CHARACTERIZATION OF CLIMATE VARIABILITY AND THE ASSOCIATEDADAPTIVE STRATEGIES BY SMALLHOLDER FARMERS IN SENETWO LOCATION, WEST POKOT COUNTY, KENYA

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DECLARATIONAND RECOMMENDATION

DECLARATION

This thesis is my original work and has not been submitted for examination in any other university

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RECOMMENDATIONS

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DEDICATION

I dedicate this thesis to my dad Musa Arukulem for his constant and endless love, consistent encouragement, prayers and support.

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ABSTRACT

In the ASAL part of West Pokot County the growing season for agricultural activities occurs during the peak rainfall season, during March, April and May (MAM) season. This study thus sought to quantify MAM rainfall variability and its associated impacts on the livelihoods of smallholder farmers in Senetwo location where the study was conducted. This was achieved by analyzing daily rainfall data from 1983 to 2013 and household survey. Using data from a survey of 125 farm households, the most common adaptation strategies used by most households include: use of soil and water conservation techniques (67.2%), changing planting dates (67.2%), use of commercial fertilizers (66.2%) and use of fast growing crop varieties (82.4%). Despite these initiatives, Senetwo location is largely characterized by limited use of climate forecast information (22%), limited support from the government and Non-Governmental Organizations (NGOs) (15.2%), low involvement in off-farm activities (16.8%) and low literacy levels (50% with at least primary education). Multivariate Logit regression model revealed that access to agricultural extension service (0.302; $p \leq 0.01$), large farms (0.341; $p \leq 0.1$), access to climate change information (0.326; $p \leq 0.05$), access to credit (0.311; $p \leq 0.01$) and perceived change in temperature (0.117; $p \leq 0.1$) have positive and significant impact on adaptation to climate variability. Annual rainfall trend between 1983 to 2013 show that in the MAM season rainfall has increased in Senetwo location with mean rainfall increasing from 203.2mm during the 1983 to 1992 decade to 346.1mm during the 2003 to 2013 period; a condition suitable for the good subsistence agricultural performance. On the contrary, the smallholder farmers of the location occasionally suffer heavy economic and resources loss due to unprecedented adverse variability in weather conditions. In conclusion, the livelihoods of smallholder farmers in Senetwo have been negatively impacted on by the alteration of rainfall performance, thus the current coping strategies are inadequate. However, there is need to invest and support weather observing infrastructure locally and continuously collect data so as to be able to generate accurate weather prediction models that can be customized, improved and utilized by smallholder farmers in ASALs elsewhere.

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LIST OF ABBREVIATIONS AND ACRONYMS

ASAL(s):	Arid and Semi Arid Land(s)
CEEPA:	Centre for Environmental Economics and Policy in Africa
CC:	Climate Change
ENSO:	El Niño Southern Oscillation
FAO:	Food and Agricultural Organization
GoK:	Government of Kenya
IPCC:	Intergovernmental Panel on Climate Change
KMD:	Kenya Meteorological Department
MAM:	March, April and May
MENR:	Ministry of Environment and Natural Resources
MEWNR:	Ministry of Environment, Water and Natural Resources
MoA:	Ministry of Agriculture
NEMA:	National Environment Management Authority
NGOs:	Non-Governmental Organisations
SPSS:	Statistical Package for the Social Sciences
UNEP:	United Nation Environmental Programme
UNFCCC:	United Nations Framework Convention on Climate Change
EPA:	Environmental Protection Agency of the United States of America
C*v*:	Coefficient of variation
KRCS:	Kenya Red Cross Society
WRI:	World Research Institute

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

According to Environmental Protection Agency of the United State of America (EPA) 2014, the threat of Climate Change on global survival systems is a critical, urgent issue today. The most significant consequence of climate change is climate variability, which is the long-term irregularity in observed climatic conditions. These include the widespread changes in precipitation amounts, onset and distribution, wind patterns and aspects of extreme weather resulting in droughts, heavy precipitation, heat waves and the intensity of tropical cyclones (IPCC, 2007). Climate change threatens community livelihoods, food security, economic sectors, as well as ecosystems and social groups. The socio-economic sectors that are adversely affected include agriculture, water resources, forestry, fisheries, human settlements, and human health (Watson *et al.*, 1998; O'Brien and Leichenko, 2000).Worrying evidence is convincing that climate change and climate variability is real, that it will become worse, and that the poorest and most vulnerable people will be affected first and most (IPCC, 2007).

According to IPCC (2010), climate change and climate variability is likely to lead to some irreversible impacts. Currently at continental and regional levels, arid and semi arid lands (ASALs) have become the most threatened ecosystem by climate variability due to its environmentally marginalized location; agriculture is the most affected economic sector by climate variability since it is majorly dependent on the stability of weather conditions; and the rural poor (which account for a large percentage of the world's poor) and smallholder farming communities are the ones adversely affected because of their high dependence on natural resources for their livelihood and their limited capacity to adapt to a changing climate.

Morton (2006) reveals that smallholder farmers are poor small farming families whose livelihood and production systems allow them to survive on a continuum between subsistence production and concentration of crop and animal production for the market. Consequently, he observed that the smallholder production system is complex and diverse in the combinations of the plant and animal species reared, the types of integration between the plants and animals, the production objectives and the institutional traditional arrangements for managing the environment and natural resources. The Food and Agriculture Organization (FAO) (2008), estimates that around 60 to 80 percent of the population in poor countries engages in smallholder agricultural production system. Similarly, according to Guste (2007), more than 500 million poor are dependent on smallholder agriculture and a further 600 million rural poor who keep livestock in Sub-Sahara Africa.

