODUCTION

1.1Background Information

There is a general consensus that the African continent is particularly susceptible to the onset of climate change (Boko *et al*., 2007). FAO (2008b) identified 13 distinct ecosystems (Agro-ecological zones (AEZs) in Africa from which various farming systems exist and which could be affected differently by climate change. The various AEZ's include; The Desert, High elevation dry savanna, High elevation humid forest, High elevation moist savannah, Lowland dry savannah, Lowland humid forest, Lowland moist savannah, Lowland semi-arid, Lowland sub-humid forest, Mid-elevation dry savannah, Mid-elevation humid forest, Mid-elevation moist savannah and High and Mid- elevation sub-humid forest. Kaloleni Sub County falls within the lowland semi-arid Agro-ecological zone which was further divided into four distinct AEZ's according to Jaetzold *et al.*, 1983.

Kaloleni Sub-County is situated at latitude 3^{o} 48' 00''South of latitude and 39^{o} 36' 00''East of longitude on the lower coastal region of Kenya. The Sub-County is endowed with a rich biodiversity of the remnant coastal forests (Burgeon and Clarke, 2000). Latest estimates show that the kayas constitute about 5% of the remaining coastal sub-tropical forests cover of Kenya. The kaya's degradation has been heightened by human activities over time. High livestock densities outside protected areas reduced grass cover and therefore encouraged growth of woody vegetation (Western, 1994). The kayas also became more and more isolated, as connection between the chains of forests diminished, which is why the Government through the National Museums of Kenya took over its Management. Adaptation varies not only with climatic stimuli but also with other non-climatic conditions also known as intervening conditions which serve to influence the sensitivity of systems and the nature of their adjustments. Therefore for the improvement of any ecosystem, it has to cope to a certain degree by responding to a certain climatic or any other intervening stimuli as noted by Barry and Smit (1993)

Smallholder farmers in Kaloleni Sub-County depend on rain fed agriculture and spend considerable amounts of time and money on controlling East Coast Fever (ECF). Most of the Livestock are left to free range in search for pasture; a factor which exacerbates the spread of disease and pests among different livestock breeds. Although the Sub-County is endowed

with a complex river network, little irrigation takes place. Due to high temperatures, evapotranspiration on crops and loss of soil moisture was evident. High temperatures cause hard pans which made it impossible for soil water retention. Where communities were highly dependent on agriculture, drought affects food security and their economic performance hence acting as an impediment to achieve MDG Goal one (eradication of extreme poverty and hunger).

In Kaloleni Sub County, smallholder farmers suffer from the effect of pest infestation and hence are compelled to shift their planting dates, crop variety and farm management strategies; in the process, low yields are realized. Priority maize farming targeted 5000 hectares with an anticipated harvest of 15 bags per hectare. Yields are low because of minimal fertilizer use. With the current short rains in the district, production has gone down to 2 bags per hectare. Smallholder farmers suffer from great losses, as erratic rainfall affects vegetation distribution, causing massive soil erosion across the four agro ecological zones within the County. According to Sub County 2008-2010 Strategic Plan, Poverty index is 72% and manifested by the inability of the population to access their basic needs especially due to challenges posed by changing climatic conditions. This has forced the communities to find ways to adapt to these weather changes. Adaptation to Climate change and variability is increasingly being considered as a significant challenge and recognized in National and International policy debate on climate change (Smit, 1993; Tol *et al.*, 1997). The ultimate objective of the UNFCCC as expressed in Article 2 is to stabilize the greenhouse concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference within the climate systems. With the application of indigenous coping strategies, required GHGs levels would be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change; thus ensuring that food productivity is not threatened. There is an opportunity for improvement of the people's livelihood and their environment depending on the type of indigenous coping strategies used by smallholder farmers in Kaloleni Sub-County.

1.2 Statement of the Problem

There is little information existing on the coping strategies used by Kaloleni smallholder farmers against food insecurity, land degradation, biodiversity loss, forest degradation, rainfall variability, and crop /livestock production. There was an indication of a direct link between climate change and development, where the impacts of climate change could largely

impede development efforts in key sectors while at the same time development strategies and plans had a negative impact on coping capacity to climate change. It was imperative to assess all the coping strategies and based on the findings; select the most suitable that could be used by farmers across the four agro-ecological zones relating them to vegetation change detection maps and rainfall variability over years 1991, 2003, and 2011.

1.3 Objectives of the Study

1.3.1 General Objective

To evaluate coping strategies to changes in climate used by small holder farmers, that affects vegetation distribution in Kaloleni Sub County, Kenya.

1.3.2 Specific Objectives

1. To identify the coping strategies applied during food insecurity in Kaloleni Sub County.
2. To assess the effect of coping strategies on climate changes to livestock and crop production systems in Kaloleni Sub County.
3. To examine and document coping strategies on forest biodiversity loss in Kaloleni Sub County.
4. To identify and document coping strategies and their impact on rainfall variability and land degradation in Kaloleni Sub County.
5. To compare Kaloleni smallholder farmers' coping strategies that effect vegetation distribution, using Land Cover maps of 1991, 2003 and 2011.

1.4 Research Questions

1. What are the coping strategies employed during food insecurity in Kaloleni Sub-County?
2. What are the coping strategies on livestock and crop production systems in Kaloleni Sub-County?
3. What are the coping strategies that affect Forest biodiversity in Kaloleni Sub-County?
4. What are the coping strategies that affect rainfall variability and Land degradation in Kaloleni Sub-County?

5. What are the coping strategies used by small holder farmers thus affecting vegetation distribution with reference to land cover maps in the range of years 1991, 2003 and 2011?

1.5 Justification

Analyses in Africa under the Assessment of Impacts and Adaptations to Climate Change (AIACC) project (Ludvine *et al.*, 2003-2007) showed that marginalized populations which were dependent on natural resources were particularly vulnerable to climate change impacts, especially when their natural resource base was being severely degraded by overuse. Forest biodiversity continued to be under pressure from the study area that neighbors conservation units. According to studies by Eriksen and Kelly, (2007) indicators selected in studies of vulnerability often provided insight on the factors, processes and structures that determined adaptive capacity.

In recent times, small holder farmers in Kaloleni Sub-County have applied climate change coping strategies to cushion them against the effect of climate extremes; however, the situation worsened as they continued to suffer from the effects of severe drought, water scarcity, rainfall variability, floods, strong winds and pest infestations. Food insecurity was thus evident in Kaloleni Sub-County, as farmers used different means to cope. According to MOA (2008), several studies had established a direct relationship between drought and animal death; therefore, livestock production in Kaloleni Sub County had also been equally affected due to inadequate forage, leading them with no other alternative but to sell their livestock. It is therefore important that studies be carried out to find out the type of indigenous climate change coping strategies used by smallholder farmers across the four agro-ecological zones in Kaloleni Sub-County. This study eventually discerned the most suitable coping strategies that were used by small holder farmers per agro-ecological zone. The final document is expected to be used by managers from relevant and related fields in influencing policies related to climate change adaptation and coping strategies that may be formulated.

1.6 Scope of the Study

The study area encompassed the four Agro-ecological Zones in the Lower Coastal Area within Kaloleni Sub-County. Forests mapped were Kambe (CL3) Jibana (CL4) and Fungo (CL5).These forests were gazetted as National Monuments and are managed by Kenya National Museums. The study assessed the indigenous climate change coping strategies and their effect on vegetation distribution around conservation areas. Coping strategies were identified and evaluated to gauge their impact on a wide range of vegetation which led to food insecurity within the County. The study examined factors on socio-economic, institutional, land use, climate and biodiversity which acted as an impediment to the achievement of the anticipated positive goals by smallholder farmers in Kaloleni Sub-County. In particular the author was interested in the most suitable coping strategies used by smallholder farmers per every agro-ecological zone, so as to effectively cope with the emerging climatic extremes.

1.7 Definition of Significant terms

Absolute Poverty-Relates to Kenyans earning less than Kshs 978 per capita per month per adult equivalent in the rural areas and Kshs 1490 in urban areas.

Adaptation to Climate Change refers to adjustments in behaviour or economic structure that reduce the vulnerability of the society to changes in the Climatic Systems (Smith *et al*., 1996).

Adaptations are adjustments whether passive, reactive, or anticipatory, proposed as a means of ameliorating the anticipated adverse consequences associated to climate change (Stachiv, 1993).

Agricultural extension is a general term meaning the application of scientific research and new knowledge to agricultural practices through farmer education.

Capacity building-that enhances farmers' skills, Knowledge and ability to plan and mobilize resources necessary for implementation of their activities.

Climate change refers to any change in climate over time that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

Climate is defined as the average weather over a period of time. The classical period for averaging weather variables is 30 years, as defined by the World Meteorological Organization (WMO).

Climate shocks are environmental conditions brought about by extreme changes in climate such as drought, strong winds, famine and floods.

Coping Ability is the degree to which a system can successfully respond to a given stimulus.

Diversification-is a process of producing new products or business activities from the same unit in order to embrace risk management.

Food Poverty-refers to consumption of food below a Minimum Nutrition Requirement (MNR) of 2100 Kilo Calories per adult equivalent per day (Translated into

about Kshs.653 per adult equivalent per month), (Ravallion, M., 1994 and Paradhan et al., 2001)

Forest Extension means 'any programme or activity that assists local people to willingly get involved in Forestry Activities from which they derive some recognizable benefit within a reasonable period of time (FAO, 1989).

Greenhouse Effect is the insulating effect of atmospheric greenhouse gases (water vapour, carbon dioxide, methane,) that keeps the Earth's temperature about 60°F warmer than it would be otherwise.

Indigenous Coping Strategies are strategies built by a group of people through generations

Kyoto Protocol is an international agreement adopted in December 1997 in Kyoto, Japan. In this agreement, the target is the percent reduction from the 1990 emissions baseline that any particular country has agreed to. On average, developed countries agreed to reduce emissions by 5.2% below 1990 emissions during the period 2008-2012; this being the first commitment period.

Land Use, Land-Use Change and Forestry (LULUCF) Land use and land use changes can act either as sinks or as emission sources with an estimation of approximately one-fifth of global emissions resulting from LULUCF activities. Parties who engage in LULUCF activities that are meant to reduce emission credits are privileged to benefit from emission credits.

Remote Sensing is the science and art of acquiring information (spectral, spatial, and temporal) about material objects, area, or phenomenon, without coming into physical contact with the objects, or area, or phenomenon under investigation.

Sequestration refers to Opportunities to remove atmospheric CO^2 either through biological processes (e.g. plants and trees), or geological processes through storage of CO^2 in underground reservoirs. Sinks is any process, activity or mechanism that results in the net removal of greenhouse gases, aerosols, or precursors of greenhouse gases from the atmosphere.

Smallholder farmer are marginal or sub-marginal households that own or/and cultivate less than 2.0 hectares of land (Agricultural census 1990-1991).

Subsistence farming-That provides food for a family and a small amount of money for basic needs or production of commodities for consumption only; income is not an immediate objective.

United Nations Framework Convention on Climate Change (UNFCCC)-is a treaty signed at the 1992 Earth Summit in Rio de Janeiro that calls for the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." This treaty includes a non-binding call for developed countries to return their emissions to 1990 levels by the year 2000. This took effect in March 1994 upon ratification by more than 50 countries with the United States being the first industrialized nation to ratify the Convention.

Value addition-is an activity that captures more of the profit from the retail price that the consumer will eventually pay for the product.

Vulnerability -refers to the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. According to IPCC 2001, vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. (IPCC, 2001)

GHGs -are emissions caused by human (anthropogenic) and whose concentrations cause the sun's heat (which would otherwise be radiated back into space) to be retained in the earth's atmosphere, thereby contributing to the green house effect, causing global warming and climate change.

PRA -Participatory rural Appraisal being a term that was coined in Kenya in the early 1986, through the collaborative efforts of Kenya National Environmental Secretariat and Clark University (Lelo *et al.*, 1994)

CFA -are groups formed with an aim of engaging in forest conservation activities. These activities are initiated by the forest extension providers, and which involves any situation whereby the local people are directly and willingly involved in beneficial forestry activities within a given period of time (Sim and Hilmi, 1987)

CHAPTER TWO

LITEREATURE REVIEW

2.1 Introduction

According to World Bank (2008), the growing period of considerable areas of semi-arid and dry sub-humid zones of Africa, is expected to fall by 5 to 20 percent by 2050. Projections by Boko *et al*. (2007) indicate that crop yields in some African Countries would drop by up to 50 per cent as early year 2020, and net crop revenues could fall by as much as 90 per cent by 2100, with small holder farmers being worst hit. Increases in rainfall variability and the frequency of extreme rainfall events are increasingly important for Kenya's rural development. Extreme events are likely to become more intense over much of East Africa. . In Kenya, rain fed agriculture still remains the dominant source of staple food production amongst the rural poor, hence the need to improve scientific and economic capacity to better understand and cope with the existing climate variability.

2.2 Vegetation Mapping

The last comprehensive vegetation map of Kilifi District was done by Moowaw (1960) and many changes must have taken place since then, leading to the conversion of indigenous forest to agriculture, grazing lands or degraded bush lands (Njuki and Downing, 1984). In 2006, the Department of Resource Surveys and Remote Sensing (DRSRS) came up with a vegetation land cover map using satellite remote sensing and ground surveys. This was done using FAO's Africover (2000) land cover classes. Spatial databases were documented from these maps on distribution of plant species and land use change which was meant to help administrators and researchers to come up with intervention measures to stem environmental degradation. Adaptation strategies vary across different ecological zones and which may reflect in the tree species extinction and re-vegetation. The gap inherent in their study would be investigated by comparing vegetation land cover maps with the coping strategies used by Kaloleni small holder farmers over the given years.

2.3 Indigenous Coping Strategies

The Tanzanian Government had a growing interest in terms of climate changes and the responsible management of the people including the indigenous people. The concern of the impacts of climate change in nation's livelihood, gives way to a creation of policies and

diversification of knowledge (Carr-Hill *et al*., 2005). Since the Hadza tribe from Tanzania realized that climate change was capable of destroying their biodiversity and other natural resource, they got involved in acquisition of broad knowledge, innovations and practices in order to protect their environment (Craw and Sena, 2007). Noticeable effects of climate change had been observed on Agriculture and mining. Prolonged drought and extreme excessive floods definitely placed the agricultural sector in a state of peril. The Hadza tribe emphasized the idea of understanding climate change and therefore they built their capacities to effectively engage in various processes wherein they could handle the challenges in climate change (Craw and Sena, 2007). The Tanzanian government called to action adaptation as an important aspect of creating recommendations on how the Hadza tribe could cope with drought and biological biodiversity. In the early days, the Hadza community depended entirely on hunting using poisonous and non-poisonous arrows and gathered fruit and honey. Since the government failed to introduce them into farming and Christianity, it recommended them to go back to their former indigenous practices in order to help them cope with the vagaries of climate change. As women specialized in harvesting tubers, berries and fruits, men gathered honey, meat and baobab fruits.

In Botswana the government recommended the communal system of grazing (Botswana Government 2007). According to studies carried out by Nsoso and Madimade (2000), the majority (72%) of livestock farmers kept their animals in communal areas and only 28% in fenced commercial areas. This type of farming allowed for the assessment of carrying capacity, controlled breeding, proper disease control, separation of weaned calves from their mother, and land rehabilitation where necessary. This management system helped the herder to cope with the vagaries of climate change.

2.4 The basis of Food Security

Traditional African agriculture was designed in such a way that the various systems offered a variety of food, although mostly with a low output per unit area of land mainly as a result of initial low inputs. Fallow lands, savannah grasslands and forests offered a further variety of fruits and other edible products. Children and adults used to eat these naturally occurring fruits and nuts while herding cattle but nowadays they depend entirely on food from home. This variety of indigenous fruits many of which were children's favorites, are no longer readily available to children and adults. According to FAO, 1989, a varied diet is likely to be a well-balanced one. More important, the use of different foods, even in small quantities,

improves the flavor of the staple foods and thus increases the overall consumption of the staple foods. Food security is a broad concept that includes issues related to the nature, quality, food access and security of food supply (Iram and Butt 2004). The 1996 World Food Summit in Rome defined it thus, '*food security exist when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life'*(FAO 1996). In general, food insecurity is linked to high food prices, poverty and low agricultural productivity (Nyangweso *et al.,* 2007; Misselhorn, 2005; GOK 2008; Davila 2010; Lewin 2011), and diminishing biodiversity especially of forest food products.

2.5 Forest Ecosystem

Vegetation in Kaloleni Sub County was mapped by Department of Resource Surveys and Remote Sensing (DRSRS) and described using remote sensing and ground surveys. The County still has a large area under natural woody vegetation but these woody resources were being degraded fast. The closed to open shrubs and thicket forest consisted of *Commiphora, Acacia, Grewia and Combretum* tree species. *Maerua decumbens* tree and shrub savanna dominated the drier western parts of the district. In between the two regions, in areas of marginal agricultural potential (700-900mm annual rainfall), *Brachystegia* woodlands were common especially in north of Bamba in Kilifi. The woodlands are however under serious pressure from charcoal burners and Pastoralists who burn woodlands to create pasturelands. In the same zone south of Bamba in Kaloleni Sub County, the once extensive *Manilkara-Diospyros* Lowland Dry forest that extended up to Lunga Lunga in Kwale County has given way to farmlands and open shrub lands, leaving kaya fungo the only remnant forest. The original forest vegetation has been replaced by *Andopogon heteranthes, Decanthium annalutum, Cynodon dactylon* and *Chloris pychnotrix*. Kaloleni Sub County is among the Counties which have varied vegetation ranging from lowland rainforests to semi-arid savanna. The communities living in this Sub County have been degrading forests and woodlands through fuel wood collection and charcoal burning, hence creating unsustainable harvesting of poles and timber. The situation has been made worse by the low priority these forests and woodlands get from the government. The government placed a higher premium on water catchment value than biodiversity preservation (Rodgers, 1995). Kenya Forest Research Institute (KEFRI) focused on woodland management, rehabilitation of degraded

sites, and domestication of indigenous species and development of drought tolerant tree species. The extent of forest degradation needs to be investigated.

2.6 GPS and Remote Sensing

In order to map these vegetation cover classes in Kaloleni Sub County, DRSRS adopted FAO Africover 2000 and described in greater details by adding dominant plant species to the cover classes. The Africover maps were derived from Landsat T.M satellite images of 1998-2000 using classification system developed by FAO (Land Cover Classification System) originally derived from Gregorio and Jansen (2000). Several points were randomly selected from each polygon, the number depending on polygon size, and their coordinates entered into GPS as waypoints. The selected points were visited in the field using GPS for navigation. In cases where a given cover class was found in more than one agro-ecological zone, sampling was done in all the zones and a given cover class could have different sets of dominant species in different areas. ARC INFO and SRC VIEW software were used to add information on the dominant species to the Africover maps. Roads, rivers and major towns were also added using the same software. The dominant species varied depending on the agro-ecological zone and the influence of human activities. Although DRSRS interest was to capture dominant tree species per agro-ecological zone, they did not relate it to the coping strategies that small holder farmers were using to cope against the vagaries of climate.

2.7 Conceptual Model

The theory of vulnerability directly applied to the conceptual framework. Both social and environmental indicators were put into consideration because they affected the small holder farmers' capacity to cope with the emerging climatic shocks. Vulnerability studies were divided into social and environmental. The latter referred to stresses originating from drought, storms, landslides and other such phenomena often exacerbated by human induced factors such as deforestation, land degradation, soil erosion and water pollution. The former involved lack of community's capacity to cope with and recover from all kind of stresses, including but not limited to environmental stresses (Brklacich and Ingram, 2006)

The Independent variables were the observed coping strategies that communities used to cope against climate change and Environmental stress. Cumulative applications of these strategies over time were anticipated to impact positively to the dependent variable. However; the negative impact by the intervening variables such as the farmers' attitude towards

agriculture, institutional framework, socio-cultural and climatic factors, acted as catalysts or impediments to the independent variable; vegetation distribution. The limitation on food systems was therefore determined by both nature and magnitude of environmental stresses, and in addition society's capacity to cope with and or recover from GEC (Global Environmental Change). The cycle had a feedback system that end up in, but not limited to food systems resilience and vulnerability.

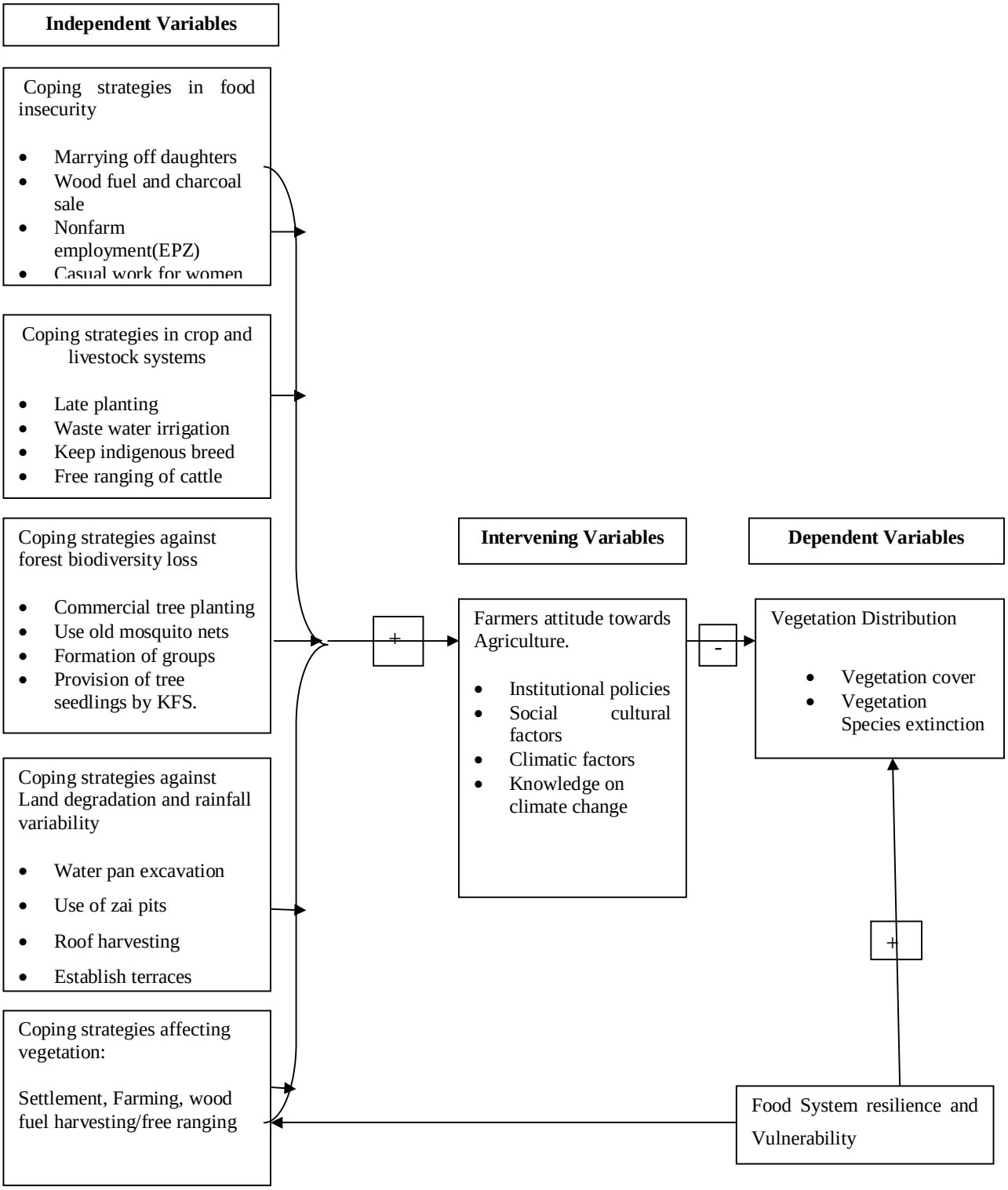

Figure 2.1: Conceptual Framework of the Study

(Adopted from Brklacich and Ingram, 2006)

CHAPTER THREE

METHODOLOGY

3.1 The Study Area

This chapter introduces Kaloleni Sub County in terms of its geographical position, demography, climate, land use, vegetation, hydrology geology and soils.

3.1.1 Geographical Location

This study was carried out in Kaloleni Sub County, which was hived off from the former Kilifi District. It is situated at 3^{o} 48' 00'' South of Latitude, and 39^{o} 36' 00'' East of Longitude along the Kenyan Coast, with an estimated area of 909 Km^2 which include 109 Km^2 of water surface in the Indian Ocean. It lies 55.9 Km^2 away from Mombasa Town and has 11 locations and 33 sub locations (Kilifi District Strategic Plan, 2002-2008)

3.1.2 Climate

The annual rainfall in Kaloleni Sub County range from 700 to 1200 mm across four distinct agro-ecological zones: a high-potential, high-rainfall area (CL3/CL4) designated transitional zone; moderate-rainfall, 'cashew nut/cassava zone'(CL4); the dry, livestock/millet zone (CL5) and the Ranching zone (CL6). The County has bimodal rainy seasons in a year. The long rains start from March to May, while the short rains start from October to November. Annual mean temperatures within the Sub County range between $22.5^{o}C$ and $24.5^{o}C$ in the months of April to June while the maximum temperatures ranged between $30^{o}C$ and $34^{o}C$, in the month of November, December and January. Kaloleni was generally hot and humid all year round, with average relative humidity of 65% at 1500 hours along the Coastal belt, and experiences relatively low wind speeds ranging between 4.8 kms and 10.9 kms per hour (Jaetzold *et al.*, 1983)

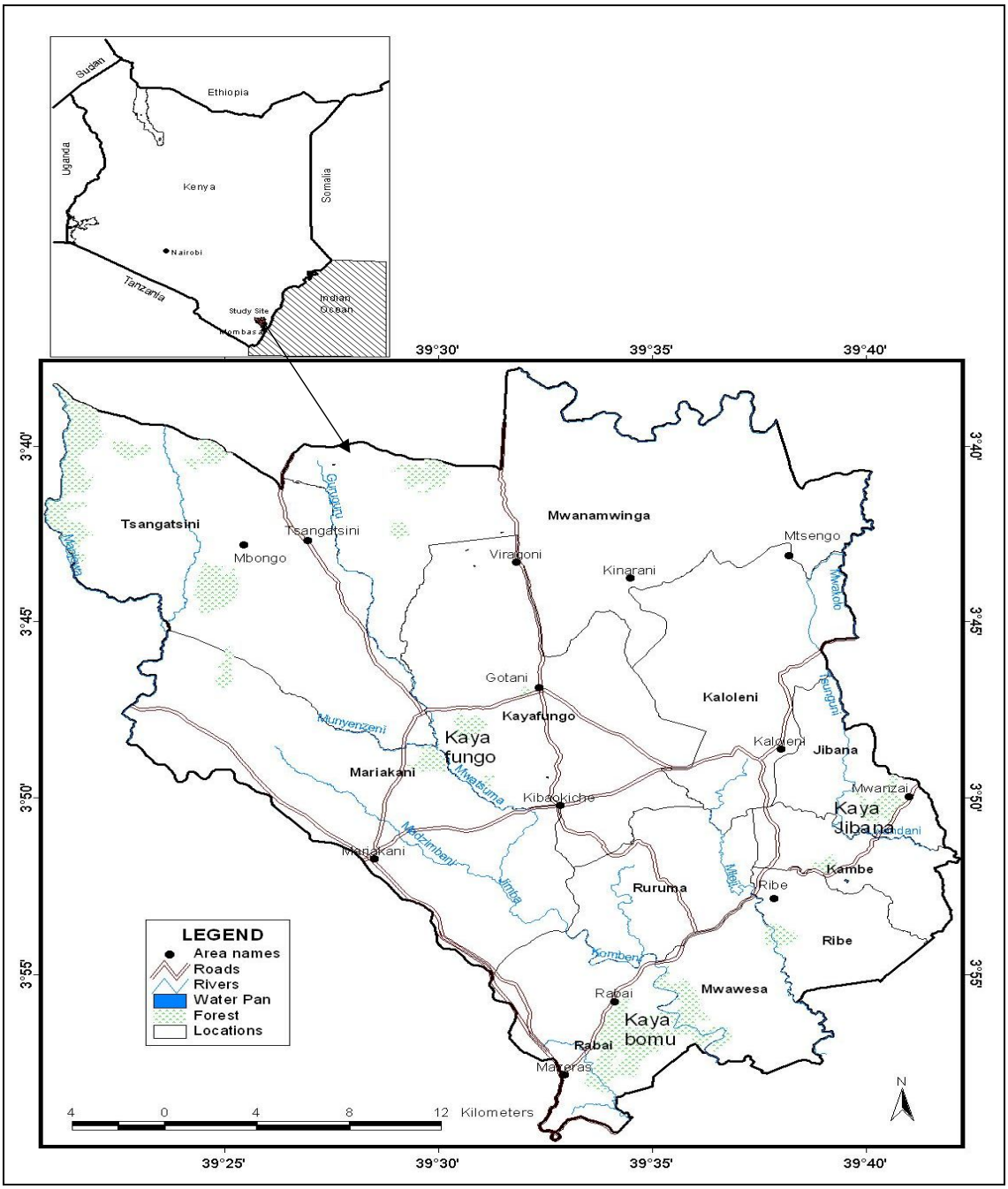

Figure 3.1: Map of Kaloleni Sub County

(Source: Maina G., ENSC Dept, Egerton University**)**

3.1.3 Hydrology

The main sources of water in Kilifi District included Athi (Galana and Sabaki) Rivers. This was a perennial water source that emptied into the Indian Ocean just north of Malindi. Seasonal water courses included short streams such as Laga Buna, Rare, Ndzoruni, Sinwe (Wimbi), Mtokuu, Tshashi and Kombeni which is found in Kaloleni Sub County. Rare Gashi was the most important seasonal river, which emptied into Kilifi Creek. Aquifers of similar lithology and within the same physiographic unit pose different ground water potential in the Counties (GOK, 1994).

3.1.4 Geology and Soils

Geographically Kaloleni Sub County is part of a system of sedimentary and basement rocks which was described according to the ages of the rocks. The rocks were classified as basement system rocks consisting of grits, sandstone and shales on the western side of the County. Sedimentary rocks included Duruma stones, Taru grits, Jurassic rocks-Kambe limestone and Jurassic shale in Magarini; Carboniferous rocks-Taru grits and a series of sandstones. Shale is found along the south western area of the Sub County, tertiary sediments (Cenozoic era) are of marine deltaic origin and consists mainly of marls, limestone, clay, sands and gravel pebble heads. Quaternary sediments occupy the areas immediately bordering the coast and consist of coral reefs, coral breccias, sandstones and sands of alluvial and marble (Jaetzold *et al.*, 1983).

3.1.5 Land Use

The land use within Kaloleni Sub County includes arable farming, livestock husbandry urban settlements and biodiversity conservation (forestry and marine parks).These land use types were correlated to four agro-ecological zones, namely CL3, CL4, CL5 and CL6. Arable agriculture is practiced in mixed cultivation and large commercial estates within the coconut-cassava zone, cashew nut cassava zone and livestock/millet zone (Jaetzold *et al.*, 1983). Livestock husbandry constitutes the commercial ranches that raise mainly beef cattle. Pasture and rangelands took up the marginal lands that constituted a fragile ecosystem. The unreliable rainfall and infertile soils have limited the production of animals as well as crops (G.O.K, 1985). The cultural land use constitutes of the scattered remnant monsoon forests (Kayas), formerly used as burial sites by the Mijikenda (GOK,1985).There are eleven Kayas in Kaloleni Sub County namely; Mazeras, Benyagundo Hill, Rabai, Ribe, Mokobeni, Kambe, Pangani, Jibana, Mbuyuni, Chonyi and Kaya fungo. Urban land use include residential with

the majority of the inhabitants being immigrants workers in hotel industry, factories, and tourists. Animal husbandry includes commercial ranches that raise beef cattle, pastoral systems and crop ranches.

3.1.6 Population Distribution

This study was carried out in Kaloleni Sub County, which was hived off from the former Kilifi District. It has a population of 155,739 according to the 2009 census data (KNBS.2009).The former Kilifi District had a total area of 4779.2 Km^2 and estimated population of 640,593 persons distributed within 90,000 households (2009 population census report). Due to increasing human population over the years, land use and Agricultural activities had also expanded proportionally. The population increase led to migration of people from high-density to rangelands, hence the expansion of human settlement into wildlife habitats. As a result of agricultural activities and other land use activities, wildlife and other resources were negatively impacted.

3.2 Agro-ecological Zones

Kaloleni Sub County has four Agro ecological zones namely; Coastal lowland three (CL3) designated Coconut/Cassava zone, with an annual rainfall of between 1000-1200mm per annum. It covers an area of 382 Km^2 in Kilifi County from where Kaloleni Sub County was hived off. The Coastal Lowland four (CL4) designated the Cashew nut/Cassava area has an annual rainfall 800-1100 mm per annum. The zone covers an area of 1190Km^2 in Kilifi County. The transitional Zone between CL3 and CL4 covers an area of 53Km^2 in Kaloleni Sub County, while the Coastal Lowland 6(CL6) which is mostly suited for ranching covers an area of 1097 Km^2 in the larger Kilifi County. Coastal lowland 5(CL5), also designated Livestock/Millet zone has an annual rainfall ranging from700-900mm per annum and covers an area of 1431 Km^2 . (Jaetzold *et al.,* 1983).

3.3 Vegetation Types

The vegetation distribution within Kaloleni Sub County was classified under bush land grasslands and shrub land (Ojwang *et al.,* 2006). In Mariakani town, cassava, cow peas and maize farms were interspersed with areas of grasslands, bush lands, and shrub lands in Gotani area (Kaya fungo location). *Acacia nilotica*, *Lamprothamus zanguebarica*, *Thespecia danis*, *Flueggia virosa*, *Terminaria spinosa*, *Diospyros cornii*, *Mangifera indica*, *Senna simea* and

cahewnuts were *the* dominant tree/shrub species. Common grasses found were *Heteropogon contortus*, *Chloris pycnotrix*, *Cenchrus ciliaris*, *Andropogon heteranthes*, *Dicanthium annulatum*, Dactyloctenium, *Panicum maxima*. Between Mariakani and Mazeras, the density of shambas was higher with grasslands, cashew nuts, mangoes and *Cassia siamea* in non-cultivated areas (GOK, 1984)

3.4 Research design

These sections include the type of methods and instruments used in collection of data in Kaloleni Sub County. Both primary and secondary data were used.

Primary data was collected by use of a household questionnaire, focus group discussions, in-depth interviews and observations in the field. Secondary data was obtained from DRSRS, Survey of Kenya, Kenya Meteorological Department (KMD) refereed books and journals, reports, pamphlets and conference proceedings. Secondary data from DRSRS 2006 included Satellite imageries of year 1991, 2003 and 2010, vegetation distribution mapping methods and findings in the study area. Survey of Kenya provided Topographical base maps of the study area-Scale 1:50,000(Series 197/2,197/4,198/1 and 198/3). Satellite imageries were obtained from DRSRS. KMD provided monthly rainfall data of the study area in excel format. Information on forest extension from Kenya Forest Research Institute (KEFRI) was used in data capture on forest conservation issues in Kaloleni County. Referenced Journals, Reports, Conference proceedings and citation from relevant Books were used to capture the works that researchers had done to improve on this kind of study. The questionnaire comprised mainly of closed-ended items and a few open-ended items. It sought communities' opinions and attitudes on effects of Climate Change on the environment and livelihoods of the respondents, indicators of climate change, effects on adaptation strategies that communities use in mitigation and the response of institutions on the improvement of adaptive capacity of the respondents. In the process, the understanding by the respondents on meaning of climate change and its indicators was captured. Issues on food security were also captured based on food availability, value addition, market accessibility among other aspects. Coping strategies on food insecurity was also captured. In relation to the cropping and Livestock systems, information on the type of livestock kept and crops grown was captured. The coping strategies on both systems were also captured such as the ones that were used in mitigating crop failure and loss of livestock. Indigenous coping strategies on land degradation and rainfall variability, water conservation methods captured through field observation, while

on the other hand soil conservation methods that were used to cope in the face of extreme climatic events. The effect of flush floods on the terrain was also evident. Effects of Climate Change on forest biodiversity were also observed from the data representing indicators of biodiversity loss and extinction on the both flora and fauna. Knowledge on the farmers' perception on the effect of climate change on biodiversity over the last 20 years was also captured through FGD and compared to the land cover maps of the same given years; 1991, 2003 and 2011. This led to provision of percentages of households using different types of energy as fuel. Data on water sources for domestic use were also captured from the respondents.

(FGDs) and in-depth interviews were used to help elicit views of the respondents on the issue of food security in Kaloleni Sub County. The FGDs specifically helped obtain information about responses to issues that required more knowledgeable and informed individuals. Such information included average size of farm in the study area, average size of land under irrigation, observation on major climatic events that have been taking place for the last 30years such as drought occurrences, Change in the growing seasons, emergence and extinction of both plants and animal species in the study area, forest degradation and the coping strategies that communities use to mitigate against these effects. In-depth interviews were used to follow up some important information that was of pertinent concern in the forest, soil and biodiversity management and conservation. This exercise was carried out after distribution and administration of household questionnaires and FGDs. The interviews answered questions on why rivers are drying and their effect on water supply and consumption. Observation was made to find out the location of the water points such as shallow pans, boreholes, water intake facilities, points and any other water infrastructure. Irrigation methods in use by different farmers were observed recorded and photographs taken to assist in the analysis. Forest cover and the inherent degradation were observed with photos taken to reflect the type of forest resources extracted by communities in the study area. The type of coping strategy on strong winds and temperature variability were also photographed.

To evaluate the factors influencing the choice of coping strategies under crop and livestock production systems in Kaloleni County, a Multinomial Logit (MNL) Model was estimated using the adaptation strategies as the dependent and the various socioeconomic characteristics as the independent variables. Computational burden of MNL specification is made easier by its likelihood function as noted by Haussmann and McFadden (1984), with each farmer

facing a set of discrete, mutually exclusive choices of adaptation measures. The findings of the model are presented in tabular form. From the model specification panels, the models fit would show that the log likelihoods were large negative number and the Chi squares significant at 1% level. This will be an indication of the predictive power and stability of the estimated model.

3.5 Sampling Procedures

The sample size was determined using (Nassiuma, 2000) for in-depth interviews as follows:

$$n = \frac{NC^2}{C^{2+}(N-1)\,e^2}$$

Where; n=Sample size, N= Population size =155,739 ;(source; Population and Housing Census report, 2009); e= Error margin (2%), C= Coefficient of variation (30%).

Stratified random sampling method was employed. The households were stratified by Agro-ecological zone (CL3/CL4, CL4, CL5 and CL6) by project (classified according to the number households per Agro-ecological Zone) (Table 3.1), by Locations (Table 3.3) and by gender (Table 3.2); men and women. The target population included smallholder farmers within the pastoral and farming households across the four Agro-ecological zones in Kaloleni County. Simple random sampling was employed in identifying the sample size of the study.

The overall numbers of households across the four agro-ecological zones in Kaloleni Sub County were determined as follows;

$n=155{,}739 \times 0.3^2$

$0.3^2+ (155{,}739-1) \times 0.02^2$

n=225 households

Thus a total of 225 Households were selected for in-depth interviews. This sample was then divided proportionally to obtain the sampling size for the households within Kaloleni Sub County. The Project list obtained from Kaloleni County Agricultural office indicated 22,500 small holder farmer's households distributed proportionally across the four agro-ecological zones CL3/CL4, CL4, CL5 and CL5.