In the final draft of the National Land Reclamation Policy (GoK, 2011), Kenya is among the poorest countries of the world and has over 80% of her land mass as arid and semi arid with about 10 million people majority of whom are smallholder farmers inhabiting these ASALs. Furthermore, Kenya also relies heavily on agriculture in which 75% is contributed by smallholder farmers who depend directly on the agricultural sector as their only livelihood option (NEMA, 2010).However, as envisaged by Huho *et al.* (2012), agricultural activities performed by smallholder farmers follow rainfall patterns. In Sub-Saharan Africa, rain-fed agriculture, which provides food for the populace and represent a major share of the countries' economy, follows precipitation pattern closely (UNEP, 2008). Therefore, short-term as well as long-term variations in seasonal rainfall patterns have important effects on the livelihoods of smallholder communities regarding their crop and livestock farming (IPCC, 2007).

Seasonal rainfall has been marked by delayed onsets, declining number of rain days and increased intensities altering farming calendars with negative effects on the yields (Huho *et al.*, 2012). Awuor and Ogola (1997) observed that climate variability will likely affect the agricultural productivity due to changes in the length of growing periods. They observed that the length of growing period would increase by about 10 days/°C increase in mean annual temperature in Canadian Praire. In Kenya, they noted that increase in temperature by 4°C will result in a dramatic shortening of the length of the growing period.

The main growing rainfall season which occur in March, April and May (MAM) has been declining since the 1980s in Ethiopia, Kenya, Tanzania, Zambia, Malawi, and Zimbabwe (Huho *et al.*, 2012). According to IPCC (2007), changes in rainfall patterns have negatively affected mixed rain-fed and highland perennial systems in the Great Lakes region and in other parts of East Africa, more so in the ASALs where agriculture has progressively become more marginal. Thus, for the development of the agricultural sector focused on enhancing the livelihoods of smallholder farmer in the ASALs, understanding the changes in growing period are very important and must be viewed *visa viz* the possible changes in seasonality of rainfall, onset of rain days and intensity of rainfall so as to build more adaptive capacity of these communities in the wake of the present and future climate. In addition, improvement in understanding of interaction between atmosphere and sea and land surfaces, advances in modeling the global climate system and substantial investment in monitoring the tropical oceans now provide a degree of predictability of climate variability and to use seasonal forecasts to reduce adverse impacts of climate variability and enhance rural livelihoods (Hansen and Indeje, 2004; Goddard *et al.*, 2001).

However, an understanding of climate impacts has mostly involved monitoring of El Niño Southern Oscillation (ENSO) phenomenon which is a major cause of year rainfall variability and extreme climate events and the amount of (potential) damage caused to a system. The link between rainfall and ENSO has contributed to the understanding of the interaction between the atmosphere, land and sea and significantly contributed to the improvement of seasonal forecasts (Phillips 2003; Hansen 2005). Studies that have analyzed rainfall variability with ENSO as the determinant include Chambers (2003), Nicholls and Wong (1990), Goddard *et al.* (2001),Yasunaka and Hawana, (2005) Nicholson *et al*. (2000) and Mamoudou *et al.* (1995).

Nonetheless, such studies do not provide information on the much needed characteristics of within-season variability as it has implication on livelihoods. Socio-economic approach to climate impacts has entailed assessment of the adaptive capacity at community and national (and sometimes regional) levels. In Kenya, there are local level initiatives by the government and Non-Governmental Organizations (NGOs) such as food relief, assistance in form of seeds and seed fairs (Orindi and Ochieng, 2005) to farming households to help them cope and recover from disasters and improve their resilience in the face of adverse climate events. However, the interactions, access to and quality of service of these institutions to the wider society remain a challenge.

Considering all the uncertainties surrounding the livelihoods of smallholder farmers, the strategies used by these smallholder farmers in their production system forms an integral part in confronting the impacts of climate variability in ASALs. The successful adoption and development of some of the ingenious indigenous strategies form the adaptation mechanisms smallholder farmers can apply in order to survive harsh climatic events.

It is in view of the above background that the challenges and problems the smallholder farmers go through in their daily struggle to achieve food sufficiency and avoid food insecurity under the harshness of their natural environment can be realized. Rainfall variability presents serious predicaments to smallholder farmers in the ASALs of Northern Kenya.

1.2 Statement of the problem

The widely observed rainfall variability is the greatest challenge that smallholder farmers of Senetwo location in West Pokot County face. The population in the area consists majorly of poor small-scale farmers whose livelihood is entirely dependent on their environment and their small farms as the principal source of livelihood and direct consumption of the farm out-put considering that agriculture in the area is purely rain fed. While there are other factors which contribute to the decrease in agricultural productivity in the area, changes in rainfall patterns have resulted in difficulties by farmers to plan for agricultural activities; the length of the main growing season is shorted and there exists uncertainty in the expected agricultural yields. This study sought to analyze the MAM rainfall patterns, the number of rainy days and the onsets of the start of rains since 1983 to 2013 coupled with identifying the adaptation strategies employed by the local community in view of unprecedented impacts of rainfall variability.

1.3 Objectives of the study

The broad objective of this study was to characterize climate variability and examine the associated adaptation strategies on the livelihoods of smallholder farmers in Senetwo location. The specific objectives were to:

1. Analyse the annual temporal rainfall trends for Senetwo location from 1983-2013.
2. Assess the smallholder farmers' knowledge and perceptions about climate variability in Senetwo location.
3. Examine the adaptation and coping strategies used by smallholder farmers of Senetwo location in coping with the challenges of climate variability.

1.4 Research Questions

1. What are the annual rainfall; onset, amount, and temporal distribution trends in Senetwo location since 1983 to 2013?
2. What is the knowledge and perception of the inhabitants of Senetwo location regarding weather patterns and climate variability?
3. What adaptation and coping strategies have the people of Senetwo location employed to guard themselves against the impacts of climate variability?

1.5 Justification and significance of the study

The threat of global climate change has caused concern among scientists as agricultural productivity and food security could be severely affected by changes in key climatic variables of rainfall and temperature both globally and locally. The local knowledge systems and agricultural practices and techniques adopted by local people remain the dominant form of adaptation to the severe impacts of climate variability.