Table 3.1: Distribution of Households per Agro-Ecological Zone

Agro-Ecological Zone	No. of Households
Zone CL3/CL4	5,700
Zone CL4	5,700
Zone CL5	5,500
Zone CL6	5,600
Total	22,500

Source: Field Survey Data (2011)

A total of 225 structured questionnaires were administered to the respondents across the four zones as follows:

Sample distribution per Agro-ecological zone;

Sample size for Zone CL3/CL4=5,700(225)/22,500=57 households

Sample size for Zone CL4=5,700(225)/22,500=57 households

Sample size for Zone CL5=5.500(225)/22,500=55households

Sample size for zone CL6=5,600(225)/22,500=56 households.

Agro ecological zone CL3/CL4 provided 5,700 households, CL4 5,700 households, CL5 5,500 households and CL6, 5,600 households. The selected households were obtained by use of systematic random sampling. Each ecological zone covered several locations sampling units as shown in table 2 to ensure fair representations of all households in Kaloleni Sub County.

Table 3.2: Distribution of households by Gender

This table shows distribution of the respondents by gender in Kaloleni Sub County.

Gender of Respondent	Frequency	Percentage
Male	153	68.0
Female	72	32.0
Total	225	100.0

Source: Field Survey Data, (2011**)**

Table 3.3: Locations/Agro-ecological zones in Kaloleni Sub County

Locations	CL4	CL3/CL4	CL5	CL6	Total
Chalani Mihingoni	0	0	4	8	12
Chanagando	0	0	1	10	11
Giriama	6	0	7	9	22
Jibana	6	50	0	0	56
Kaloleni	38	1	1	4	44
Kaya Fungo	1	0	36	1	38
Kivyega	0	0	1	0	1
Kizurini	2	0	0	0	2
Kwale	0	2	0	0	2
Maluani	0	2	0	0	2
Mikiriani	0	0	5	24	29
Mitulani	2	0	0	0	2
Tsagwa	0	2	0	0	2
Vikindani	2	0	0	0	2
	57	57	55	56	225

Source: Field Survey Data, (2011)

Jibana location within zone CL3/CL4 produced the highest number of households (56); Kaloleni location (44) households in ecological zone CL4; Kaya Fungo location (38) households within zone CL5 and Mikiriani location (29) households selected from zone CL6.This type of distributions indicate that a larger area of the given Agro-ecological zones fell within the given locations. A proportion was worked out for ecological zone depending on the number of the households. Using the project lists of the small holder farmers, systematic random sampling was carried out to select the specific households to be included in the study for each agro-ecological zone.

The Distribution of Locations per Agro-ecological Zone

CL3/CL4−These comprise of Jibana, Kaloleni, Kwale, Maluani and Tsagwa.

CL4−. The locations included are Giriama, Jibana, Kaloleni, Kaya Fungo, Kivulini and Mitulani.

CL5−The locations found in this zone are namely; Chanagando, Chalani Mihingoni, Giriama, Kaloleni, Kaya Fungo, Kivyega and Mikiriani.

CL6−The locations found in this ecological zone include, Chalani Mihingoni, Chanagado Giriama, Kaloleni, Kaya Fungo and Mikiriani.

Focus Group Discussions

Purposive sampling was employed in selection of individuals who participated in FGDs and in-depth interviews. The FGDs included 6 representatives (Mulwa and Nguluu, 2003) comprising of three government officials; one from Ministry of Education (MOE), one from the Ministry of Agriculture (MOA) and another one from the Ministry of Water and Irrigation, one WWF official (an NGO promoting green energy consumption in Kaloleni Sub County), one Community Based Organization (CBO) area representative and one Agricultural extension provider based in Kaloleni Sub County. Participants for inclusion in in-depth interviews were identified during the course of administering household questionnaires and during FGDs. They included officials from WWF and Kenya Forest Service (KFS), two officers from The Ministry of Education (MOE), two officers from the local Youth group, two from the local women groups and one from local area water and Irrigation projects, the local chief and one administration officer.

3.6 Data Analysis

Statistical Package for the Social Sciences (SPSS) computer software version 17 and Stata software were used to analyze data from the questionnaires. The results obtained were presented in form of frequency distribution tables, bar graphs, pie charts, measures of central tendency, cross tabulations, Multinomial Regression (MNL) tables and statistics. Results from PRA and FGD realized tables which were used to carry out deductive analysis using frequency distribution and descriptive statistics. From the satellite imageries, land cover vegetation maps were obtained. Real time photography was also used during PRA.

Table 3.4: Summary of Methods and analysis tools

Method	Tools	Analysis
PRA and FGD	Group discussions Participant observation	Tabulations Descriptive statistics Real time photography
Surveys	Questionnaires (SPSS Stata, Instat and Excel)	Descriptive statistics Cross tabulation Frequency distribution tables Pie charts/line graphs Correlation Regression Models MNL tables
In-depth discussions	Checklist	Tabulation
Digital Mapping	ARC-Gis Software version 10.1 ERDAS Imagine, image software	Scanning Georeferencing Classification Enhancement Filtering Digitizing Symbolization Final print out (PDF) Tables and vegetation land cover maps.

Source: Researcher's own compilations, 2012

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Coping strategies during food insecurity in Kaloleni Sub County

This chapter introduces the factors that affect food security in Kaloleni Sub County and the mechanisms that were used to cope with the food insecurity situation.

4.1.1 The basis of food security in Kaloleni Sub County

As shown on Table 4.1 below, some of factors that contribute to food insecurity among Kaloleni residents include; erratic rainfall characterized by high temperatures, floods and strong winds. Further investigations had revealed that indeed the shifting in the start of the rainy days was the main cause of climate change which prompted the farmers to dig water pans meant for water storage used for irrigation and domestic use (table 4.1). Change in the pattern of wind caused changes in periods of precipitation, gave rise to dry and wet extreme weather events, causing crop failure. Contrary to the high temperatures experienced in the past, the residents were compelled in year 2011 to buy blankets in order to cope with the low temperatures (below 22.5^{o}C). In the year 2010, strong winds from the sea destroyed crops and blew off roof tops. Due to seasonal changes experienced in the year 2011, small-scale farmers opted to apply late planting as coping mechanism to increase crop production. The shift in the starting of the rain dates which has mainly contributed to crop failure. There was also theft of immature crops from the farms in order to curb hunger pangs (table 4.1). Small holder farmers in Kaloleni were thus compelled to use their young boys to keep vigil on the farm. Theft of crops happened majorly during the dry seasons. The study revealed that the Ministry of social services in which the Youth affairs docket exists, came up with commercial tree planting by the youth. The youth group had no patience with this initiative since the results were long term. This has led to the increase in numbers of idle youths who engage in stealing of immature crops. The other youth initiative was the establishment of water Kiosks whose income boosted the Youth docket especially during the dry seasons.

Table 4.1: Coping strategies on food insecurity

Basis for Food insecurity	Coping mechanism
Erratic rainfall	Water pans, Late planting
Food shortages at household levels	Non-farm employment of the children (Export Processing Zone for boys and house help for girls)
Pests and diseases	Late planting
Security (crop theft)	Guarding crops by young boys
Low temperatures	Use of blankets
Strong winds	Placing soil mounds at the foot of cereal stalks
Change in weather conditions	Shift planting dates

Source: Survey and PRA (2011) results

Innovation adopted during different seasons

Table 4.1 depicts coping mechanisms that are used by small scale farmers in Kaloleni in different seasons. A normal season is when there was minimal deviation from the mean weather conditions, meaning that mean annual precipitation (700mm-1200mm), mean annual temperatures (22.5^oC-34^oC) and wind speed (4.8-10.9kms per hour) experienced by the residents were within the expected range. Adverse seasons means unfavorable climatic conditions when the weather was unpleasant characterized by low annual mean rainfall (below 700mm p.a), high mean annual temperatures (above 34^oC) and wind speed (above 10.9 kms per hour) as noted by Jaetzold *et al.*,(1983).

Table 4.2: New Innovation adopted during different seasons

Normal Season	Adverse Seasons	Favorable Season
Keeping grains in cereal banks (Posho mills).	Food rations in schools Food for work program	Eating well/variety meals
Food diversification	Variety in consumption reduced	Eating four times a day
Food preservation	Children, elderly and disabled were given priority.	Employment at EPZ
Value addition on cassava	Charcoal burning Fuel wood sales Brick making/weaving baskets/mats	School feeding programme.

Source: Survey and PRA (2011) Results.

Table 4.2 above shows that during the favorable season there was plenty of food, enough to provide families with meals four times a day. However during the adverse seasons food became less and therefore the food had to be given in rations. Most school going children dropped out of school during adverse seasons. School drop outs were reported in the year 2011 due to hunger pangs, whereby the boys ended up working at the Export Processing Zone (EPZ), while the girls ended up being house helps (Table 4.1). The study further revealed that Kaloleni residents depend on Food for Work Program (Table 4.2) whereby the residents were issued with food in exchange for labor by non-governmental organizations (NGO's) whose mandate was to fund water pan excavation in Kaloleni Sub County. During the period under review, school going pupils were provided with only one meal per day. When food was less available, girls were given into marriage in exchange for dowry in order to purchase food (Table 4.2). Married women were also allowed to engage in casual jobs like rock blasting and digging of water pans to get money for food purchase. This was against their cultural practice where women only worked in their households. The study also revealed that at times women gave their share of food to the children thus skipping their meals. Theft of pre-mature crops such as cassava and sweet potatoes were also reported on farms in Jibana location. In addition to the theft, at times children were forced to feed on wild cassava which can be poisonous and hence get sick.

During the normal season, food was plenty on the farm, with the only type of food preservation method being sun drying. Previously there was a cassava processing plant at Kaloleni previously established by Nairobi University. The processing plant which was meant to pick up for value addition of cassava in 2009 never took off because of leadership wrangles experienced amongst the women group.

4.1.2 Consumption of Maize compared to Sorghum over the last 20 years in Kaloleni

Figure 4.1 below shows the distribution of cereals consumed by Kaloleni residents for the last 20 years; the main crops consumed being *maize and sorghum.* Maize monoculture had been practiced in Kaloleni County for the last 10 years.

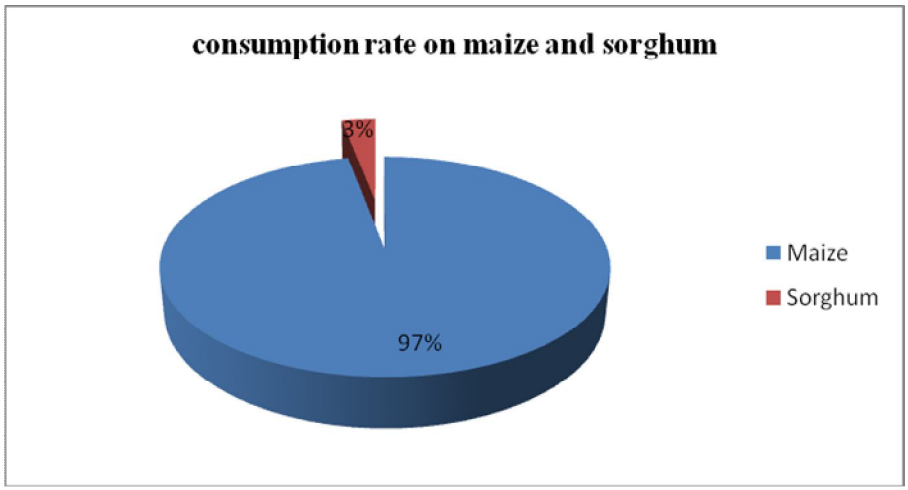

Figure 4.1: Consumption rate of Maize against Sorghum (Field Survey data, 2012)

Major cereals consumed were; *Sorghum vulgare* (sorghum), *Zea mays L* (maize), *Triticum aestivum* (wheat) and millet *Pennisetum glaucum* (millet). Although maize consumption stood at 17,500 bags per month, only 10,000 bags were realized by the smallholder farmers in Kaloleni during year 2011. The deficit in maize production was being felt due to on farm application of poor quality seed. Farmers from the drier areas used the 6 series (614) maize variety on their farms instead of planting PH1 hybrid maize seeds which mature within six months, of which were provided by the government.

97.3 % (n=220) of the respondents indicated that maize has been the most utilized cereal for the last 20years. Maize production had generally decreased due to diseases, poor seeds, unpredictable weather patterns, late application of fertilizer, poor soils and maize monoculture. The maize stalk borer (*Chilo partellus)* was the most prevalent pest that destroyed maize production in Kaloleni. To curb the problem of pest and disease most farmers preferred to start planting in June instead of May; this late planting contributed to low crop yields as Robert *et al.,* (2002) asserts that delayed planting shortens the effective growing season for maize, which can lead to moisture stress at flowering stage. These results are contrary to reports given by Kucharik *et al.,* 2008 who cited that late planting of maturing of early maturing maize varieties allows them to perform optimally. In Kaloleni Sub County, the type of maize varieties that were early maturing and which were planted in the drier areas were; PH1, DH02, DH04, Duma43 and Olerai 22**.** PH stands for pwani hybrid seeds**.** For wet areas there was the 6 series seed variety; 614**,** 622**,** 628 and 629**.** DH stands for dry land hybrid**.** For the late maturing maize variety there was a challenge because the less rainy days experienced due to a shift of planting dates from March to June in Kaloleni. Strong

winds blowing from the ocean also affected the stalk stability hence farmers were advised to place strong soil support at the foot of the stalks in order to develop strong pop roots. Those of the factors that influenced crop production in Kaloleni.

4.1.3 Cereals experiencing the greatest Impact from Climate Change.

This section presents the variety of crops consumed by Kaloleni residents and the rate at which they are being impacted by climate change. Table 4.3 shows the impact of climate change on various crops in Kaloleni, rating from the most to the least impacted.

Table 4.3: Crop variety experiencing the greatest impact

Crop variety	No. Respondents	Percent frequency
Maize	121	53.5
Sorghum	10	4.9
Rice	87	38.5
Cow peas	7	3.1

Source: Field Survey Data, (2011)

The Table 4.3 indicates that 54% of the respondents felt that maize was the most impacted by climate change, followed by Rice (38.5%), Sorghum 4.9% and 3.1% indicated cowpeas. Sorghum was among the least impacted cereal by climate change possibly due to its resistance to drought. According to MOAs 2008/2009 crop yield report, the target sorghum production during the 2011 long rains was 1275 bags, only 550 bags were produced. Sorghum is tolerant to water logging and its yields are comparatively higher on infertile soils. Its leaves do not wither during drought, but its main challenge is attacks from the Red horn billed (*Quillea quillea*) birds and the large grain borer (*Prostephanus truncates).* Although Sorghum does well in Kaloleni Sub County, FGD reported laxity on the part of farmers to plant it on their farm or included it in their diet.

Table 4.4 depicts the general crop performance during the long rains that occurred in Kaloleni Sub County between mid March and August, 2011.

Table 4.4: General crop performances in Kaloleni Sub County (Long rains, 2011)

Crop	Target(ha)	Target bags(ha)	Target prod bags(ha)	Achieved(ha)	Achieved bags/ha	Prod bags/ha
Maize	5000	15	75000	5375	2	10750
Sorghum	85	15	1275	275	2	550
Rice	325	15	4875	330	3	990
Millet	20	10	200	1	2	2
C/Pea	1270	10	12700	560	4	2240
G/gram	800	10	8000	471	4	1884
P/pea	55	10	550	1	2	2
Beans	170	10	1700	15	1	15
Cassava	1400	10tons	14000	400	10tons	4000tons
S/potatoes	165	10tons	1650tons	25	10tons	250tons

Source: Survey and PRA (2011) report.

The type of rice grown on paddy plains consisted of indigenous varieties: *Singae, Sindano* and *Kimumbo*. Of the 4,875 bags per hectare targeted during the 2011 long rains, only 990 bags per hectare were produced. According to reports from FGD, *Nerica* rice which is an emerging breed in recent times was introduced as an early maturing variety in order to improve on yields.

4.1.4 Market food accessibility

This section depicts food accessibility in the market by Kaloleni residents during the normal season. Food accessibility was dependent on the monetary status of each respondent. Different respondents gave their views as indicated in the Table 4.5

Table 4.5: Market food accessibility in normal seasons- cassava

Normal season		
Price	**Frequency**	**Percent**
Expensive	25	14.6
Less expensive	41	16.8
Moderate	120	53.1
Cheap	38	15.5

Source: Field Survey Data, (2011)

Table 4.5 shows the perceptions of the respondents in relation to the market price of cassava during normal seasons. About 70% of the respondents felt that cassava prices were cheap and moderate meaning that cassava was available in plenty during normal season and hence the most affordable and consumed root crop by Kaloleni residents. Affordability of cassava was attributed to the availability of the early maturing variety which was readily provided to farmers by Kenya Agricultural Research Institute (K.A.R.I).

Availability of different varieties of indigenous cassava varieties such as Kabandameno which were huge and produced a lot of flour, sweet but don't dry well and hence doesn't store well. Kaleso cassava variety was also huge, sweet and cooks well, but had less flour. Other cassava varieties which were bitter but edible are Chikorokotwe, Mwakiba and Mumali. Preparation of these cassava varieties involved boiling and sieving of the water used for boiling before eating to remove the poison.

According to Ministry of Agriculture (MOAs) 2008 /2009 annual report, the Ministry provided 318,162 cuttings of *Manihot esculenta (Var. Guzo)* which was tolerant to cassava mosaic virus disease. CMD was the most frequently occurring cassava disease that causes fast pathogen multiplication, causing yield reduction to as low as 90% as noted by Lozano *et al.*,1981. Manihot esculanta (*Var.Guzo*) took more than one year to mature, unlike the new early maturing varieties known as Karembo, Tajirika, Nzalauka and Shibe which took 8 months.

4.1.5 The effect of food insecurity on forest ecosystem

Kaloleni Sub County is endowed with a chain of indigenous forests known as the Kayas. Initially the Kaya forest were solely dedicated as sacred places for rain making prayers, but recently the attitude of the people towards the sanctity of the forests has changed. Most of Kaloleni residents encroached into the forest to harvest various forest resources.

Table 4.6: Type of Activities taking place in Forest area

Activities	Frequency	Percent
wood fuel collection	39	17.3
logging	79	35.0
fruit harvesting	5	2.7
bee keeping	7	3.1
poaching	6	2.5
farming	63	27.9
settlement	26	11.5

Source: Field Surveys Data, (2011)

In order to curb food insecurity during adverse seasons, Kaloleni Sub County residents turned to charcoal burning and fire wood sales. To confirm this report, delineation of three forests found in three different agro-ecological zones depicted that indeed deforestation was taking place in Kaloleni. In order to discourage charcoal burning, small holder farmers were encouraged by World Wildlife Fund (WWF) representative (South Coast), on the use of biofuel crop as an alternative source of energy. *Jatropha* seeds produce oil which can be used in the place of paraffin at household level. *Jatropha carcus L* has therefore been noted as the future bio-diesel as noted by Tee May (2009). Previous studies by Tsado (2012) indicated that energy from bio-fuels appear to be more environmentally friendly, needing little investments to combat the potentially high carbon emissions peculiar to fossil fuels. The use of energy saving stove that uses only three pieces of wood to cook various foods at one go was embraced by households in Kaloleni.

Over 50% of Kaloleni residents were involved in wood fuel collection and logging (Table 4.6) in a bid to curb food insecurity. Getting into fuel wood sales helped in boosting the economic status of small holder farmers in Kaloleni Sub County. In-depth interviews from Kambe forest elders revealed that the residents had started discarding their cultural beliefs on the sanctity of Kaya forests hence encroaching into the forest for wood fuel harvesting and logging. In order to discourage the issue of charcoal burning, the Kaya elders were encouraged to register with nature based programmes that plants *azadirachta indica* (neem) and *aloe volkensii* Engl. (aloe vera) oil products for sale.

In the context of vegetation distribution, degraded forest is that part which has been deforested or affected by factors such as farming, cattle rearing, wood fuel/timber harvesting and settlement. Forest area is that part of the forest which is presumed as not deforested but

which is also at risk of being affected by these factors. The effect levels of degradation on both forested and the already degraded forest parts are as shown on the table 4.8 below

Table 4.7: Changes in Kaya Kambe Forest cover

KAMBE KAYA							
Class Type	1991	2003	2011	Δ1991-2003	Δ2003-2011	ΔMean	
Degraded Forest	0.220	0.238	0.338	0.018	-0.10	0.059	Increased
Forested area	0.804	0.779	0.804	0.025	-0.025	0.000	No - Change

Source: Maina G., ENSC Dept, Egerton University.