The communities in West Pokot county and especially the people of Senetwo location are relentlessly involved in daily survival activities and challenges posed by the harshness of their ASAL environment. This area is characterized by high rainfall variability which causes wide fluctuations in water availability for agriculture, livestock keeping and domestic use. As a result, the population in the area remains vulnerable to effects of climate variability on two levels, food security and living conditions. This research has therefore generated invaluable information to assist the individuals, the communities, and other external actors in enhancing the threatened smallholder livelihood mechanism and cushion their production system against the harmful effects of the changes in climatic conditions. This research has therefore generated invaluable information to assist the individuals, the communities and external actors

The study findings can be used in mainstreaming current and future climate vulnerabilities into development as an urgent prerequisite for sustainable development. This information will be critical for developing and improving weather observation infrastructure, provision of timely extension services and technical support and understanding coping strategies which could be replicated elsewhere.

1.6 Definition of Terms

Agriculture: Cultivation of the soil for crop production and the rearing of domestic animals.

Adaptation: To adjust to any changes in affecting livelihoods and making the changes suitable for a purposeful life

Climate variability: When long rains fall before/after the month of March, and short rains fall before/after the month of October.

Livelihoods: People’s way of life that contributes to basic needs and income.

Rain-day: A rainy day in this study is defined as a day when total rainfall amount was at least 0.85 mm and above.

Smallholder farmers: People living outside a 5 kilometer perimeter of a town/shopping center and have less than 10 acres of land.

Vulnerability: The susceptibility of people and their livelihoods to variability of the climate. It is determined by geographical location, gender, age, and access to resources and wealth (entitlements) as well as exposure.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

According to the United Nations Framework Convention on Climate Change (UNFCCC), climate change refers to a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. On the other hand, climate variability is the departure from normal or the difference in magnitude between climatic episodes (UNFCCC, 2012). Thus, climatic variations are attributed mainly to natural processes, while the observed climate change is due largely to anthropogenic causes. These climatic changes may be due to internal processes and/or external forces. Among the external forces, those like solar radiation and volcanic activities occur naturally and contribute to the overall natural variability of the atmosphere. However, other external forces such as changes in the composition of the atmosphere that began with the Industrial Revolution in the early 18th Century are results of human activities (Guzman, 2009). Like in the rest of the world, the two phenomena (climate change and variability) are already taking place in Kenya and their effects are being felt (Okoth-Ogendo *et al.,* 1995).

2.2 Regional status of climate variability

The IPCC in its fourth Assessment report (IPCC, 2007) warns that warming by 2100 will be worse than previously expected, with a probable temperature rise of 1.8^{o}C to 4^{o}C and a possible rise of up to 6.4^{o}C. As temperatures continue to rise, the impacts on rural communities in ASALs will be significant (Doering, 2002). These impacts are already being experienced by many communities in countries of the Southern hemisphere. There will also be an increase in droughts and heavy precipitation events, which will further damage crops through crop failure, flooding, soil and wind erosion (IPCC, 2001).

The climate of Africa is warmer than it was 100 years ago and model-based predictions of future GHG induced climate change for the continent clearly suggest that this warming will continue and, in most scenarios, accelerate (Hulme *et al.,* 2001; Christensen *et al.,* 2007). Observational records show that during the 20th century the continent of Africa has been warming at a rate of about 0.05°C per decade with slightly larger warming in the June-November seasons than in

December-May (Hulme *et al.,* 2001). By 2000, the five warmest years in Africa had all occurred since 1988; with 1988 and 1995 being the two warmest years. This rate of warming is not dissimilar to that experienced globally, and the periods of most rapid warming—the 1910s to 1930s and the post-1970s-occur simultaneously in Africa and the rest of the world (IPCC, 2001).

In East Africa large water bodies and varied topography give rise to a range of climatic conditions, from a humid tropical climate along the coastal areas to arid low-lying inland elevated plateau regions across Ethiopia, Kenya, Somalia and Tanzania. The presence of the Indian Ocean to the east, and Lake Victoria and Lake Tanganyika, as well as high mountains such as Kilimanjaro and Kenya induce localized climatic patterns in this region (KNMI, 2006). Thus the projections for rainfall are less uniform in East Africa. Hulme *et al.,* (2001) illustrated that the large regional differences exist in rainfall variability. The long rains (March–May) are less variable, so inter annual variability is related primarily to fluctuations in the short rains. These are also linked more closely to large-scale, as opposed to local, atmospheric and oceanic factors. Rainfall fluctuations show strong links to ENSO phenomenon, with rainfall tending to be above average during ENSO years (Nicholson 1996).

Kenya's climatic conditions vary from a humid tropical climate along the coast to arid areas inlands. While mean temperature varies with elevation, the more remarkable climatic variation is with respect to precipitation. The climate pattern in the country is influenced mainly by its position relative to the equator, its proximity to the Indian Ocean and Lake Victoria, varied topography and the El Niño-southern oscillation (ENSO) phenomenon resulting from the interaction between the surface of the ocean and the atmosphere in the tropical pacific. The Inter-Tropical Convergence Zone (ITCZ) is also a major synoptic feature which influences the climate over the country. The influence of the ITCZ is modified by altitudinal differences, giving rise to varied climatic regimes. Rainfall is the prime climatic factor underpinning dynamics of the landscape, but it is highly variable at a hierarchy of temporal scales.

Kenya experiences a bimodal seasonal pattern as it lies astride the equator: the long rains season starts around March and runs through to June, with the peak centered on March to May; the short rains run from September and taper off in November or December (coinciding with the shifting of the Inter-Tropical Convergence Zone). Over two-thirds of the country receives less than 500 mm of rainfall per year, particularly areas around the northern parts of the country (Osbahr and Viner, 2006). This shows that rainfall is highly variable, especially in the ASAL regions, and unreliable for rain fed agriculture and livestock production.