Table 4.7 shows that between 1991 and 2003, the level of degradation of the 'degraded forest' had increased from 0.220 Km^2 to 0.238 Km^2 (0.1Km^2) .Between 2003 and 2011 the level of degradation of the 'degraded forest' had again increased from 0.238 Km^2 to 0.338Km^2 (0.18Km^2). This change was possibly contributed by wood fuel/timber harvesting from the forest as reflected cited by the respondents that over 90% used wood fuel as their main source of energy. Similar results were obtained by Di Gregio and Jansen (2000) who cited that change in vegetation cover can be derived from satellite imageries using food and agricultural organization (FAO) Land Cover Classification System. Vegetation cover in the 'forest area' in 1991 was 0.804Km^2 and 0.779Km^2 in 2003, thus recording a decrease of 0.025Km^2 in total. Between 2003 and 2011, an increase in the 'forest area' from 0,779Km^2 to 0.804Km^2 which was 0.025Km^2 .The decrease in degradation levels (in square kms) that occurred in forest area between 1991 and 2003, cancelled the increase in forest area degradation between 1991 and 2011.Thus the figure 0.000 indicating no change. This could have been attributed to re-vegetation that occurred in the 'forest area' between 2003 and 2011. Since over 60% (n=135) lived near forested areas, the overall decrease in forest areas could have been attributed to wood fuel and timber harvesting by the communities living on the periphery of the forest. This concurs with previous reports from Dr.Western, 1994 that the communities living near the Kaya forest areas were degrading it fast.

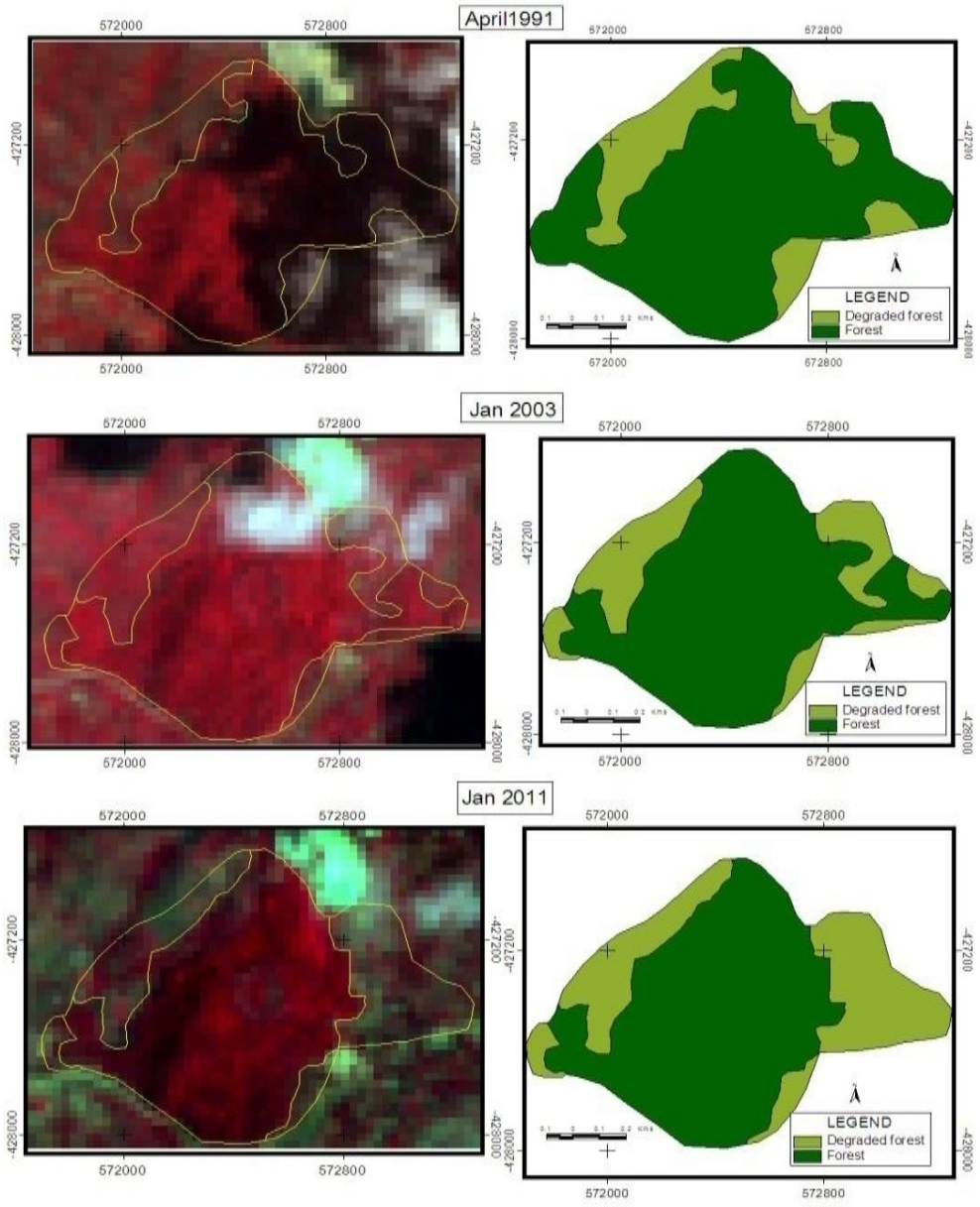

Figure 4.2: Vegetation distribution at Kaya Kambe1991-2011

(Source: Maina G., ENSC Dept, Egerton University)

4.1.6 Vegetation distribution in Kaya Fungo

The dark red pixels on the satellite imageries is an indication of thick forest cover, while the light red color stands for degraded forest. Delineation of the two cover classes enabled statistical calculations on the same. The results on the Table 4.8 indicate that there was a decrease in 'degraded forest area' by 0.568 km^2, implying re-vegetation (extra growth) that occurred between 1991 and 2003. Between 2003 and 2011, there was an increase in

'degraded forest area' by 0.023Km^2.This could have been attributed by wood fuel/harvesting in this area. The same pattern was noted on the 'forest area' between 1991 and 2003 whereby there was an increase in vegetation cover by 0.668Km^2; while reduction cited on the same area by 0.263Km^2 between 2003 and 2011.The overall effect of degradation on the kaya fungo forest was reduced, which could have been attributed by the designated status of Kaya Fungo forest as protected area by the National Museums of Kenya in 2008. The historical timeline data of Kaloleni Sub County revealed that there were El Niño rains, characterized by flush foods and hailstorms, resulting to bumper harvest in 1997, which could also have contributed to re-vegetation in both the forest and degraded forest areas in Kaloleni Sub County, between 1991 and 2003

Table 4.8: Change in Kaya Fungo forest cover

KAYA FUNGO							
Class Type	1991	2003	2011	Δ1991- 2003	Δ2003- 2011	ΔMean	
Degraded Forest	1.318	0.750	0.773	-0.568	0.023	-0.2725	Reduced
Forested area	1.134	1.702	1.439	0.668	-0.263	0.2025	Increased

Source: Maina G., ENSC Dept, Egerton University

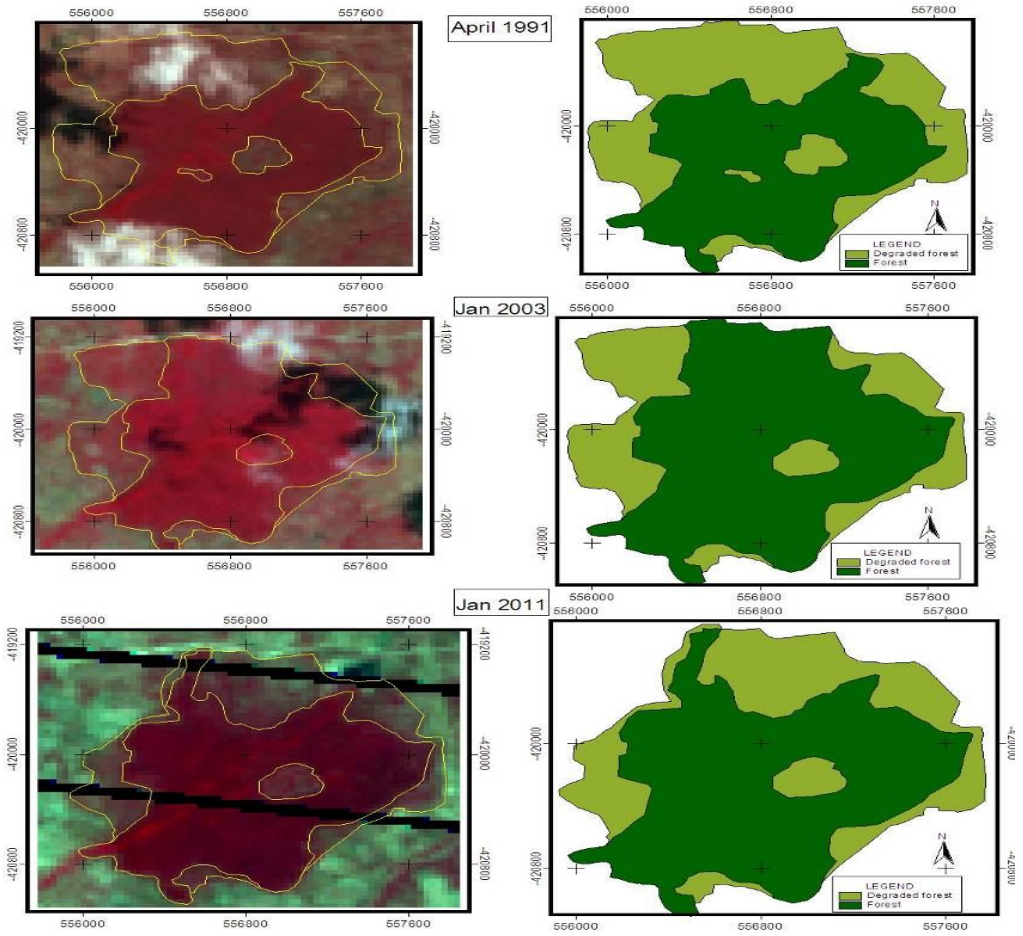

Figure 4.3 :Vegetation distrbution at Kaya Fungo (1991-2011)

(Source:Maina G.,ENSC Dept.EgertonUniversity)

4.1.7 Factors influencing choice of coping strategies during food insecurity in Kaloleni

To evaluate the factors influencing the coping strategies adopted by residents in Kaloleni Sub County, a multinomial Logit model was used to estimate the coping strategies.

Table 4.9 Multinomial logistic regression on factors influencing choice of coping strategies during food scarcity in Kaloleni.

Log likelihood -245.058

Strategies	**Allow women work**		**Marry Daughter**		**Water vending**		**Food for work**		**Stealing from farms**	
	Coef.	z	Coef.	z	Coef.	z	Coef.	Z	Coef.	z
AEZ	-0.223	-0.73	-0.028	-0.08	1.331	1.36	-0.396	***-2.31*****	-0.720	***-3.28*****
Sex	1.017	1.42	2.847	***4.18*****	-4.747	-0.29	0.919	***2.21*****	0.151	0.29
Age	-0.001	-0.1	-0.001	-0.14	-0.004	-0.19	-0.009	***-1.98*****	-0.002	**-1.66***
Marital status	-1.924	**-1.83***	-1.164	***-2.79*****	-1.983	-0.12	-0.547	***-2.28*****	-0.007	-0.03
Education level	0.043	0.15	-0.037	-0.11	-1.554	-1.34	-0.021	-0.13	-0.331	-1.57
Household size	-0.731	-1.35	-1.297	***-1.96*****	4.132	***2.07*****	0.111	0.4	1.145	***3.25*****
Experience farming	0.381	1.59	-0.024	-0.1	0.373	1.52	-0.031	-0.27	-0.085	-0.59
Acres owned	-0.001	-1.46	-0.290	-1.25	-0.005	-0.41	-0.005	-1.49	0.006	1.2
Tenure	-0.242	-0.35	-0.514	-0.7	-8.986	-0.55	0.469	1.42	-0.164	-0.39

(copefood =FPE feeding program is the base outcome)

****, **,* significant at 1%, 5% and 10% probability levels.*

Number of obs = 225

LR chi2 (45) = 316.18

Prob>chi2 = 0.0000

PseudoR2=0.3921

Agro-ecological Zones

From table 4.9 above, AEZ had a negative influence on food for work (z=-2.31) significant at 5% probability level. Since AEZ's have different microclimates, not all the respondents were likely to engage in food for work programmes. Respondents from the livestock/millet (CL5) and the Ranching (CL6) zone were most likely to engage in food for work programme due to the harsh climatic conditions that attracts drought and famine.

AEZ also had a negative influence on the on-farm theft of premature food (z=-2.31) at 5% significant level. Small holder farmers from the Coconut/Cassava (CL4) were most likely to suffer from on-farm stealing of food than farmers in the drier zones (CL5 and CL6). Stealing from farms was negatively influenced by the age of the respondents (z=-1.66), significant at 10% level. This corroborates well with previous reports, that young boys were more likely to steal premature crops from the farms. This was caused by the demand for food in relation to family size.

Gender of the respondents

Gender of the respondents had a positive influence on food for work (z=2.21) significant at 5% probability level. Due to the fact that women bare the food burden of their families, they were more likely to use food for work as coping strategy against food insecurity. Men and young people kept off as they cited hardship in water pan excavation projects. Food was issued instead of cash, after completion of work.

Age of the respondents

Age of the respondents had a negative influence on food for work programme (z=-1.98), significant at 5% level. Older people were less likely to engage in excavation, since the soil consists of hard pans.

Marital Status

Marital status had a negative influence on coping strategy that allows women to work (z=-1.83) significant at 10% level. This corroborates with PRA reports that married women were allowed to work as casual laborers against their culture. Women in Kaloleni Sub County engaged in water pan excavation and sand blasting in order to earn money for food purchase.

Marital status also had a negative influence on marrying daughter as a coping strategy (z=-2.79), significant at 5% level. Daughters from female headed households were more likely to be given into marriage because of the weak economic base and independent decision making from the female headed household. Further it was noted that marital status also had a negative influence on food for work as a coping strategy against food insecurity (z=-2.28) significant at 5% level. Married women went against their culture by using food for work as a coping strategy against food insecurity.

Household size

Household size had a negative influence on marrying daughter as a coping strategy against food scarcity (z=-1.96) significant at 5% level of probability. Daughters from larger families were more likely to be given into marriage in exchange of dowry for food purchase. This is due to the fact that larger households need higher consumption of food than smaller households. There was a negative influence of household size on water vending (z=-2.07) significant at 5% probability level. Larger households need more water during food scarcity than smaller households and thus are less likely to engage in water vending business. Family members from larger households are more likely to steal food from the farms (z=-3.25) significant at 1% level. This means that family members from larger households need more food for consumption to curb their hunger pangs during food scarcity.

4.2 Factors influencing the choice of coping strategies under crop and livestock production systems

In Kaloleni Sub County, there are various indigenous coping strategies adopted by farmers under crop and livestock production systems. The MNL Logit Model set by default keeping indigenous breeds is the base outcome in the livestock system model and planting early maturing crops is the base outcome in the crop's system models. However, farmers have to make choices on the preferred coping strategies they can adopt to cope with climate change fallacies. This includes the following:

4.2.1 Factors influencing choice of coping strategies under crop production

Table 4.10 presents MNL regression results on determinants of factors influencing the choice of coping strategies under crop production significant ***,**,* at 1% , 5% and 10% probability respectively.

Irrigation

This involves on-farm irrigation. Use of irrigation as a coping strategy was significantly influenced by the years of experience in farming by the respondents (P>|z|= 0.074), significant at 10% level of probability. This implies that farmers with more years of experience in farming were more skilled and thus more likely to adapt to irrigation as a coping strategy on crop production.

Early planting of crops

Early planting was influenced by the acres of land owned by the small holder farmer (P>|z|=0.041) significant at 5% level of probability. 18 % (n=41) of the respondents preferred planting early. Farmers owning large tracks of land were more likely to be confident in getting crop yields on the strength of the farm size, despite the challenge due to rainfall variability and pest infestation in Kaloleni Sub County.

Waste water for Irrigation

Use of waste water for gardening as a coping strategy under crop management systems was influenced by the education level (P>|z|=0.009), significant at 5% probability level. Over 10% (n=23) of the respondents used waste water to cope against rainfall variability in Kaloleni. Women were more likely to have acquired skills in waste water gardening from the agricultural extension providers. Further it was noted that household size had a positive influence on use of waste water gardening (P>|z|=0.059), significant at 10% probability level. Larger households were more likely to put more effort on waste water gardening because they needed higher food production for their consumption than smaller households. This correlates well with the findings on food security, where young people from large households were engaged in stealing premature crops from farms (z=3.25) significant at 1% level of probability (Table 4.9)

Planting Improved Crop Variety

There was also a positive relationship between years in farming experience and planting of early maturing crop varieties (P>|z|=0.002), significant at 1% probability level. 20% (n=45) of the respondents used improved crop variety in order to improve on yields. Small holder

farmers with more years of experience had the higher likelihood of adapting to planting of early maturing crop variety as the coping strategy to climate change. Results on table 4.10 indicate that there was a positive relationship between sex and adaptation by planting of improved crop variety (P>|z|=0.01), significant at 5% probability level. Women were more likely to adapt to improved crop variety due to the fact that they bear the economic burden of their families when there is food shortage.

Table 4.10: Multinomial logistic regression on factors influencing the choice of coping strategies under crop production systems

Log likelihood -237.503								
	Planting improved variety		**Irrigation**		**Irrigate with waste water**		**Early planting**	
	Coef.	P>|z|	Coef.	P>|z|	Coef.	P>|z|	Coef.	P>|z|
AEZ	0.031	0.882	1.330	0.173	0.004	0.986	0.130	0.469
Sex	1.22	***0.01****	-0.366	0.838	1.002	***0.058****	-0.265	0.562
Age	0.001	0.363	-0.006	0.801	-0.001	0.222	-0.001	0.334
Education level	0.081	0.667	0.309	0.708	0.600	***0.009****	-0.085	0.618
Household size	0.261	0.425	-1.469	0.296	-0.709	***0.059****	-0.248	0.371
Acres owned	0.002	0***	-0.074	0.847	-0.001	0.429	-0.001	***0.041****
Farming years	-0.457	***0.002*****	-1.052	***0.074****	-0.270	0.16	0.253	0.143
Tenure	0.002	0.254	0.001	0.99	0.002	0.105	0.001	0.410
constant	-2.386	0.082*	-2.368	0.685	-1.737	0.281	-1.163	0.391

Coping strategy =Planting early maturing crops is the base outcome

******,**,* significant at 1%, 5% and 10% probability levels respectively***

Number of observations = 225

LR chi 2(48) = 142.43

Prob> chi2 = 0.000

Pseudo R2 = 0.2307

4.2.2 Climate change coping strategies to crop production

This section presents the coping strategies used by farmers to cope with the effect of climate change on crop production. Since Kaloleni Sub County is an Arid and Semi Arid Land (ASAL) area with unpredictable weather conditions, it was imperative that these strategies be applied in order to increase yields. Figure 4.4 depicts the various strategies used by Kaloleni Small holder farmers in the face of climate change. These were planting improved seed variety, early planting, use of waste water gardening, planting early maturing crop variety and early planting.