The ASALs are also prone to floods, despite their low levels of rainfall of 300-500 mm annually (WRI, 2007). Otiende (2009) stated that flood-related fatalities account for 60% of all disaster victims in Kenya. In recent years, critical drought periods have also been experienced in the country in 1984, 1995, 2000, 2005/2006 and 2009 (UNEP/GoK, 2009). Kenya faced a major drought in 2009 that affected all regions; leading to hunger and starvation of an approximate 10 million of people countrywide after a poor harvest, crop failure and rising commodity prices (KRCS, 2009). The impact of these droughts on ASAL residents are increasing due to high population growth and increasing encroachment of agricultural activities in the ASALs. These ASALs are intensifying, and changing, from rangeland to mixed systems. Transition from pastoralism to agro-pastoralism is ongoing in many places throughout Africa as well (Reid *et al.*, 2004; 2008). This is demonstrated by the reductions in land area in the rangeland based systems replaced by mixed systems, and the substantial increases in the livestock populations in the mixed systems leading to more intensive types of production systems. The changes from purely pastoral to sedentary systems are projected to occur at rates of 1.2-2% per year in terms of area (Herrero *et al.*, 2008).

2.3 Climate variability and vulnerability

The majority of the world's rural poor, about 370 million of the poorest, live in areas that are resource-poor, highly heterogeneous and risk-prone. The worst poverty is often located in arid or semi arid zones, and in mountains and hills that are ecologically vulnerable (Conway, 1997). In many countries, more people, particularly those at lower income levels, are now forced to live in marginal areas (in floodplains, exposed hillsides, arid or semi arid lands), putting them at risk from the negative impacts of climate variability and change. For these vulnerable groups, even minor changes in climate can have disastrous impacts on their lives and livelihoods. Implications can be very profound for subsistence farmers located in remote and fragile environments, where yield decreases are expected to be very large, as these farmers depend on potentially affected crops (maize, beans, potatoes, rice, amongst others) for their food security (Conway, 1997). Consequently, apart from the landless and urban poor, small farmers are among the most disadvantaged and vulnerable groups in the developing world. The share of surveyed smallholder households falling below the poverty line is close to 55% in most continents (Altieri, 2008).

The impacts of climate change phenomena are progressively emerging as an unprecedented global challenge to development in general and poverty reduction in particular especially among millions of rural people living in marginal regions with minimal livelihood options (Brown and Crawford, 2008). Scientific evidence increasingly suggests that climate is becoming more variable with significant impacts on rural households particularly in sub-Saharan Africa (Cooper *et al.* 2008; IPCC, 2007). Most climate change models predict that damage will be disproportionately borne by small farmers, particularly rain-fed agriculturalists in the Third World. In some African countries, yields from rain-fed agriculture (the predominant form of agriculture in Africa) could be reduced by 50% by 2020. Additionally, agricultural production in many African countries is projected to be severely compromised especially in dry lands (IPCC, 2007). Some researchers predict that as climate change reduces crop yields, the effects on the welfare of subsistence farming families may be quite severe, especially changes in quality and quantity of production may affect the labour productivity of the farmer and negatively influence his/her family health (Rosenzweig and Hillel, 1998).

Jones and Thornton (2003) predict an overall reduction of 10% in maize production in the year 2055 in Africa and Latin America, equivalent to losses of $2 billion per year, affecting principally 40 million poor livestock keepers in mixed systems of Latin America and 130 million in those of sub-Saharan Africa. These yield losses will intensify as temperatures increase and rainfall differences are less conducive to maize production. It is obvious that climate-related environmental stresses are likely to affect individual households differently compared to more market-oriented farmers.

Numerous studies have shown that as variability in climatic elements increases, the vulnerability of rural livelihoods and the ability of smallholder household have to deal with its shocks and stresses increases (Lioubimtseva *et al.* 2009). This is particularly so among rural households in Kenya who often suffers immense social and economic effects due to effects of climatic condition (Deressa *et al.* 2008). Indeed, in the past two decades, the effects of climate variability on crops and livestock are increasingly blamed for deteriorating livelihoods among most rural areas in Kenya (Mutimba *et al.* 2010; Obando *et al.* 2010).

Climate has been a robust determinant of agricultural sector, and thus general economic performance in Kenya and elsewhere in Africa and other rain-fed developing countries. With agriculture accounting for about 26% of the GDP and 75% of the jobs, the Kenyan economy is sensitive to variations in rainfall. Rain fed agriculture is and will remain the dominant source of staple food production and the livelihood foundation of the majority of the rural poor in Kenya. There is therefore a need for the development of the scientific and economic capacity to better understand and cope with existing climate variability (Washington *et al.,* 2006).

2.4 Climate variability impacts in Kenya

Between 1960 and 2005, the demand for ecosystem services grew significantly as the world population doubled to over 6 billion people and the global economy increased more than six-fold. To meet these growing demands, food production increased by roughly two-and-a-half times, water use doubled, wood harvests for pulp and paper production tripled, and timber production increased by more than half (Stockholm Environment Institute, 2007). A more recent study by the Stockholm Environment Institute on the Economics of climate change in Kenya revealed that the future economic costs of the impacts of climate change and variability on market and non-market sectors might be close to 3% of GDP per year by 2030 and potentially much higher than this (more than 5% of GDP per year) by 2050 (Stockholm Environment Institute 2009). Kenya is a natural resource and agriculture based economy. The key economic sectors include: Agriculture, tourism, livestock, horticulture, fisheries and forest products, all if which are highly vulnerable to climate change. For the purpose of conducting this study the impacts of climate change and variability on key areas are as discussed below:

2.4.1 Agriculture

The Ministry of Agriculture’s ‘Economic Review of 2009’ indicated that the production of other major crops like tea, sugarcane and wheat had also declined. This could reduce Kenya’s foreign exchange earnings in the long term, given that a commodity like tea is the country’s principal export product. The ripple effect of this scenario to Kenya’s economy is frightening when one considers the pertinent role that foreign exchange plays in international trade and investment (Heinrich, 2010).