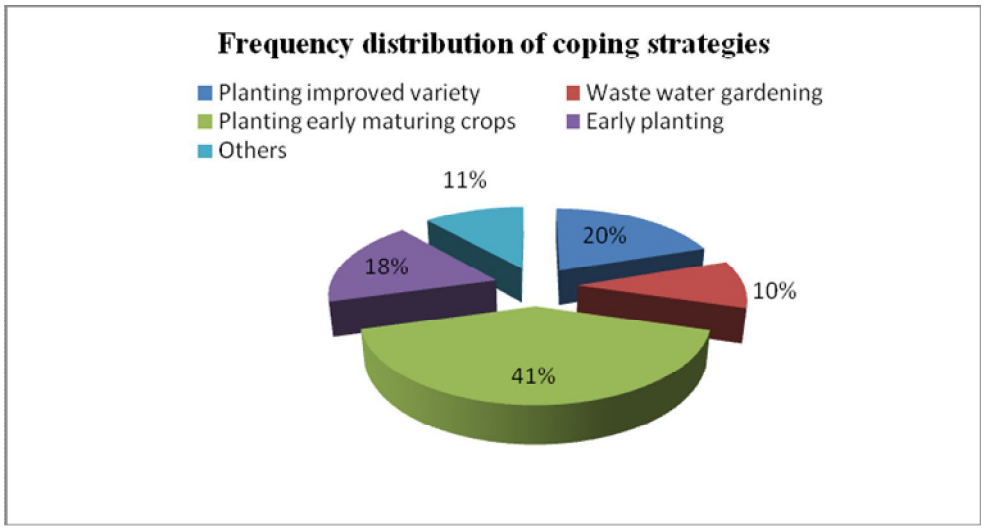

Figure 4.4: Coping strategies on crop production

(Source: PRA and Survey (2011) report)

From the results on Figure 4.4, over 40% of the respondents indicated that they preferred planting early maturing crop varieties as a coping mechanism against the effect of climate change, planting improved seed variety (20%), Early planting (18%) and the rest (11%) implied use of irrigation using wastewater, and early harvesting. According to MOAs 2008/2009 report, planting of early maturing crops was mainly encouraged by KARI, through the provision of early maturing cassava varieties such as Karembo and Tajirika. Early maturing crop varieties were important because of the less rainy days experienced in Kaloleni, as the onset of the rains had shifted from March to May. There were additional strategies observed in the field such as storied gardening (sack farming). To cope with the effect of windstorms on crop production, small holder farmers in Kaloleni used soil mounds at the root of maize crop in order to develop strong prop root for anchor.

4.2.3 Cropping patterns

Figure 4.5: A 2 feet by 2 feet Zai- pit

(Photo by author, 30/01/2012)

Occurrence of events such as windstorms, drought, extreme cold, floods and fog were experienced in Kaloleni Sub County. Field verification revealed that small holder farmers from Kaloleni applied coping strategies to crop production by digging 2 feet by 2 feet Zai pits (Figure 4.5) as coping strategies to drought. During the dry season, water was fetched from the dams using jerricans and applied on each zai pit. Since the soils are sandy loams, farmers covered the pits with dry grass (mulch), hence preventing evaporation.

Figure 4.6: 8 feet by 2 feet fertility pits

(Photo by author, 30/01/2012)

Small scale farmers in Kaloleni also used fertility pits to plant their crops at the onset of drought. The pits measuring 8 feet by 2 feet (Figure 4.6) are half filled with dry grass (mulch), while the remaining depth filled with fertile soils imported from other areas within the county.

4.2.4 Coping strategies on water conservation

There were water tanks that were constructed for the youth by the Ministry of Gender and youth affairs; therefore, when taps ran dry, they were able to sell the water at twice the normal price thus making huge profits. Despite the water scarcity being experienced, there was hope in the establishment of piped water from Baricho water project emanating from Mzima Springs. The community in Kaloleni Sub County effectively embraced soil and water conservation measures. Zai pits and roof harvesting were the major conservation measures used by small scale farmers in Kaloleni County. In 2009, MOA in a bid to promote micro water harvesting introduced water conservation structures in Kaloleni County. Out of the 150 farms laid out, 45 were implemented with two main types of water harvesting approach embraced; Zai pits (15) and roof catchments (18). Field surveys revealed that soil erosion was taking place in Kaloleni County. Further observation revealed natural and artificial water pans, which had further implications on improved crop production within the Sub County

4.3 Factors influencing coping strategies to livestock production

To evaluate the factors influencing the choice of coping strategies under livestock production systems in Kaloleni County, a multinomial Logit model was estimated using the adaptation strategies as the dependent and the various socioeconomic characteristics as the independent variables. The findings of the model are presented in Table 4.11. The results obtained shows factors that significantly influenced the likelihood of choice of a coping strategies under Livestock production systems compared to keeping indigenous breeds (base outcome) were sex, age, education level, size of farm(acres) owned and Land Tenure. The following are the choice of coping strategies used by small holder livestock farmers in Kaloleni Sub County;

Livestock Sales

Women were allowed to control the sales of small livestock (chicken and goats) while men took control of the sale of larger livestock (cattle) and its proceeds. 11.9% (n=27) respondents cited sales of livestock as a coping strategy during draught episodes. It was also noted that the more experienced farmers had the privilege to sell their livestock in time of need, based on stock availability.

There was a positive relationship between land tenure and livestock sales (P>|z|=0.051), significant at 10% probability level. Land tenure is the basis of proper utilization of land without having doubts on eviction. This means that a more valid tenure would attract comfortable land utility by the owner, hence enabling more livestock production.

Livestock sales was positively related with years in farming experience (P>|z|=0.003) significant at 1% probability level. Pastoralists with more years of experience in livestock management were more likely to use sales of livestock against the fallacies of climate change.

Use of maize germ

There was a positive relationship between the use of maize germ and acres of land owned (P>|z|=0.00), significant at 1% probability level. This means that farmers with large pieces of land were able to give higher yields of maize germ and hence more livestock feeds than farmers with less acreage of land. This corroborates with statistical results indicating that 13.7% (n=31) of the respondents preferred using maize germ when livestock feed during drought episode.

Table 4.11: Factors influencing the choice of coping strategies under livestock production

	keeping few animals		use of maize germ		Livestock sales		use free range system	
	Coef.	P>|z|	Coef	P>|z|	Coef	P>|z|	Coef	P>|z|
aez	-0.117	0.547	0.309	0.254	0.060	0.809	0.049	0.801
sex	1.393	0.002	0.673	0.269	1.538	***0.009*** **	0.666	0.164
age	0.001	0.187	0.001	0.117	0.001	0.156	-0.000	0.865
educlevel	0.304	0.08	0.099	0.662	0.229	0.337	-0.146	0.443
hhsize	-0.365	0.216	-0.586	0.168	0.307	0.43	-0.371	0.236
acresowned	0.001	0.194	0.003	***0.000*** ***	-0.000	0.964	-0.001	0.286
experience~g	0.001	0.966	-0.058	0.72	-0.502	***0.003*** ***	0.006	0.602
tenure	0.710	0.051	0.710	***0.051****	0.709	***0.051****	0.672	0.129
constant	-3.167	0.012	-4.291	***0.021**** **	-3.863	***0.022**** **	-1.549	0.227

Coping strategy =keeping indigenous breeds is the base outcome

****,**,** significant at 1%, 5%, 10% probability levels respectively*

Source: Kanyua J. Dept of Agro-econ, Egerton University

Number of observations = 225

LR chi 2(48) = 115.91

Prob> chi2 = 0.00

Pseudo R2 = 0.1165

4.3.1 Livestock management systems

Table 4.12: Livestock Management Systems in Kaloleni

System	Frequency	Percent
Zero grazing	6	2.5
Paddocking	10	4.2
Free ranging	158	65.8
Ranching	8	3.3
No animals kept	58	24.2

Source: Field Survey Data, 2011

Table 4.12 revealed that majority of the respondents (65.8%) practiced free ranging as livestock management strategy, meaning that small holder farmers took their animals for veterinary services as shown on Table 4.13.These findings are similar to that of Botswana Government citing records held at the central statistics office, that 85% of farmers were found in the communal areas. The same report was confirmed during focus discussions in Kaloleni that indeed during drought episodes there was free ranging of livestock in search for pasture.

Table 4.13: Coping strategies used on livestock production.

Strategy	Frequency	Percent
Keeping fewer animals	50	22.1
Use of maize germ	31	13.7
Livestock sales	27	11.9
Keeping indigenous breeds	79	35.0
Use free ranging systems	39	17.3

Source: Field Survey Data, 2011

In coping with the effects of climate change on livestock, the majority of the respondents (35%) preferred keeping of indigenous breed such as goat for milk, 22.1% preferred keeping fewer animals while 17.3% preferred free ranging (Table 4.13). Thus, just as the FGD discussions revealed, most cattle owners in Kaloleni prefer keeping the indigenous cattle, small livestock (Figure 4.7), indigenous chicken and the duck as coping strategy against climate change effects. Indigenous breeds reduce the risk attached to food insecurity and also help to generate and accumulate wealth as noted by Wilson (1995). Similar results were also noted by Thomas *et al.,* (2007) found that during dry spells, farmers tended to reduce their investment in crops or even stop planting and focus instead on livestock management. The advantage with indigenous livestock species was that they were resistant to drought.

Figure 4.7: Keeping Goat for milk

(Photo by author, 30/01/2012)

Smallholder farmers in Kaloleni keep either indigenous or exotic breeds of livestock. 54% (n=123) indicated that they kept grade animals while 46% (n=102) kept indigenous breed. The study revealed that of the 225 respondents, 20% (n=44) kept goat for milk, 61 %(n=139) kept grade chicken, 70 %(n=157) kept the grade cow, while only 8% (n=18) respondents reared guinea pigs. Availability of milk from the goats and the grade cows contributed to the increase of ghee and milk in Kaloleni as agreed by 57.5% (n=130) of the respondents. The mean income of small holder livestock keeper made from livestock products per month was Kshs.400, meaning that livestock products were not actually for sale but rather for family consumption.

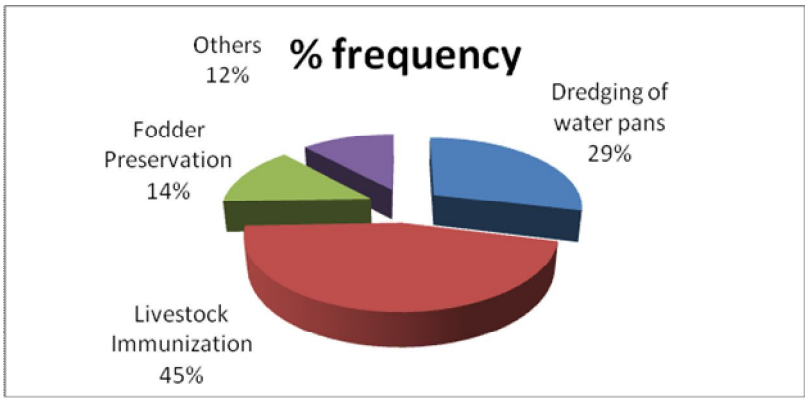

Figure 4.8: coping strategies against anticipated Climate Change effects.

In order to cope with anticipated effects of climate change on livestock, the majority of the respondents (45.0%) indicated that they immunized their livestock, 29.0% who indicated that they engaged in dredging of water pans for water storage, while 14% indicated fodder preservation was their way of cushioning against expected feed shortage (Figure 4.8). Contrary to these findings, majority of livestock farmers (47%) in Botswana indicated that they don't immunize their livestock, but instead let nature take its own course. Statistics showed that most of their livestock had reduced in numbers due to episodes of drought and disease (Botswana Government, 2009).

4.3.2 Methods of coping against livestock disease

This section shows the distribution of coping strategies as applied by small holder farmers across different agro-ecological zones. Each zone has its own micro-climate, meaning that each zone would have its own challenges on livestock health issues. The drier zones are likely to be impacted differently by pests than the ones in the cooler zones. Table 4.14 shows the distribution of coping strategies on livestock disease across the four agro ecological zones in Kaloleni County.

Table 4.14: Methods of coping against Livestock disease per Agro-ecological Zone

Agro-Ecological Zones	**Coping Strategies used in Mitigating Livestock Disease**				
	Confinement	**Dipping**	**Use of Veterinary service**	**others**	**Total**
CL4	3	4	50	0	57
CL3/CL4	5	16	36	0	57
CL5	3	6	43	6	55
CL6	4	6	42	4	56
Total	**15**	**32**	**171**	**7**	**225**

Source: Field Survey Data, (2011)

Table 4.14 shows the methods that small holder farmers use in coping with livestock disease in Kaloleni Sub County. Cases of livestock disease were rampant due to mixing up of flocks from different areas in search for feeds. Historical timeline data of Kaloleni Sub County indicated that in 2009 that huge losses were experienced by the Maasai livestock farmers who tried to evacuate their livestock from heat stress and drought; most of the cattle died. In order to avoid such incidences, the study revealed that different coping mechanisms were being applied by the residents across the four Agro-ecological zones. Over 70% (n=171) respondents indicated that they took their livestock for veterinary services in order to avoid

livestock loss due to disease. Small holder farmers in Agro-zone CL4 had the highest score with over 20 % (n=50) of the farmers taking their animals for veterinary services. This could have been attributed by the type of breed that was kept by these farmers. As shown on table 4.20.the study revealed that over 60% (n=154) small holder farmers kept exotic livestock breed. Taking livestock for veterinary services meant that there was disease incident being felt by small scale farmers in Kaloleni. Derressa *et al.,* (2008) for example cited that livestock ownership and management are essential for adapting to long term changes in climate.

4.3.3 Livestock species mostly affected by Climate Change

Table 4.15: Livestock Species vulnerable to climate change effects

Livestock species affected by climate change	Coping mechanisms on different livestock breeds				
	Confinement	Dipping	Use Veterinary	Other	Total
Indigenous Cattle	4	0	13	0	17
Indigenous Poultry	0	2	2	0	4
Grade (exotic)cattle	11	25	154	7	197
Goat	0	2	2	0	4
Duck	0	3	0	0	3
Total	15	32	171	7	225

Source: Field Survey Data, (2011)

From table 4.15, the indigenous duck needed the least attention, being that it was resistant to disease as confirmed by FGD reports. The study revealed that 54% (n=123) of the small holder livestock farmer reared exotic animal breeds while 46% (n=102) reared the indigenous animal breed. Since the grade cattle was vulnerable to disease, it was most likely to be kept in confinement (n=11) to avoid mixing with other livestock. Dipping of exotic cattle helped in eliminating animal ticks. Since indigenous cattle had a higher resistant than the exotic, only a few farmers (n=4) indicated keeping them in confinement. FGD discussions also included milk goats, indigenous chicken, and other livestock in general due to the frequency of disease incidence such as New castle, chicken caccidosis, foot and mouth disease.

4.3.4 Distribution of Livestock coping strategies per Agro-ecological zone

This section aims to show the distribution of coping strategies to livestock management across the four agro ecological zones. Since each zone had its own micro-climate, it was imperative to investigate the type of coping strategies that was suitable for each zone**.** Table 4.16 show the distribution of coping strategies across the four agro-ecological zones.

Table 4.16: Cross-tabulation: Livestock coping strategies across Agro-ecological zones

Coping strategies on Livestock due to climate change	**AGRO ECOLOGICAL ZONES**				
	Cashew nut/Cassava zone **(CL4)**	Transition zone**(CL3 /CL4)**	Livestock /Millet zone**(CL 5)**	Ranching zone**(CL6**	**% frequency**
Keeping fewer animals	7.1	6.2	4.0	4.8	22.1
Use Maize germ	3.2	4.1	2.3	4.5	14.1
Livestock sales	2.2	2.7	3.6	2.6	11.1
Keeping Indigenous breed	9.8	5.8	11.1	8.4	35.1
Free ranging	2.7	6.6	3.5	4.3	17.1
Others	0.5	0	0	0	0.5
% Total	25.4	25.3	24.5	24.6	100

Source: Field Survey Data, (2011)

In order to cope with the vagaries of climate change, 35 % (n=79) of the respondents preferred keeping indigenous breeds (Table 4.16). 22.1% (n=50) of the respondents preferred keeping fewer animals in order to cope, while free ranging rated third at 17.1%. These results agreed with livestock census report by Botswana Government (2003) implying that most households preferred keeping indigenous breeds due to their resistance to drought.

Overall percent frequency of small holder farmers keeping indigenous breed was 35.1%. Free ranging was mostly practiced at the transitional zone (CL3/CL4) at 6.6% .The Transitional zone has its own micro-climate which contributes to evergreen vegetation that can be used as Livestock feed. Majority of the livestock farmers (4.5%) who preferred using maize germ as feed supplement were found in the Ranching zone (CL6) meaning that livestock farmers in the AEZ-Coastal Lowland 6 (Ranching zone) planted maize germ in order to cope with the problem of livestock feed deficit.

4.4 Impacts of coping strategies on forest biodiversity

This section shows the coping strategies used by small scale farmers of which has far reaching effects on biodiversity in the neighboring forest conservation areas. It is therefore important to study these impacts, since they have far reaching effects on both flora and fauna that are found in the ecosystem.

4.4.1 Sources of energy used by respondents in Kaloleni

Figure 4.9 shows the number of respondents that are involved in the use of different energy sources. The type of energy used determines whether the small scale farmers are involved in biodiversity conservation by using environmentally friendly or destructive sources.

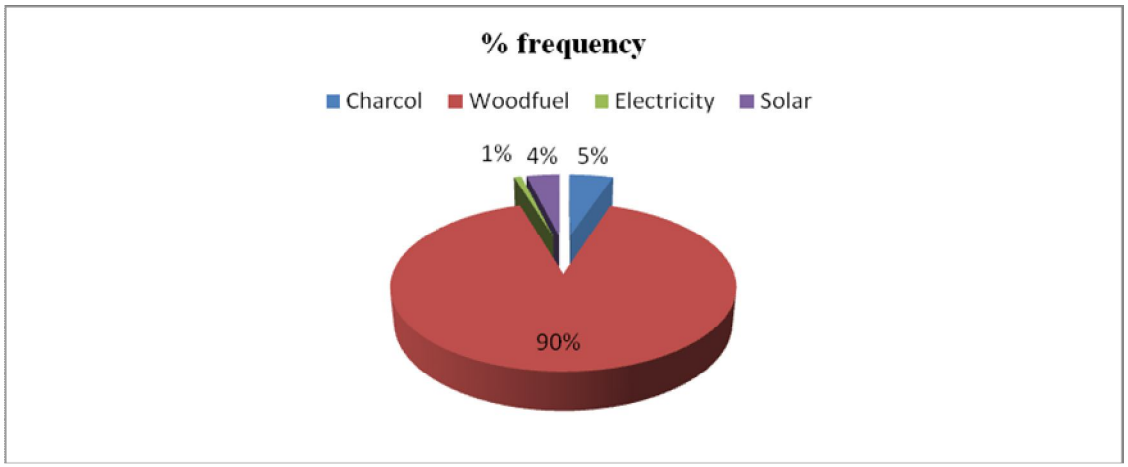

Figure 4.9: Sources of energy used by respondents in Kaloleni

According to the study findings, 90% of the respondents utilized wood fuel as the main source of energy, 5% utilized charcoal, 4% utilized solar and 1% used electric energy. (Figure 4.10).These findings indicated that 95% of energy needs of the people in Kaloleni were derived from forests, meaning that indeed small holder farmers were using wood and timber resources as a coping strategy in the face of climate change. Since most of them (Over 60%) lived on the periphery of the kaya forests, it was evident that they were actively involved in forest degradation as noted by western (1994) and GOK (1996, 2000, 2002)

4.4.2 Impact of human activities on Kaya Jibana Forest Biodiversity

Jibana has a cool micro-climate with slight showers of rain experienced in the area. Trees observed in Jibana forest were; C*upressus lusitanica* (mvinje), *Ziziphus mauritiana*

*(*zambarau*),Afzelia quanzensis* (mkilifi), *Balanites aegyptiaca* (msabuni*), Milicia excelsa (*mvule*) Vitex feruginea (*fudzu*), Cocos nucifera (*kunazi*), Mangifera indica (*miembe*)*. Reports from in-depth discussion with the Kaya elders indicated that the forest was still being used as a sacred prayer site especially for rain making. The Kaya elders indicated that the *Milicia excelsa* (mvule*)* is an indigenous tree within the forest that never dries up, due to the existence of a spring underneath, which is also a habitat for snakes and turtles. The elders also reported the existence of the leopard, lion, and the elephant in the forest in early 1960s. Due to human interference, they later migrated to Mazeras and Malindi. Springs in this forested area were drying up. A case in point being *Mukhologodo* springs (Figure 4.12) at the entrance of the Jibana forest, where snakes and turtles are believed to have steered the waters into existence. Ghosts (*mizimwi*) were also believed to take bath in this spring.