Agriculture in Kenya is important for rural livelihoods, food, and the national economy (earning 60% of foreign exchange and 24% of GDP) as well as providing employment for 80% of the population. Agriculture is generally the first economic sector to be affected by climate extremes through drought whereby a lack of soil moisture has an immediate impact on crop output, and then later by floods. Already the unpredictability of Kenya's year to year productivity causes substantial problems for poor subsistence farmers, as rain fed crops are lost during unusually dry or wet seasons. A poorly performing agricultural sector put the country's food security at risk. Kenya has in the recent past reported successive seasons of crop failure, increasing the country's food insecurity. The country's famine cycles have reduced from 20 years (1964-1984), to 12 years (1984-1996), to 2 years (2004- 2006) and to yearly 2007/2008/2009, necessitating the Government's distribution of 528,341.77 metric tonnes (MT) of assorted foodstuff s worth Ksh. 20 billion over the last five years to feed a population of between 3.5 million and 4.5 million people annually (Heinrich, 2010).

In the recent past, the horticulture industry has been growing fast and steadily recording an average of 15% to 20% annual growth. It is ranked among the top three foreign exchange earners together with tea and tourism. The industry has greatly contributed to the country's economy, creating employment opportunities for rural people. The industry directly employs about 4.5 million people countrywide with another 3.5 million benefiting indirectly thought trade and other activities. However, climate change is not likely to bode well for the industry. The impacts of climate change on horticulture are in two fold, the direct impacts and indirect impacts. Directly, the industry is going to be greatly affected due to reduced water availability for irrigation purpose, due to the frequent droughts. For instance horticultural farms in Laikipia and Kieni Districts are reeling from reduced water supply as a result of reduced water volumes in rivers originating from Mount Kenya and the Aberdares. Horticulture in the coast is expected to suffer, due to sea level rise that will result in the inundation of coastal agricultural land. Income losses from three crops grown along the Kenyan Coast – mangoes, cashew nuts and coconuts – could be as high as US$ 472.8 million for a 1 m sea level rise (Kenya Horticulture Council, undated).

Indirectly, the returns from horticulture are likely to be further affected by increasing pressure from European markets and consumers seeking to reduce their fresh produce ‘food miles’, i.e. the amount of GHG emissions associated with the production and consumption of fresh produce. The horticulture industry is under threat from increasingly carbon conscious western consumers who now prefer fresh produce from their own countries to those imported from abroad. However life cycle assessment of produce from Kenya has shown to be less carbon intensive than those produced in Europe. This information needs to be communicated continually and widely (PKF Consulting, 2005).

2.4.2 Livestock

Pastoralism is the main form of livelihood for communities living in ASALs of the Kenya. This practice has experienced the brunt of climate change manifested in the form of frequent, intense and long lasting droughts. For instance the country experienced three major and more pronounced droughts in the 1990s. The drought of 1991/92 had much destruction; with up to 70% loss in livestock herds, and high rates of malnutrition of up to 50%. As a result about 1.5 million people in the ASALs were dependent on relief food. The 2006 to 2009 droughts are testament to the devastation that climate change could cause to the livestock sector. In 2009, most pastoralists lost more than half of their herds to drought (Heinrich, 2010). In addition, outbreaks of diseases like the Rift Valley Fever (RVF) and a myriad of others (Wildlife Conservation Society, 2008), have been linked to climate change. The outbreak of RVF is known to occur during periods of high humidity that follow abnormally long rains especially those associated with El Niño-Southern Oscillation (ENSO) events (Anyamba *et al.*, 2001). This has great toll on livestock production as the industry loses the local and export market.

2.4.3 Water resources

Kenya is classified by the U.N. as a chronically water-scarce country, with poor replenishment rate. The country’s natural endowment of freshwater is highly limited, with an annual renewable freshwater supply of about 647m^3 per capita significantly below the 1,000m^3 per capita set as the marker for water scarcity (Heinrich, 2010). The current level of development of water resources in Kenya is very low. Only 15 percent of the safe yield of renewable freshwater resources has been developed currently (Mogaka, 2006).The low level of development means that water supply storage per capita has declined dramatically from $11.4m^3$ in 1969 to about $4.3m^3$ in 1999-simply because of population growth.

However, the country possesses sufficient water resources to meet demand. A recent study has estimated that, based on current water use efficiencies, the predicted aggregate demand will rise to 5,552 million cubic metres per year in 2020 (Heinrich, 2010). This would still be within the country's safe yield (8,447 million cubic metres per yr), although the cost of supplying each additional increment of water is likely to rise steeply as readily accessible sources are progressively tapped. The country's water resources are unevenly distributed in both time and space in five drainage basins namely Lake Victoria, Rift Valley, Athi River, Tana River, and Ewaso Ng'iro. The severe weather events like frequent and prolonged droughts and floods, which have been attributed to climate change, will severely affect freshwater availability. Major rivers including the Tana, Athi, Sondu Miriu, Ewaso Ngiro and Mara have experienced severe reduced volumes during droughts and many seasonal ones have completely dried up. The Eastern, North Eastern and Rift valley have been severely affected. Floods carry fertilizer and pesticide residues into water bodies, resulting in eutrophication which has detrimental impacts on water quality and aquatic life (MENR, 2010). The availability of water is oft en a key factor in determining the patterns of human settlement and the value of land for agricultural and livestock production. Within ASALs the food security of pastoral and farm households improves considerably during the wet years. Improved grazing fundamentals in several pastoral areas has resulted in favorable livestock body conditions, increased calving rates, and improved milk output-together bringing market improvements in pastoralist food security (Heinrich, 2010).

2.4.4 Natural resources

Forests not only serve as water catchment resources and carbon sinks, but also provide food, wood fuel, fodder, pasture and medicinal material for an estimated 80% of about 1 million of households living within a stretch of 3km from forest boundaries (MoE, 2002). In addition most of the households in informal settlements depend on wood fuel as the main source of energy for cooking and heating. The country's forest cover has declined over the years to as low as less than 2% cover falling way below the global recommended cover of 10% (MENR, 2010). This is largely attributed to human activities such as illegal logging, unsustainable charcoal production and clearing of forests to create land for farming and settlement.