Figure 4.10: Maize plantation in the Kaya jibana forest

Photo by author; 17/08/2011

Field transects carried across kaya Jibana in 2011, revealed that agricultural activities took place inside the forest; this was indicated by the Maize plantations in the forest area (Figure 4.10). Wild plant varieties of cassava, oranges, pineapple and spices were also observed at Kaya Jibana Forest. Despite the existence of cultural beliefs, people still encroach into this forest for wood fuel harvesting.

Figure 4.11: Kaya Jibana elder at the Mukhologodo Springs

(Source: Photo by author, 17/08/2011)

4.4.3 The Impact of human activities on Kaya Fungo forest biodiversity.

Kaya fungo forest in Kaya fungo Location, Kaloleni Sub County is situated in the dry Livestock/Millet Zone (CL6) which is semi-arid in nature. Transects carried across this zone revealed massive destruction of the forest ecosystem. Woody vegetation characterized with scattered bush and thicket dominated the vast rangeland. *Euphorbia triculii* tree species was observed across these transects. Scattered settlements were also observed, with agricultural activity taking place in the area. Few maize plantations with withered crops were also observed. Hard pans on the agricultural fields were the main cause of crop failure. Evapotranspiration was high on soils and crops and hence maize crops withered and failed before reaching their tussling stage.

4.4.4 The impact of human activities on Kaya Kambe forest biodiversity

Kaya Kambe forest is located in Kambe Location, Kaloleni Sub County.The forest is located in the moderate rainfall-cashewnut/cassava zone. The zone is characterized by a gentle sloping terrain. Kambe forest is designated protected area by the Kenya National Museums and hence there was need to aquire permission from their office before accessing the forest. Most of the rivers and streams are reported to have dried up. The community around this area

attributes the drying of river Kombeni and Jangura to pollution from Athi river mining Industry.

River Kombeni dried up due to forest destruction on the upper catchment area, leaving the terrain almost bare (Figure 4.15). Performance of agriculture in this area is moderate with maize crop in this area was doing moderately well. The type of hardwood trees in this forest are ;*Strychnos cerusifera* (mazaje*)* and *Rafia farinifera* (mware*)*. Fruit trees, which were planted by the forest settlers in 1940's, include; *Rafia farinifera* (mzaje), *Mangifera indica* (miembe*), Cocos nucifera (*mnazi*)* and *Adansonia digitata* (mbuyu*)*. People encroach into the forest because they no longer value it as a sacred place of prayer. One of the medicinal trees found in Kambe forest is *Milicia excelsa* (mvule*)*. Indeginous wild roots which were used during dry seasons were found in Kambe forest such as *Moringa oleifera* (Moringa) which is medicinal in nature. Its roots can be peeled, placed in a plastic mesh and anchored by the riverside to be washed for hours to remove the bitterness.

In-depth discussion with Kaya Kambe elders revealed that there were some bird species such as the Red-billed quillea (*Quillea quillea*) appeared mainly during rice harvest periods. *Kozi* is another bird species which used to appear in times of fruit harvest but is no more. The birds that had emerged in recent times were the owls, hornbill, hawk and the black Indian crow. The wild animals that were found at Kambe forest were the warthog, cobra and the tortoise which appeared in the rainy season, while the vervet monkeys were reported to have disappeared. Timber harvesting (Figure 4.12) was observed on the forest edge, an indication that some of the community members had started discarding the existing cultural beliefs on the sanctity of the Kayas.

Figure 4.12: Illegal timber harvesting Kaya Kambe forest

(Source: Photo by author, 17/08/2011)

Figure 4.12 shows deforestation that took place in Kaya Kambe location. In line with Western (1994), the habitat outside protected areas was likewise altered by human activities, as high livestock densities outside protected areas degraded the grass cover, hence encouraging the growth of woody vegetation. FGD report revealed the general courses of climate change as; change in wind direction, extreme temperature changes, change in the onset of the rains and deforestation. In order to promote a forestation and re-forestation programmes, Kenya Forest Services (KFS) provided tree seedlings to community members; however, there was great concern on the replacement of indigenous trees with the exotic ones. In line with Kaloleni County's MOA's (2008/2009) annual report, out of the 12,800 tree seedlings provided, 9,600 survived. The species included *Casuarina equisetifolia*, *Grevillea robusta* and *Cocos nucifera* to be planted by farmers, CBOs and other institutions. Since the indigenous tree seedlings were not available, *cocos nucifera* was used for afforestation.

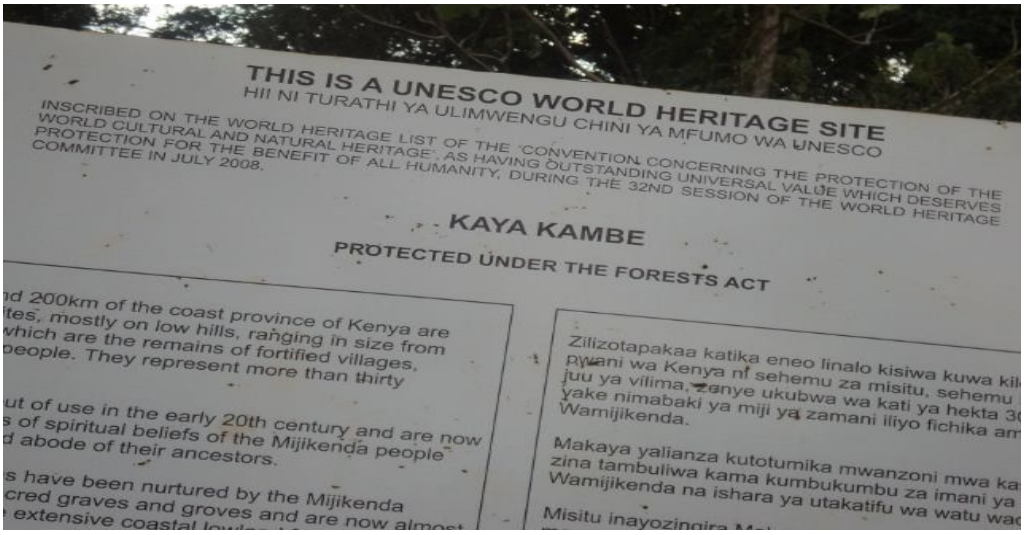

Figure 4.13: Notice on protected status on Kaya Kambe

(Photo by author,17/08/2011)

Figure 4.13 shows notice on protected area of Kaya Kambe forest. In-depth discussion by Kaya Kambe elders revealed that the forests had protection status by the National Museums of Kenya. No group or individual were allowed into the forest except by permission from the prescribed authority. To some extent, this notice has been of great importance in keeping away wood fuel harvesters and loggers.

4.4.5 Coping against forest degradation and biodiversity loss.

Based on FGD report, the stakeholders noted that there was a decrease in forest cover due to deforestation in the study area. There was an indication that indigenous trees were being replaced by the exotic. The communities were not sensitized and hence engaged in illegal logging /wood fuel harvesting and wildlife habitat was also disturbed. Tree nurseries consisting of exotic tree species were set up in schools and areas of administration (chief camps). Field transect carried out at Kaya Fungo chief's camp tree nursery revealed that the main tree seedlings planted are the grafted mangoes.

Since defforestation was a big menace in Kaloleni Sub County, recent report (The Standard, September, 2013) reported that a United States of America (USA) based non-profit social enterprise (Komaza) came to the rescue of the degraded biodiversity by engaging small holder farmers in rehabilitating the degraded dry land. Komaza worked with small scale

farmers to plant a half to one acre tree farms in the semi arid area. This organization encouraged farmers to plant a drought resistant strain of *Eucalyptus* clones on unused dry land. Komaza therefore provided tree seedlings, water retaining plastic bags (polymers) to cushion the farmers from dry spells, fertilizers and seeds for nitrogen fixing short term crops to each household. The profits are shared into half between Komaza and the small holder farmers, considering input like seeds and tools (The standard, September, 2013). Training was also consistent during the period under review for 50 shillings per farmer was paid to Komaza. Smallholder farmers planted around 200 seedlings of the cloned *Eucalyptus* on their farm. The advantage with these cloned seeds is that they do not die after harvesting and thus the farmer would not be engaged in planting more *Eucalyptus* after harvesting. For every half an acre of trees, the farmers earned between shs.257, 400 to shs.514, 000. Komaza aims to plant 900,000 commercial trees by the year 2017 which would replace an equivalent of 49,000 indigenous trees per year. This intervention by Komaza would reduce cases of wood fuel harvesting and logging practiced by the 22,500 small scale farmers in Kaloleni Sub County.

Table 4.17: Variation in occurrence of plant species over last 20 years

Disappeared completely	Decreased in number	Increased in number	Emerged
-	*Tamarindus indica* (ukwaju) *Ziziphus Mauritiana* (zambarau) *Garcinia livingstnei* (fodzohi,) *Vitex ferruginea* (fudzu) *Landolphia kirukii* (vitoria) *Dalium orientale* (mpepeta)	*Aloe-Volsekii* (aloe vera)	*Citrulus lanatus* (water melon) *Pennisetum clandestinum (*kikuyu grass*)* *Prosopis juliflora* (mathenge) *Moringa oleifera* (moringa)

Source: PRA and Survey, 2011 Results

Table 4.17 shows how deforestation has affected biodiversity over the last 20 years. Although *Proposis juliflora* (mathenge) tree species was introduced into the county for dry land rehabilitation, its emergence brought with it more problems such as the decay of goat teeth,

meaning that it interfered with the production of the main Livestock (small livestock) kept by small holder farmers in Kaloleni.

Other plant species that have emerged is the *Moringa Oleifera* (Moringa) plant which is exotic and introduced for use as vegetable and has medicinal value. Clearing of papyrus from the river riparian gave rise to *Pennisetum clandestinum (*kikuyu grass*)* grass species. To cope with destruction of the papyrus, small holder farmers opted to use iron-roofed houses instead of the traditional grass thatched one. Reports by Key informants revealed that siltation caused the disappearance of frogs, crabs and trauts that lived in river Kombeni and whose water had greatly been reduced due to deforestation in the upper catchment area (Figure 4.14). To cope against this problem of deforestation, FGD reported that the community was being sensitized by Kenya Forest Services (K.F.S) about the importance of re-afforestation. K.F.S provided tree seedlings which were natured in nurseries by the 4K club established within schools and other interested institutions.

Figure 4.14: The degraded upper catchment of river Kombeni

(Source: Photo by author, 17/08/2011)

4.4.5.1 Human/Wildlife Conflict

Table 4.18 shows the distribution of animals and birds in Kaloleni Sub County over the last 20 years. It was important to list them in order to find out which of the listed have either disappeared completely, decreased in number, increase in number or emerged.

Table 4.18: List of wild animals and birds

Wild animals	Birds
Lion Leopard Elephant Khomba Vervet monkey Warthog Field mice Turtles Snakes Hyena Dik dik Hog	Black Indian crow White stripped crow Hawk Eagles Kite Owl Red hornbill (Quillea quillea)

Source: PRA and Survey (2011) Results.

Table 4.18 shows the type of wildlife that exists in Kaloleni Sub County and their interaction with human and the environment. Variability in occurrence of wild life species was caused by the human interference on biodiversity and climate change. It was therefore important to find out the level of human wildlife conflict in Kaloleni Sub County and how it can be dealt with. Although the elephants were decreasing in numbers (Table 4.18) the remaining lot was still a menace to the farmers living next to conservation areas. To cope against the elephant menace, men kept vigil at night by lighting fire on the farms so as to prevent them from destroying their crops. The red hornbill (Quillea quillea) birds had also increased, causing destruction of rice on farms by feeding on the rice; small holder farmers engaged young boys to chase them away from affected farms. The eagle, Black Indian crow and the hawk had one thing in common; they predated on the free ranged chicken. Other duties undertaken by the young boys were to lay traps in order to keep away the wild mice from feeding on the sweet potatoes and the cassava on the farms.

Table 4.19: Variation in occurrence of wild animals and birds over last 20 years

Disappeared completely	Decreased in number	Increased in number	Emerged
White stripped crow Hyena Khomba Velvet Monkey Lion Leopard	Hog Wild Mice Dik-dik. Elephants Snakes Turtles	Black Indian crow.(kunguru) Red hornbill quillea	Warthog Eagles Kite Black Indian crow. Warthog Hawk Owl

Source: PRA and Survey (2011) Results

Due to encroachment into the natural habitats, there was a variation in occurrences of wildlife. As human beings interfered with the wildlife habitat, such as in the case of Kaloleni Sub County, the white stripped crow disappeared completely, thereby being replaced by the black Indian crow which has been a menace in Kaloleni. Table 4.19 indicated that the population of black Indian crow had increased. FGD revealed that there was a myth behind the existence of this bird. The fishmongers at the coast believed that this type of crow emanated from the Lake Victoria region in pursuit of the fish fingerlings that were transported down the coast by the traders. They also fed on virtually anything along their path. Most of the time, they were found on garbage dumps. Reports from in-depth discussion with the Kaya elders revealed that the dik dik and the hog disappeared due to illegal game hunting in areas surrounding the forests. The emergence of the black Indian crow also posed a threat to small-scale farmers' chicken rearing activities in Kaloleni. Therefore, as coping mechanism, farmers covered their chick using old mosquito nets (Figure 4.15). Small holder farmers from Ruiru village (Nakuru County) also had the same problem with their free ranged chicken. Often times they experienced scavengers such as the hawk and the eagle. A Non-governmental Organization (NGO) known as Farm input Promotion Africa (FIPA) in the year 2010 (The Standard, September, 2013) introduced the coping mechanism through the help of an agricultural extension officer. The chicks (3-7 days old) were painted in pink and purple. Farmers paid 3(three) shillings per chick for the service. The hawk and the eagles were scared away by these colors, each time they landed on the ground to predate on the chicks.

Figure 4.15: Use of old mosquito nets to guard the young chicks

(Source:Photo by author , 17/08/2011)

4.4.5.2 Distribution of Insects over the last 20 years

This section shows the distribution of insects over the last 20 years .The effect was due to climate changes and alteration of the ecosystem by human activities such as change in forest land use into farming land use. Table 4.20 shows the changes in occurrence of these insects' species over the given period of 20 years.

Table 4.20: Variation in occurrence of insects over last 20 years

Disappeared over time	Increase in number over time	Decrease in number over time	Emerged over time
Locusts	*Prostephanus truncates*(Large grain borer) Army worms White stripped beetle	Rhino beetle Hoppers	*Prostephanus truncates* (Large grain borer)

Source: Field Survey Data and PRA Results, 2011

From table 4.20, reports from FGD cited that the *Prostephanus truncates* (Large grain borer) emerged and thus increased in numbers. This means that the millet, wheat, sorghum and maize were affected by this pest, and yet they were the main food crops being consumed by Kaloleni residents. The army worms which were also very destructive on the leaves of crops were also cited, meaning that there was need for pesticide application in order to curb this

menace. The white stripped beetle was treated traditionally by application of wood fuel ash on the leaves of affected crops.

4.4.6 Institutional involvement on Biodiversity Issues

The institutions were ranked using Pair wise method (Table, 4.21) so as to come up with the order of impact. The stakeholders involved in biodiversity issues in this area were Kenya Forest Service (ranked first) who engaged the community in forest extension activities. Athi River Mining (Ranked Second) built schools and hospitals for the community members. The Kaya A forestation group (Ranked Third) provided tree seedlings, while the Miko Eco CBO (Ranked Fourth) provided energy saving Jiko to the community. Ministry of Social Services (Ranked Fifth) helped in registration of groups.

Table 4.21: Institutional Ranking (Pair wise ranking)

Institution	ARM	MSS	KFS	ME-C	KAG	Score	Rank
Athi-River Mining(ARM)		ARM	KFS	ARM	ARM	3	2
Ministry of Social Services.(MSS)			KFS	ME-C	KAG	1	4
Kenya Forestry Service(KFS)				KFS	KFS	4	1
Miko Eco(CBO)-M.E-C					KAG	2	3
Kaya A forestation Group(KAG)						0	5

Source: PRA and Survey (2011) Results.

4.5 Coping strategies on Rainfall Variability

This section shows the difference in mean rainfall distribution as the main cause of rainfall variability. In this study, the mean monthly rainfall was calculated over a period of 30 years and results generated as shown in figure 4.16

4.5.1 Evaluation of coping strategies on mean rainfall variability

Farmers in Kaloleni had adopted a number of indigenous coping strategies to cope with the various challenges posed to them by climate change. These strategies apart from cushioning

these farmers against extreme events also tried to address challenges faced by farmers as a result of degradation of the environment.

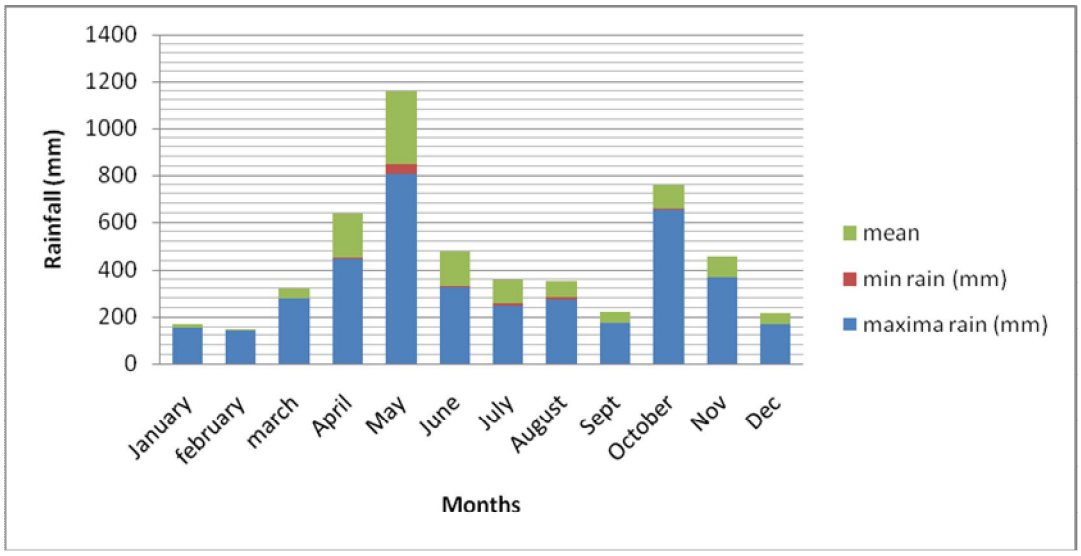

Figure 4.16: Mean monthly rainfall totals (mm) from Msabaha, Malindi, and Mtwapa Stations (1980-2010).(Source: Kenya Meteorological Department, 2011)

In the study area, reports from FGD indicated that the onset of the long rains had shifted from early March to end of May, ending in August, while October marks the onset of short rains, July, cessation of long rains, while October to December (short rains). Calculations derived from Mtwapa, Malindi, and Msabaha rainfall data between 1980 and 2010 indicated that rainfall was bimodal, in line with data derived from Kenya Meteorological Department (KMD, 2011). The 30 year period as agreed by Carter *et al.*, (1994), is termed "normal" as defined by the World Meteorological Organisation (WMO) and recommended by the Intergovernmental Panel on Climate Change (IPCC) for use as a baseline period.

From Figure 4.16, the maximum mean monthly rainfall totals recorded was 1160mm while the minimum mean monthly totals was 800mm; the latter of which exceeds data from the Kenya National Bureau of Statistics that indicates the minimum mean monthly rainfall totals of 700mm. According to the Kenya Meteorological Department (KMD, 2011), the mean annual monthly totals lie in the range of 700-1200mm across the four agro-ecological zones in Kaloleni Sub County. This agrees with Mearns et al, (1984) and Wigley (1985), that the difference in mean (800mm and 700mm) was likely to instigate frequency of occurrence of

events such as erratic rainfall that caused floods. Contrary to the findings in Kaloleni, Kranjac-Brisavljeric *et al.*, (1999) noted that Climate pattern in Ghana had shown that annual precipitation had slightly decreased over a period of 60 years, while temperatures and evapo-transpiration slightly increased.

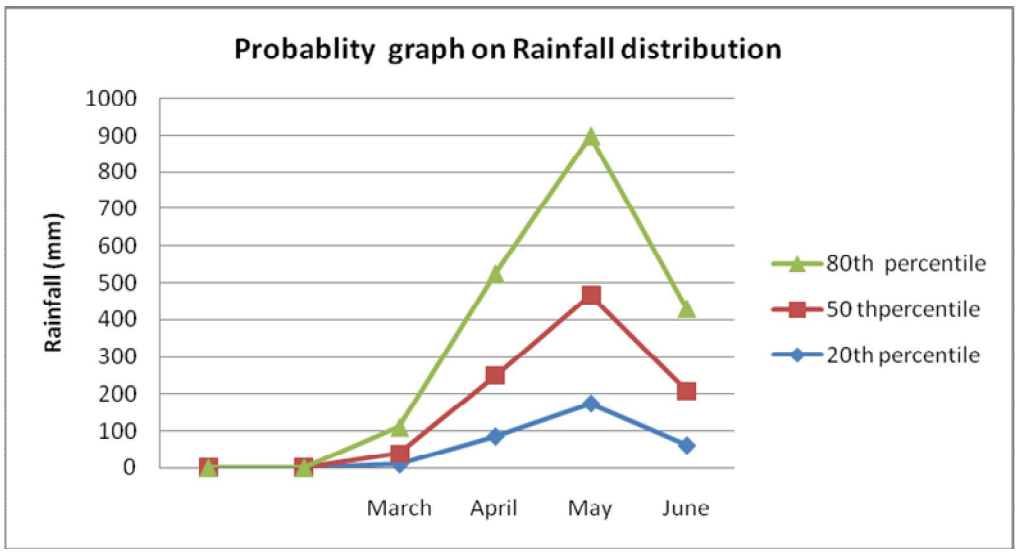

Figure 4.17: Probability on rainfall occurrence (March-June, 1980-2010)

Source: KMD 2011

From figure 4.17, the probability of Kaloleni small holder farmers experiencing 900mm of rainfall in the month of May was 4 times within 5 year period (80^{th} percentile), below 500mm of rainfall was experienced once in every two years (50^{th} percentile) and less than 200mm once in every five years. (20^{th} percentile). In March, the probability of small holder farmers experiencing below 10mm of rainfall was once in five years (1:5), below 30mm once in two years (1:2) and 100mm 4 times in every five years (4:5). These results corroborates with PRA report captured from Kaloleni Sub County that cited the onset of the rainy season to have shifted forward from March to May. In order to cope with the effects due to rainfall variability, small holder farmers shifted their planting date from March to June. The overall trend in rainfall, as demonstrated by the trend line appears to have slightly increased over the whole period of study. This supports Boko (2007) and Nicholson (2005) who recorded slight increases in rainfall over recent years following declining trends and frequent dry spells

between the 1960s and 1980s in Ghana. It is also evidenced that climate change does cause changes in the rainfall patterns.

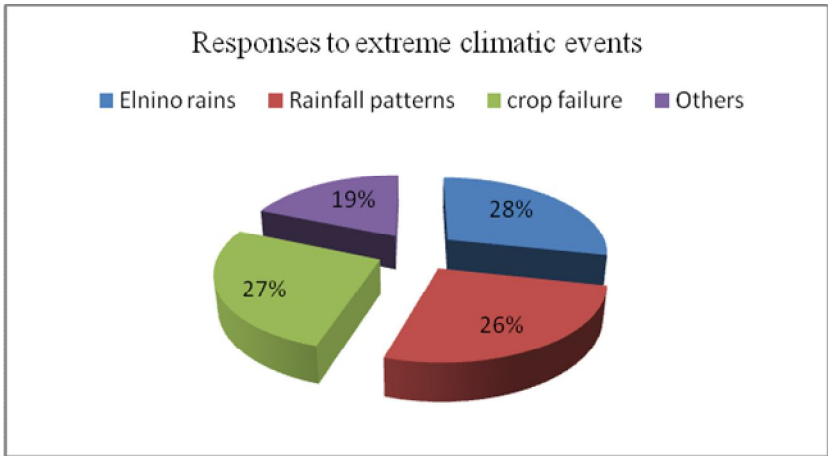

Figure 4.18: The occurrence of extreme weather events over 20 years (Field Survey Data , 2011).

As shown on Figure 4.18, majority of the respondents (28. %) noted the El Niño rains as the leading extreme event observed in the last thirty years, meaning that indeed the El Niño rains were caused by the difference in mean rainfall that occurred between 1980 and 2010 as shown on figure 4.18 above, followed by rainfall patterns (27%) and crop failure (26%). The El Niño rainfall which was common at the coastal area was mainly controlled by El Niño oscillation from the ocean. Kenya Meteorological department (KMD) representative revealed that El Niño oscillation at sea was the main cause of high tides that caused destruction of old and valuable palm trees and buildings next to the sea. This means that the El Niño rains resulted to additional volumes of water at sea, thereby causing the water level to rise within and beyond the oceanic basin. To cope with the problem of beach erosion, the community living closer to the beach moved to higher grounds in order to avoid being washed away by the tidal waves. Re-afforestation in place of the washed away palm trees was also encouraged. In order to adapt to the effect of rainfall variability, both water and soil conservation measures were required to be put into place, such as the re- enforcement of the sea walls using gabions.

Table 4.22: Sources of water in Kaloleni

Water Source	Frequency	Percent
Borehole	133	59.1
Tap water	56	24.9
Rain water	2	.9
Roof catchment	1	.4
Others	33	14.7

Source: Field Survey Data, 2011

Results from table 4.22 revealed that 59.1% (n=133) of the respondents used borehole water, 24.9% (n=56) indicating tap water use, while the rest (16%) indicated rain water and roof catchment as a means of water acquisition. Most of the boreholes and tap water were found in the transitional zones (CL3/CL4) and Coconut/cassava zone (CL4). Small holder farmers in Agro-ecological zones CL5 (Livestock/Millet zone) and the CL6 (Ranching zone) mainly depend on water pans which fell within the other sources of water at 14.7% (n= 33). Small holder farmers in the drier zones used the water pans both for domestic and irrigation purpose. According to FGD report, most of the pans were excavated through the effort of groups known as 'Merry go round' .It involved excavation of pans made on the farms of each group member. Field verification carried out in August, 2011 revealed poorly maintained water pans (Figure 4.19) in Tsangatsini and Mariakani. Plastic lining was required for each pan to stop seepage, while the riparian vegetation such as *Arundinaria alpina* (bamboo) vegetation was also needed around the pans to reduce siltation and pollution. Natural water pans were observed on the lower catchment of river Kombeni where horticultural irrigation took place, while some were anthropogenic, mainly as a result of mining. Water from the pans is both for domestic and irrigation use. According to FGD report, there was need to excavate more water pans in order to curb water shortage in Kaloleni County, especially within the drier zones.

Figure 4.19: Dilapidated water pan in Kaya Fungo location

(Source: Photo by author, 17/08/2011)

4.5.1: Historical timeline data of Kaloleni County

This section presents a number of notable occurrences which residents attributed to climate change. These events were heavy rainfall in 1969 and 1997; long drought spells 2004, 2006, 2009 and 2011. These events indicated in Table 4.23 shows that droughts were a common phenomenon in recent times compared to heavy downpours experienced in the 1990's.

Table 4.23: Historical Timeline data of Kaloleni Sub County

Period	Events
1969	Heavy rainfall resulted in bumper harvest
1997	Elnino rains, characterized by flush foods and Hailstorms, resulting in bumper harvest.
2004	Drought occurrence, causing shortage of livestock feed and hence sale of livestock.
2006	Drought characterized by very strong winds from the sea experienced in Mariakani area, causing collapse of a bridge.
2009	Heat Stress and Drought affected livestock, as the Maasai tried to evacuate the animals in a lorries. Most of them died.
2011	Heat waves associated with windstorms. Drought causing the residents to feed on poisonous cassava. Deaths reported.

Source: PRA and Survey (2011) Results

FGD reports indicated that there has been frequency in drought occurrences: 2004- 2006-2009-2011 with an indication of a three -year lapse drought in recent times, hence causing 3

years of good harvest and 3 years of poor harvest. The start of the rains in Kaloleni was noted to have shifted from March to May. In the year 2011 no rains were experienced until the month of August. Change in rainfall patterns was attributed to change in wind direction. Change in temperature was no longer in July but in August, with dry air blowing from the sea causing destruction on roof tops and crops. To cope against these affects, the government encouraged re-afforestation by providing tree seedlings to be planted in schools and homesteads. A total of 199 tree seedlings were issued to schools and these comprised of *Eucalyptus grandis, Casuarina equisetifolia, Afzelia quanzensis, Mangifera indica* and *Cocos nucifera.*

4.6 Coping Strategy on Land degradation

This section shows that soil erosion was evident in Kaloleni Sub County which required soil conservation measure which was important in soil fertility and farming sustainability. In line with MOAs 2008/2009 annual report, areas where land is steep with over 30%, soil conservation is encouraged. In instances where sheet erosion is observed, conservation is encouraged on a relatively flat area. Kaloleni Sub County is situated in a relatively flat area, but some areas needed conservation works.

Figure 4.20: Soil erosion in Kaya Fungo Location

(Source: Photo by author 17/08/2011)

Figure 4.20 shows how soil erosion took place in Kaloleni Sub County thus the most effective way was to build terraces especially on steep terrain. Field transects carried out in Kaloleni revealed that most of the terraces were existing and thus provided water conservation for their crops. Majority of the small holder farmers planted hedge crops that would arrest the surface runoff across the terrain. Although soil erosion measures were taken into consideration, some runoff leaked into the lower areas, hence causing soil erosion (Figure 4.20) on the terrain. Some the water pans into which the runoff had to be arrested were in a dilapidated state (Figure 4.19) but were being rehabilitated by placing plastic lining and planting bamboo trees on the edge in order to prevent siltation.

CHAPTER FIVE

SUMMARY /CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Findings

Table 5.1: Summary of Results

Variables	Coping Mechanism
Food insecurity	• Women forego meals and do casual jobs • School dropout and Non-farm employment (EPZ) by the youth. • Girls given into marriage or become house helps. • School feeding programme by government • Food for work • On farm theft by the youth mainly from larger families • Logging and Charcoal burning.
Crop Production failure	• Women used waste water irrigation and preferred planting early maturing seed varieties. • Farmers with more years of experience used waste water for irrigation and also preferred early maturing seed varieties. • Young boys laid traps on farms to keep away rodents and birds. • Men kept vigil at night to keep away elephants from destroying crops. • Placing of soil mounds at the feet of cereal stalks in order to enhance its stability against forces of wind. • On farm application of fertilizer • Early planting of crops to mitigate pest infestation. • Late planting due to rainfall variability. • On farm food preservation.

	• Stored food in cereal banks.
Livestock Production challenges	• Women control sales of small ruminants while Men took proceeds from sales of larger animals (cattle). • Livestock farmers from Cashew nut/Cassava zone free ranged their cattle into the forest. • Kept small ruminants for sales during drought episodes. • Planting of maize germ by livestock keepers from Livestock/Millet zone. • Kept indigenous breed due to their resistant to drought • Immunized livestock due to the onset of ECF, Tuberculosis, and foot and mouth disease. • Kept grade (exotic) cattle in confinement due to its delicate nature.
Forest and Biodiversity loss	• Use of old mosquito nets to protect young chicks against the black Indian crow. • Use of iron sheets for roofing instead of using grass thatched roofs. • Provision of protected forest status by the National Museums of Kenya. • Provision of exotic tree seedlings by Kenya Forest Service (KFS). Re-planting of riparian vegetation in order to reduce siltation in river beds. • Introduction of commercial tree planting programme. • Formation of groups by the Kaya Forest elders in order to attract grants that would enable them venture into production of Aloe Vera and Neem oil and soap products.
Land degradation and Rainfall variability	• Water pan excavation • Use of Zai pits and Fertility pits • Planting of drought resistant crop varieties such as sorghum

	• Establishment and maintenance of terraces. • Building of gabions. • Roof water harvesting by use of gutters.
Coping strategies affecting vegetation distribution in 1991, 2003 and 2011?	• Settlement in the kaya forest • Wood fuel and timber harvesting • Farming in the kaya forests. • Free ranging in Forest area.

5.2 Conclusions

Climate change was noted in Kaloleni as depicted by the rainfall variability graphs in this report. Forest degradation was one of the factors thought to have attributed to the changing rainfall patterns. The study aimed to assess the coping strategies used by small holder farmers to adapt in the face of climate change fallacies. Based on the specific objectives of the study, various coping strategies were documented; however, there was need to integrate the effective coping strategies into their daily agricultural activities in order to enhance production. The following conclusions were made from the study:

i) It was noted that food security affected women and girls , in that girls were given out in marriage in exchange of dowry for food purchase, whereas women bore the economic burden of their families by doing casual work and sacrificing their meals to other family members.

ii) Crop production suffered from both human induced and weather related factors. Adaptation was enhanced through human intervention such as laying of traps on farms to curb the manace of rodents and chasing away the rice eating birds. Technological intervention from various institutions such as KARI and MOA were also embraced in order to increase yields.

iii) In order to cope against the vagaries of climate change on livestock, small holder farmers embraced technological method in curbing livestock disease. They preserved maize germ and also free ranged their animals into the kaya forests.

iv) Forest biodiversity was destroyed and thus effects were being felt through the emergence of new insect and bird species. The scavangers fed on free ranged chicken as they used old mosquito nets to adapt. Most of the wild animals migrated to new habitats due to human interference. KFS offered tree seedlings for afforestation and reforestation, while National Museums of Kenya had to intervene by imposing protection status on the Kaya forests in Kaloleni.

v) Rainfall variability was felt in Kaloleni, with the minimum mean annual rainfall rising from the normal 700mm to 800mm during the 30 year period (1980-2010).These differences instigated occurrence of extreme climatic events such as erratic rainfall and flush floods. Land degradation was thus experienced in the process, which led them to cope using water conservation measures.

vi) Change in forest cover was also observed and confirmed by forest cover maps which recorded reduction in forest vegetation between 2003 and 1991.These changes were attributed by wood fuel and timber harvesting from the Kaya forests. Small holder farmers destroyed the forest to engage in charcoal burning and sales of wood products.

5.3 Recommendations

The study results showed that climate change coping strategies were being used by small holder farmers in Kaloleni to cope with extreme climatic conditions. I therefore recommend the following:

1. Kenya Forest Services (K.F.S) and the National Museums of Kenya (NMK) to help in the establishment of indigenous tree seedling nurseries in order to curb extinction of indigenous tree species. It should also empower the community in diversification of livelihoods such as commercial tree planting, sale of *Neem* and *Aloe* products. Ministry of Agriculture (MOA) to enhance keeping indigenous breed and small livestock for sale in order to cope against the vagaries of climate change.

2. Establishments of relevant factories that would enable food preservation, processing and value addition. Setting up of more food banks within a certain buffer zone is also recommended to avoid long distance travel by farmers.

3. A Project to fence off using electric fence would enhance Kaya Forest biodiversity conservation with an aim of preserving indigenous tree species.

5.4 Suggestions for further research

1. Document the early maturing crop varieties that would be suitable to thrive under Kaloleni's adverse Climatic Conditions; this would improve crop yields and to a larger extent food security. Investigation to be done on the efficacy of the traditional wood fuel ash on powdery mildew.
2. To investigate the nutrition status of women in Kaloleni Sub County.
3. To investigate the distribution of rainfall stations in Kaloleni Sub County.

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APPENDICES

Appendix I: Questionnaire

I am an MSc student at Egerton University carrying out Research in Kaloleni County. Its focus is on *"An assessment climate change coping Strategies that Influence Vegetation Distribution within communities in Kaloleni Sub county-Kenya'*. Please answer the questions below with utmost sincerity to make the research a success. The information you provide will be treated confidentially.

Anne A. Osio (Cell Phone-0720797276) (A) Household Information

Enumerator's cell phone No.....

District……. ……

Head of Household Number…….

Division…… Location……..

Sub-location …….. Village ……..

Area of residence……Urban [ ] Rural [ ]

Agro ecological zone ……. Soil type……

Average rainfall (mm) per annum……

Average Temperatures …….....^{0}C Min……^{0}C Max ……^{0}C.

(A1) 1Information of the household head

sex	Age in Yrs	Marital status	Formal education	Household size	Source of energy most frequently used	Source of water
1=Male 2=Female		1=Married 2=Single 3=Divorced 4=Widowed 5=Other (specify)	1=Primary 2=Secondary 3=Tertiary 4=others (specify)	People living in the homestead over the last one year	1=Charcoal 2=Wood fuel 4=Electricity 5=Solar 6=Petroleum products 7=Other(specify) _____	1=River 2=Bore–hole 3=Tap water 4=Rain water 5=Roof catchment 6=Other (Specify) _____
[ ]		[ ]	[ ]		[ ]	[ ]

(A.2) HOUSEHOLD COMPOSITION

	Household Member's Name	Sex	Age (Years)	Relationship to the household head	Highest level of Formal education attained	Months resident at the location during the last 12 months	Experience in farming
1							
2							
3							
4							
5							
6							
7							
8							
		1=Male 2=Female		1=Household head 2=Spouse 3=Daughter 4=Son 5=Other relative 6=Other non-relative (Specify)_____			Number of years in farming

(A3) Farm area (in acres)

	Size in Acres	Rental Price (Ksh.) Per acre	Approximate Value (Ksh.) Per acre	Land tenure
1=Owned				
2=Rented				
3= Leased				
4=Others (specify)_____				

Codes for land tenure

1=Freehold with certificate/title deed

2= Freehold without certificate/title deed

3= other (specify)…….

(A4) Land use

Land use	Size in Acres	Years in Same use	Rank : 1 for major
1. Homestead			
2. Forest			
3. Subsistence Crops			
4. Cash crops			
5. Livestock			
6.Other (specify)			

PART B1- GENERAL CLIMATE CHANGE ISSUES

B1a) What are the indicators of the evidence of climate change in your area? ☐

1=Heat Stress 2=Windstorms 3=Hailstorms 4=Fog 5=Change in rainfall amounts 6=Change in rainfall patterns 7=Floods 8=Disease occurrence 9=Draught 10=others. (Specify)……

B1b) What extreme events have you experienced in your area in the last 20 years? ☐

1=Strong winds 2=Elnino rains 3=Severe draught 4=Floods 5=Rainfall patterns 6=Livestock loss 7=Crop failure 8=Disappearance of rivers 9=Others (Specify)……

PART B2-B8 BIODIVERSITY ISSUES

B2) list the traditional /indigenous trees, crops: cereals, vegetables, pulses, root crops, fruits, animals, birds, pests that you know.

sn	trees	cereals	vegetables	pulses	Root crops	fruits	rodents	pests	Birds
1									
2									
3									
4									
5									
6									
7									

B3)What activities have you observed taking place within the nearest forest over the last 20 years? [ ]

1=wood fuel collection 2=Logging 3=fruit harvesting 4=beekeeping 5=Poaching 6=Farming 7=Settlement 8=others (Specify)……Descriptive statistics

B4 (i)What type of fruit trees have disappeared within your area for the last 20years?

ii) What type of fruit trees have emerged from your area for the last 20 years? [ ]

ii) What are the indigenous fruit trees planted in your area? [ ]

1=Mpera (Guava),2=Makwaju 3=FuduMadzu= 4= Ngambo 5=Zambarau 6=Fodzohi 7=FuduUnga 8=Pepeta 9=Victoria

10=Madzaje, 11=Makanju, 12=Kunazi, 13=Kungu 14=Makoma 15=Maviru 16=Tsikitsi 17=Matomoko, 18=Mbelenga, 19=Fula

20=Tundukula, 21=Mavelu, 22=Mauyu 23=Maembe 24=Lulu 25=Fonzoli 26=Malongazi. 27=Oranges 28=bananas 29=Others.(Specify)……

B5) What type of trees have you planted on your land for re-a forestation purpose? [ ]

1=Eucalyptus 2=Casuarinas 3=Msonobari 4=Mango 5=Others. (Specify)…….. [ ]

B6) What type of medicinal tree have you observed in the nearest forest in your area?