The impact of climate change will affect the growth, composition and regeneration capacity of forests due to attacks by invasive species, altered patterns, duration and amount of precipitation, and extended range of pests and pathogens, that will affect some tree species. Invasions have already been witnessed with *Prosopis juliflora* ('mathenge') taking site dominance of important ecosystems in Baringo, Tana River, Garissa and other semi arid areas of the country. In addition, excessive growth of some tree species has been observed including the excessive growth of *Acacia reficiens* (acacia) after the 1997 El-niño in North-Eastern Province (NEP) that suppressed the growth of various species that form grasslands for wildlife and livestock. Changes in temperature will lead to a shift of vegetation to higher elevations while some species could become extinct. Indeed, across the country, some tree species including *Melia volkensii*, *Terminalia spinosa*, *Delonix elata*, and *Hyphenea corriaceae* in North Eastern Province, and *Psychotria* species in the Taita Hills, Coast Province, are either extinct or their numbers have tremendously dwindled (Heinrich, 2010). In addition, the projected rise in temperatures and long periods of drought will lead to more frequent and more intense fires. Forest fires have in the recent past affected Kenya's major forests including the Mt. Kenya Forest. Indeed, Kenya has, over the past 20 years, lost more than 5,700 ha of forests per year to forest fires, wreaking phenomenal economic damage that is yet to be quantified (MENR, 2010).

2.4.5 Gender and climate change

Women are more strongly affected by the effects of climate change and climate variability because they are more prone to the effects of climate change (Heinrich, 2010). Climate variability is dependent on issues such as wealth, technological power, access to information, all of which are major problem areas for women. Despite the importance of recognizing gender-related differences, both the UNFCCC and the Kyoto Protocol fail on referring the issue. Nonetheless, experience has shown that women generally understand better the causes and local consequences of changes in the climatic conditions and have the knowledge and skills for orienting the adaptation process (Heinrich, 2010). It is also stated that women have unique capacities as community leaders or managers of natural resources and that they are underutilized in strategies for managing emergencies. Their responsibilities in households, communities and as stewards of natural resources position them well to develop strategies for adapting to changing environmental realities (Carvajal-Escobar et. al. 2008).

2.5 Coping and adaptation to climate variability

Smallholder, subsistence, and pastoral systems, especially those located in marginal environments, areas of high variability of rainfall, are often characterized by livelihood strategies that have been evolved to reduce overall vulnerability to climate shocks (“adaptive strategies”), and to manage their impacts *ex-post* (“coping strategies”) (Morton, 2006). The distinction between these two categories is however frequently indistinct: what start as coping strategies in exceptional years can become adaptations for households or whole communities (Davies, 1996).

Many defining features of dry land livelihoods in Africa and elsewhere can be regarded as adaptive strategies to climate variability (Mortimore *et al.*, 2001). This may include: allocating farm labour across the season in ways that follow unpredictable intra-season rainfall variations: “negotiating the rain”, making use of biodiversity in cultivated crops and wild plants, increasing integration of livestock into farming systems (at a cost of increased labour demands), working land harder, in terms of labour input per hectare, without increasing external non-labour inputs and diversifying livelihoods(Mortimore and Adams, 2001).Other mechanisms are on-farm storage of food and feed, strategic use of fallow, and late planting of legume crops when cereals fail as drought responses (Morton, 2006).

Shifting to irrigation farming is sometimes seen as a coping strategy in the face of climate variability across the developing world. Eakin (2003) describes this for Mexico but notes that the interaction of market uncertainty with climatic risk may in fact increase the vulnerability of households making this shift. In South Asia, agricultural strategies such as increasing livestock production relative to crops, and selection of crop varieties, are responses to both drought and floods, but several case studies show the importance of livelihood diversification, in the villages and in towns, and both responsively to disaster and proactively (Moench *et al.*, 2004). These and other studies also show the importance of information and networks or social capital in coping with climate change and variability (Winkels *et al.,* 2002).

However, there is a great variety of possible adaptive responses available to deal with climate variability. These include technological options (such as more drought-tolerant crops), behavioural responses (such as changes in dietary choice), managerial changes (such as different livestock feeding practices), and policy options (such as planning regulations and infrastructural development) (Thornton *et al.*, 2009). For example, in the ASALs, livestock herders migrate with their animals in search of pasture and water, with the average distances trekked tripling in drought years. Herding communities typically reserve some pastures in their homesteads for grazing by vulnerable animals left under the care of women during migration seasons. The herders also ensure that the composition, size and diversity of their animal herds suit their variable feed resources and serve to protect them against droughts that could otherwise wipe out their animal stock.

2.6 Conceptual Framework

The conceptual framework used for this proposed study is a modification of the Southern African Vulnerability Initiative (SAVI) (Haramata, 2008) that provides a lens for viewing the role of multiple factors on local adaptive capacity towards climate variability and change. It is clear from this framework that adaptation to climate change and other risks goes beyond the need for a short-term coping mechanism. The framework shows that climate variability may create changes in the social, economic, biophysical, cultural, technological or institutional context, diminishing the capacity of household, community, or group to respond to other changes. These changes may produce outcomes that negatively impact the livelihood of the smallholder farmers. Thus intervention through research, with the use of smallholder farmers' indigenous knowledge and other ecological approaches, yields adaptation and coping strategies that are sustainable and thus enhance the smallholder farmers' livelihood.

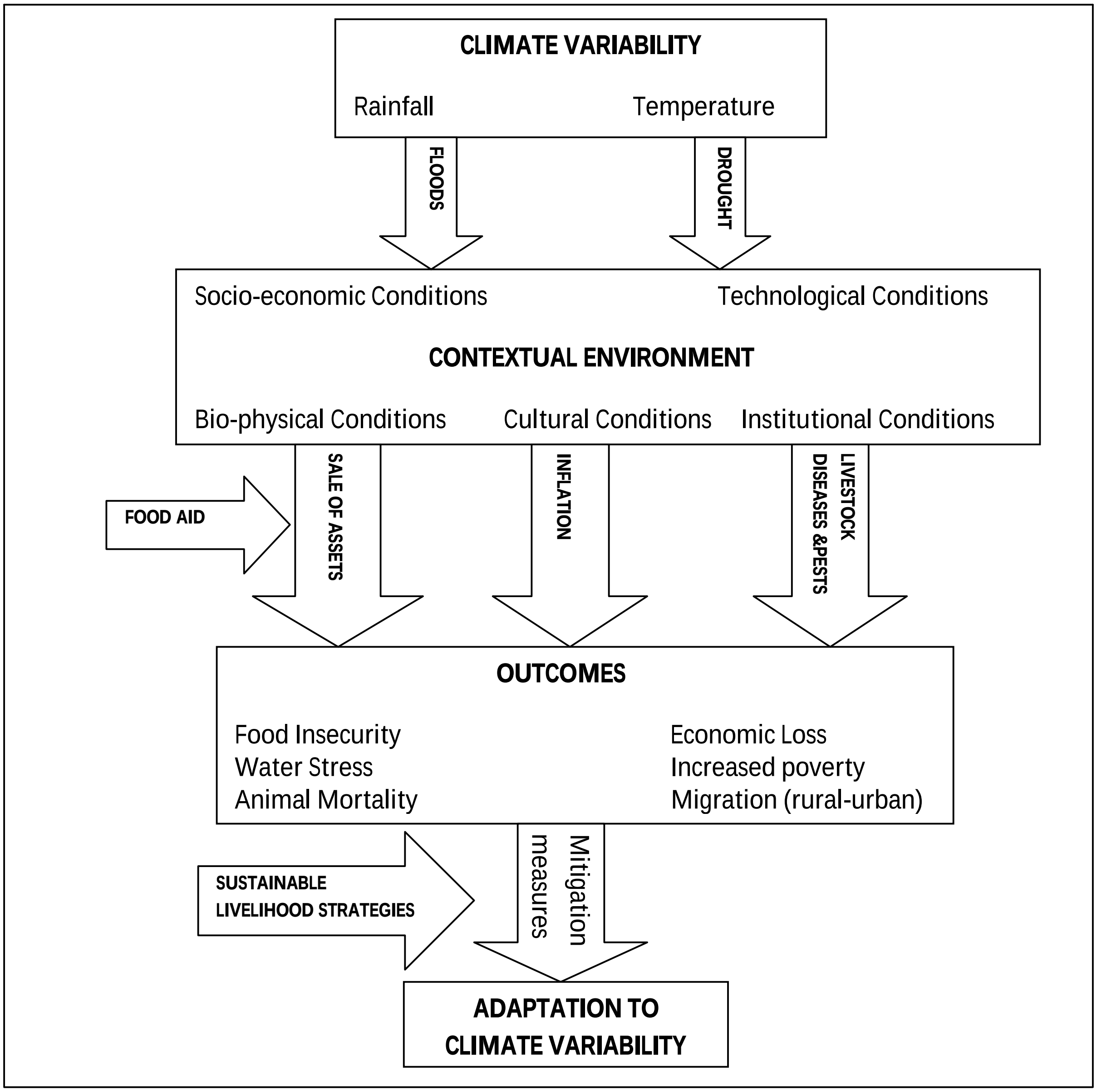

Figure 2.1: Conceptual Framework of the study.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Study Area

The research study was conducted in Senetwo location within Chepareria division in West Pokot County (Figure 3.1). West Pokot County is located in the ASALs north-west of Kenya (Marinda *et al.*, 2006). Chepareria division lies within 1° 19” N latitude, and 35°12” E longitude. The altitude of the area is between 1600-1950 m above sea level contributed by a few hills in the area (GoK, 2005). The climate is semi arid with mean annual temperatures of about 22° C, and mean annual rainfall of about 750 mm with only one long rainy season from April-August and one short rainy season from October to November (Pretzsch and Darr, 2006). Chepareria division has several seasonal rivers and streams but no permanent river. The inhabitants of Senetwo location are mainly small scale farmers cultivating maize and beans to a large extent and millet and sorghum to lesser extent; they also keep cattle, sheep, goats and poultry in a small scale (Marinda *et al.*, 2006).