1=Mrihi 2=Mchungu 3=Mkura (Mbawa) 4=Mbome 5=Mserere 6=Mtanga 7=Mgafari 8=Other. (Specify)…… [ ].

B7) What type of sea animals have you observed to have disappeared over the last 20 years?

1=Crocodiles 2=Hippos 3=Shell animal (Kombe) 4=Slug (Kovi) 5 Slug=Kola 6=Water snakes 7=Others.(Specify)……..

B8) What type of wild animals have you observed to have disappeared from the nearest forest for the last 20 years?

1=Hyena, 2=Warthog (Nguruemwitu) 3=Antelope (Swala) 4=Elephants 5=Cheetah 6=Leopard 7=Others. (Specify)…….

PART C1-C3 -MPACT OF CLIMATE CHANGE ON LIVELIHOODS

C1)Apart from livestock and crops, what other source of livelihood do you have? [ ]

1=Making bricks 2=Sand harvesting 3=Making ballast 4=Bodaboda 5= Making Sisal products 6=Water sale 7=mining 8=Others.(Specify)…… [ ]

C2)What are the indicators of the effects of climate change on livelihoods? [ ]

1=Breaking in business premise 2=stealing of crops 3= Early marriages 4=School dropouts, 5=others (Specify) …… ☐

C3) What Institutions are involved in the adaptation strategies of these livelihoods?

1=Provincial Administration 2=Police 3=Equity bank 4=KWFT (Kenya Women Finance Trust) 5=Faulu Kenya 6=K-Rep 7=Alpha Plus 8=Durep 9=Rural Support Programme 10=world vision 11= Department of Agriculture 12= livestock department 13= fisheries department 14=CBO's 15=Others (Specify)……..

PART D1-D7 - IMPACT OF CLIMATE CHANGE ON LIVESTOCK MANAGEMENT

D1) What species of livestock are most affected in the face of climate change? ☐

1=Indigenous cattle 2=indigenous poultry 3=Grade (Exotic) cattle 4 =Sheep 5=Goat 6=duck 7=others (Specify)…… ☐ .

D2) In the face of the effects due to Climate Change, what coping strategies do you use in livestock production?

1=Keeping fewer animals 2=Use of maize germ 3=Livestock Sales 4=Keep indigenous breed 5=Use free ranging systems.

6=Seek AI service 7=Fodder production 8=storage 9=others (Specify)…….. ☐

D3) What coping strategy do you use in mitigating livestock disease?

1=Confinement 2=Dipping of animals 3=Use of Veterinary services 4=Others (Specify)…….. ☐

D4) Among these group of people, who are the most engaged in livestock management?

1=Men, 2=Women 3=Children 4=Young men 5=Women.

D5) What effort did you make to mitigate anticipated effects of climate change? ☐

1=Dredging of water pans 2=Immunization of livestock 3=Fodder preservation 4=Others. (Specify)……..

D6) Which a Institutions have been in the frontline in your community in helping to cope/adapt/mitigate the effects of climate change on livestock? ☐

1=Ministry of Agriculture (MOA) 2=NGO'S 3=CBO'S 4=Others.(Specify)……..

Indicate what each of the institutions listed above has been doing to help in coping/adapting or mitigating the effects of climate change on livestock

sn	institution	Activities related to climate change
1	MOA	
2	Livestock department	
3	Ministry of Education	
4	Kenya wildlife service	
5	Provincial administration	
6	Ministry of youth affairs	
7	World Vision	

D7) What support as a community would you like to receive in mitigating livestock against effect of climate change? ☐

1=Provide A.I Services 2=Extension services 3=Education 4=Others(Specify)……..

PART E1-E8 - IMPACT OF CLIMATE CHANGE ON CROP PRODUCTION

E 1) In the face of climate change effects on crop production what coping strategies do you use?

1=Early harvesting 2=Planting improved crop variety 3=irrigation 4=Use of waste water for gardening 5=Planting early maturing crops 6=Early Planting date 7=Others.(Specify) …….. ☐

E 2) What climate change hazards have severely impacted on your crop production? ☐

1=Draught 2=Disease 3=Pests 4=floods 5=Strong,winds 6=Others(Specify)…….

E 3) Which crop variety has experienced the greatest impact? ☐

1=Maize 2=Sorghum 3=Green grams 4=Rice 5=Cowpeas 6=Other. (Specify)……

E4) What changes have you made in managing your land? ☐

1=Stopped burning 2=Intercropping 3=Ridges and bunds 4=Mulching 5=Hedge cropping 6=Contour ploughing 7=Crop rotation 8=Early land preparation 9=Early planting 10=Late

planting 11=Start using chemical fertilizer 12=Start Using Manure/Compost 13=Stopped using Manure/Compost 14=others.(Specify)……

E5) What work do the following persons engage in, so as to mitigate the effects of climate change? ☐

Men ☐ Women ☐ ☐Young women Young men ☐

1=Watering Livestock 2=Feeding livestock 3=Chasing,away predators4=others(.Specify)……..

E6) When weather related changes occur which institutions are in the frontline to mitigate its effects? ☐

1=World Vision 2=Provincial administration 3=Ministry of Health (MOH) 4=World Food Programme (W.F.P) 5=Redcross 6=Ministry of Agriculture (M.O.A), 7=Ministry of Education (MOE) 8=Other (Specify)……☐.

E7) What specific support do you get from these institutions? ☐

1=Relief food 2=Seeds 3=Blankets 4=Building 5=materials,6=others (Specify)……

E8) Through what means do you receive weather information? ☐

1=Radio 2=T.V 3=Friends 4=Fellow farmer 5=Internet 6=Mobile SMS 7=Extension officer 8=Others.(Specify)……..

PART F1-F7 - IMPACT OF CLIMATE CHANGE ON FOOD SECURITY SYSTEMS

F1) Types of Traditional food used over the last 20 years

Cereals	Legumes	Vegetables	Fruits	Livestock products	Pulses
1=Maize	1=bean	1=mkunde	1=Mpera	1=Samli(ghee)	1=Cow pea(mbaazi
2=Sorghum{Mawele}	2=Others(Specify)	2=Bombo	2=Zambarau	2=Maziwa fresh	2=Kunde(chicken pea)
3=Millet {Wimbi}		3=Kigwanda	3=Mazala	3=Maziwalala	3=Mubombo
4=Rice		4=Mgenje	4=Papaya	4=Nyamu	4=Others (Specify)
5=Other……..(Specify) ☐	☐	5=Others (Specify) ☐	5=Others. (Specify)…… ☐	5=Others…… …..(Specify ☐	☐

F2) Which of the following food varieties have been 1=Decreasing 2=Declining 3=Without remarkable change

Food Type	Ranking
Cow pea(Mbaazi)	
Mkunde(Chicken Pea)	
Bombo	
Kikocho	
Mapera(Guava)	
Zambarau(Grapes)	
Samli {Ghee}	

F3) From the list below of Livestock, fruit, Vegetable, grain, and tubers, which are the emerging varieties in your area? Tick where applicable.

F4) From the list below, mark foods availability in the market during the following seasons and indicate whether 1=expensive 2=Less expensive3=Moderate 4=Cheap.

Vegetable	Grains	Fruits	Livestock
Kale(Sukuma wiki) ☐	Sindano rice ☐	Avocado ☐	Grade animals ☐
Cabbages ☐	Singae rice ☐	Passion ☐	Goat for milk ☐
Spinach ☐	Kimumbo rice ☐	Hybrid Mangoes	Reddish/Purple cassava
Carrot ☐	Ndengu(green gr ☐	Papaya ☐	Grade chicken ☐
Mapenda ☐	Mbaazi{Cowpea}	Pineapples'(big)	Grade cow ☐
Biriganya ☐	Millet {Wimbi} ☐	Oranges(Hybrid) ☐	Guinea pigs ☐
Others{Specify}…… ……..	Others(Specify)…… …… ☐	Others.(Specify)…… …… ☐	Others(Specify)…… …….. ☐

Normal Seasons	Adverse seasons	Favorable season
Cassava ☐	Matongo ☐	Traditional Mangoes ☐
Sweet potatoes ☐	Cucumbers ☐	Kales ☐
Green maize ☐	Cassava ☐	Spinach ☐
Others (Specify)……	Appenes ☐	Rice ☐
	Palm nut ☐	Irish potato ☐
	Ndunga ☐	Cabbages ☐
	Others (specify)……..	Others.(Specify)…… .

F5) what are the innovations adopted in your community in terms of food acquisition, consumption and management during the following seasons? Tick where applicable

Normal Seasons	Adverse Seasons	Favorable seasons
Feeding vulnerable groups ☐	Charcoal burning ☐	Advance payment for food to be harvested ☐
Food diversification ☐	Fuel wood sales ☐	Food diversification ☐
Value addition ☐	Building bricks ☐	Value addition ☐
Food bank in local posho mill ☐	Food for work ☐	Others. ☐ (Specify)…… ……..
Others (Specify)…… ….	School-feeding programme ☐	
	Famine relief ☐	
	Others (Specify)…… ……..	

F6) Who are the stakeholders involved with food security in your area?

1=Kenya Red Cross 2=World food programme (WFP) 3=Local businessmen 4= Local Church organizations 5Others (Specify)……

F7) What coping strategies does the community use in the face of food insecurity? ☐

1= Going against cultural belief, by allowing women to work; 2=Marrying off daughters early in exchange for money 3=Free primary education where there is a feeding program. 4=Water vending 5=Food for work 6=Robbery with violence 7=Robbery at farm level. 8=Others (Specify)……..

Appendix II-Focus Group Discussion-Checklist

Date_____

A. PRODUCTION ENVIRONMENT

Name of the location _____

Division_____ District _____

Weather station: _____ GPS of the site _____

B. CLIMATE CHANGE ISSUES

What is your understanding of climate change?

1. Describe the indicators or evidence of climate change in your area? *(Rainfall amounts/patterns , Drought ,Water quality, Water availability, Flooding, Heat stress, Wind storms, Hail storms, Fog, Snow, Biodiversity, Human health, etc)*
2. List down occurrences of extreme events? *(Drought, Flooding, Heat stress, Wind storms, Hail storms, Fog, Snow).*

3. Indicate in the last 20 years when each of these has happened or the frequency.
4. What, in your opinion are the possible causes of climate change?

C. 1 IMPACTS OF CLIMATE CHANGE ON CROP PRODUCTION

1. Climate hazards impacting on Crop Production

a. Which months do the long and short seasons normally begin and end in this region?
b. Has there been a remarkable change in season pattern? (*Start of the season, end of the season)*
c. If yes, explain the changes that have actually occurred?
d. Which of the climate change hazards have severely impacted on Crops?

Land management	Yes or no Crop 2
Stopped burning	[__ __]
Introduced intercropping	[__ __]

e. Which Crops and Varieties experienced severe impacts? And which ones did not*?*
f. How has climate change affected the crops listed in question (f) above?
g. What changes have you made in the way you manage your land (soil) in the last 10 years and why? e.g. Stopped burning, Introduced intercropping, Introduced crop cover, Introduced/built ridges or bunds, Introduced mulching, Introduced hedges, Introduced contour ploughing, Introduced rotations, Earlier land preparation, Earlier planting, Later planting, Started using or using more mineral/chemical fertilizers, Started using manure/compost, Stopped using manure/compost, Started using or using more pesticides/herbicides

2. Coping and adaptive strategies for crops

a. What did you do when weather related changes occurred in order to manage or mitigate their impact on crops?
b. Did you make efforts to prepare/plan for weather related changes in future?
c. List down these planned adaptation strategies and rank them in order of effectiveness giving reasons.

d. Briefly describe the roles played by each of the following gender groups in the climate change adaptation efforts.

i. Men
ii. Women
iii. Young men
iv. Young women

3. Institutions supporting adaptation efforts in crops

a. When the weather related changes occurred, did you receive some support from any institution?

a. If the answer is yeas to question a, list the institutions

b. What specific support did you receive?

c. Who provided the support? *(Relatives/neighbours/government/NGO/)*?

d. Was the support offered in time?

e. Rate with reasons the level of effectiveness of the support you received *(1=minimal….5=very effective)*

f. Rank the Institutions supporting adaptation efforts in crop production

g. Are there other specific support you would wish to receive when weather related change occur?

C. 2 IMPACTS OF CLIMATE CHANGE ON LIVESTOCK MANAGEMENT

1. Climate hazards impacting on livestock

a. Which of the climate change hazards impacted on Livestock production?

b. *what aspects of livestock production was affected (e.g. feeds, diseases, productivity etc)*

c. Which species and breeds of livestock experienced severe impacts? And which ones did not?.*(In the affected breeds and species indicate within various categories of stocks: males, females, young, old, lactating, gestating)*

2. Livestock Coping and adaptive strategies

e. What did you do when weather related changes occurred in order to manage or mitigate the impact on your livestock?

f. Did you make efforts to prepare/plan for weather related changes in future?

g. List down these adaptation strategies and rank them in order of effectiveness giving reasons.

h. Briefly describe the roles played by each of the following gender groups in the climate change adaptation efforts.

i. Men

ii. Women

iii. Young men

iv. Young women

3. Institutions supporting adaptation efforts in Livestock

a. When the weather related changes occurred, did you receive some support from any institution?

b. What specific support did you receive?

c. Who provided the support? *(Relatives/neighbours/government/NGO/)*?

d. Was the support offered in time?

e. Rate with reasons the level of effectiveness of the support you received *(1=minimal….5=very effective)*

f. Rank the Institutions supporting adaptation efforts in Livestock production

g. Are there other specific support you would wish to receive when weather related change occur?

C. 3 IMPACTS OF CLIMATIC SHOCKS ON FOOD SECURITY.

1. Types of Food that were traditionally (> 20 years) produced and consumed

a. What types of Food were traditionally (> 20 years) produced in terms of Quantity in the diet: (Range from Largest to least)

i. Cereals (specify)

ii. Pulses and Legumes (specify)

iii. Vegetables (specify)

iv. Fruits (specify)

v. Livestock products (specify)

b. Which of these types of foods have been; increasing, declining, without remarkable change?
c. What have been the major causes of the changes for each of the foods in (a)?
d. Of the types of food traditionally (> 20 years) produced in(a) above, which contribute to the diet: (*Largest, Large, Moderate, least*)
e. What are the underlying factors associated with the changes in the foods that are
    i. Increasingly consumed
    ii. Declining
    iii. Without remarkable change

f. Which foods are relatively new in the diet (those outside the traditional ones)?
g. What factors have contributed to adoption of these new foodstuffs?
h. How do you manage <u>each</u> of the foods produced or obtained in other ways when there is; surplus, deficit, just enough?(*Exchanged with other commodities, sold for cash, processed, value added, given to friends, stored, consumed on spot etc.)*

2. What is the nutritional status of household members(men, women, boys, girls and children under five years) during Adverse seasons and why? *(Categorize answers as: Well nourished; moderately Nourished; or Malnourished for each category of household member)*

3. Foods available in the local markets

a. List the foods available in the local markets (in terms of Most abundant to least abundant) during:
    i. Normal seasons,
    ii. Adverse seasons,
    iii. Favorable seasons (Above normal Production)

b. How <u>affordable are the major foodstuffs</u> at the local market (Range from most expensive, moderate, to least expensive for <u>each foodstuff</u>) during:
    i. Normal seasons,
    ii. Adverse seasons,
    iii. Favorable season (Above normal Production))

4. New innovations in food acquisition, consumption and management

What are the new innovations in food acquisition, consumption and management? (These depend on the area e.g. famine relief, school feeding programmes, food banks in local posho mills, advance payments for foods to be harvested, reduce no of meals per day, priority feeding for vulnerable groups, food diversification, value addition, preservation etc.) During:

i. Normal seasons
ii. Adverse seasons
iii. Favorable seasons (Above normal Production

5. Stakeholders involved in new innovations on food security

a. Who are the stakeholders involved in new innovations in food acquisition, consumption and management?
b. Which food stuffs and activities are each dealing with?
c. What support do they give to the community?
d. Rank the stake holders(pair wise ranking)

C. 4 IMPACTS OF CLIMATE CHANGE ON BIODIVERSITY

1. List the biodiversity changes which have emerged over time
    a. What has happened on forest over time? (*Increased, decreased, remained the same, destruction of some tree species, shamba system introduced/abolished, replanting*)
    b. Are there some plant species that have
        -Disappeared completely?
        -Emerged?
        --Increased in numbers?
        -Decreased in numbers?
    c. What has happened on wild animals and birds over time? *(Specify species)*
        -Increased in numbers
        -Decreased in numbers
        -Emerged

-Disappeared

d. Are there some animals and birds that have

-Disappeared completely?

-Emerged?

-Increased in numbers?

-Decreased in numbers?

e. Are there some insects that have

-Increased in numbers over time?

-Decreased in number over time?

-Disappeared completely over time?

-Emerged over time?

f. What has happened on wildlife/human conflicts over time?

-Increased frequency

-Decreased frequency

- Disappeared completely

-Emerged

g. What has happened to the *Land terrain, Rivers, Lakes* over time?

2. Who are affected by these changes? Why are they affected? and How are they affected?
3. What are the coping strategies and adaptation strategies to these changes?
4. Rate with reason the effectiveness of the adaptation strategies to climate induced biodiversity changes (*(1=minimal….5=very effective).*
5. Who are the stakeholders involved in biodiversity issues in this area?
6. What are their activities?
7. What kind of support does each provide?
8. Rank these stake holders *(Pair wise ranking)*

C. 5 IMPACTS OF CLIMATE CHANGE ON LIVELIHOODS

1. What are other sources of livelihoods (apart from crops and livestock)of community in this area?

-Kiosk/Shops *(Specify what is sold*)

- Value addition and marketing of crop /livestock products *(Specify*)

- Marketing of farm produce/animal products *(Specify*)

- Transportation/carts/lorry/donkey/ farm inputs *(Specify what is transported)*

-Other *(Specify*)

2. Identify *indicating Why and How* the livelihoods and people vulnerable to climate change hazards
3. What are the livelihoods adaptation strategies to climate change hazards?

   -Diversifying livelihoods

   -Changing the livelihood

   -Insuring the livelihood

   -Abandoning the livelihood

   -Other (specify)
4. Indicate with reasons how effective these adaptation strategies are *(1=minimal….5=very effective).*
5. Which institutions are involved in the livelihoods adaptation strategies?
6. What support do they provide?
7. Rank these institutions (*Pair wise Ranking)*

Appendix III:In-depth interviews (For the key informants)

At Kaya Jibana (Zone CL3/CL4)

1. Are there any indigenous trees currently found in Jibana Forest?
2. Are there any animals and birds noted to disappear in the last 20 years?
3. Are there fruit trees you have noted to have disappeared in the last 20 years?
4. What are the cultural norms associated with Kaya Jibana forest?
5. Does the government play any role in controlling forest activities?
6. What is the condition of the rivers and springs within the forest?
7. What kind of illegal activities are taking place in the forest?

At Kaya Kambe (Zone CL4)

1) What kind of illegal activities are taking place in the forest?

2) Does the government play any role in controlling forest activities?

3) Are there any indigenous trees currently found inKambe Forest?

4) What is the condition of the rivers within and around the forest?

5) Are there any fruits, tubers or vegetable from the forest consumed during dry seasons?

At Kaya Fungo (Zone CL6)

1) What are the reasons behind degradation outside forest area?
2) Are there any indigenous trees currently found in Kaya Fungo Forest?
3) Does the government play any role in controlling forest activities?
4) What is the condition of the rivers within and around Kaya Fungo forest?
5) How does the inhabitant of this area affect Kaya Fungo's forest conservation?