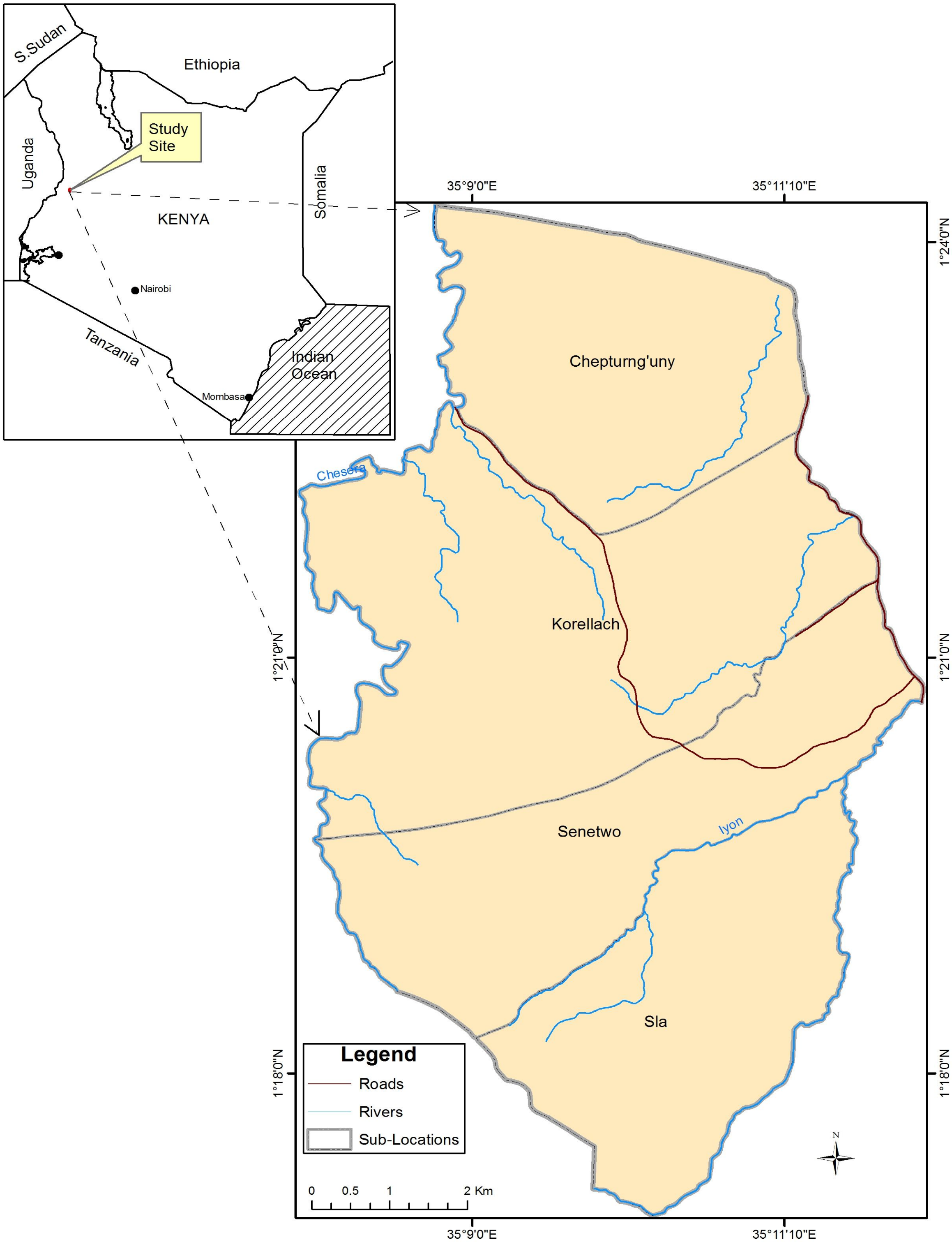

Figure 3.1: Map showing the location of the study area (Source: Maina G.M., 2013)

3.2 Study design

The study utilized an exploratory survey design as it involved collection of data over a broad population for a widely known phenomenon that already exists. A multi-stage purposeful sampling technique was used and 125 households from the three sub-locations were included in the survey. Questionnaires and in-depth interviews were used to collect data. The items on the questionnaire and interview schedules were developed on the basis of the study objectives, and were administered and translated by the researcher himself. This enabled the respondents to understand clearly the items on the questionnaire. In-depth interviews were used to collect information from key informants such as ASAL programs coordinators, agricultural extension officers, water officers, environment officers, and leaders of community based organizations involved in ASAL conservation and development in the area of study. The purpose of the study design was to understand the people's perception and knowledge about climate variability; identify adaptation strategies and conduct data analysis to summarize and report on community-level perceptions, concerns, and appropriate interventions.

3.2.1 Target population

Senetwo location has a population of 4,296 people and 784 households, and consists of three sub-locations namely: Korellach sub-location with 1,857 people and 321 households, Senetwo sub-location with 1,498 people and 277 households and Chepturnguny sub location with 941 people and 186 households (KNBS, 2009).

3.2.2 Sampling procedure and sample size

According to Kathuri and Pals (1993), for a survey research, 100 cases are adequate for each major sub-group. Since the study involved only one major sub-group (i.e. Senetwo location), 100 cases or more were regarded as adequate. The sampling frame was obtained from a list of all the households of Senetwo location in the area from the Chief's office. Systematic random sampling was used to select the households to be interviewed. According to Mugenda and Mugenda (2003), every K^{th} case in the population frame is selected for inclusion in the sample. In my case K was 6 hence every 6^{th} household head was interviewed. A sampling interval of 5 households was obtained by dividing the total number of households for each sub location by the sample size respectively.

3.2.3 Data collection

The study utilized two sets of data, primary and secondary sources. Primary data consisted of daily rainfall data, the administration of a questionnaire to randomly selected household heads, field observations and interviews with the key informants. This was meant to establish the role of bio-physical and socio-economic factors in communities' vulnerability to climate variability. The study first identified available rainfall stations in and around Chepareria division. Following an inquiry at the Kenya Meteorological Department (KMD) office in Kapenguria, a total of four rainfall stations were found in West Pokot County and only one was found in Chepareria division at Nasukuta Livestock Improvement Centre which falls in Senetwo location where the study was conducted. The rainfall data was deemed to be adequate as it had less than 10% of missing data for the years from 1980 to 2013.

Pre-testing of questionnaires was conducted using thirty five questionnaires in Kanyarkwat location which possesses similar characteristics as the area of study. After the pre-test, errors in the questionnaire were rectified and later administered to the households in the selected villages and study sites for actual data collection. This helped to deal with aspects of reliability and validity, thus aiding in moderation and improvement of the data collection tools. The selection of respondents was informed by household population in the location. In each sub-location, 16% of the households were selected for interview (considering the relatively low number households in the study area) which explains the difference in totals in the three sites.

Table 3.1: Sample size of households by study sites and gender

Sub-location	Male	Female	Total sample size
Senetwo	26	18	44
Chepturnguny	18	12	30
Korellach	34	17	51
TOTAL	**72**	**53**	**125**

Source: Survey data (2013)

Household survey collected information on demographic characteristics of the households, livelihood characteristics, climatic conditions and impacts as well as adaptation and coping strategies. A total of thirteen officers (in both private and public sectors) operating from Chepareria division were interviewed. Interviews with households and public & private sectors actors sought to tap information on household livelihoods, income flow, information flow and adaptive capacity to climate variability.

3.2.4 Data analysis

To quantify seasonal rainfall variability in Senetwo location, the amount of rainfall and dates of onset were analyzed for the main MAM rain season. To analyze rainfall characteristics, the study examined a 30 year period (1983 to 2013). This period was divided into 3 decades; the 1983 to 1992, 1993 to 2002 and 2003 to 2013 decades. Comparisons of rainfall characteristics were based on the three time periods. Decadal average number of rain days and rainfall intensities were obtained as follows:

$$\bar{x} = \frac{\sum x}{n} \quad \text{..} 1$$

Where **X**= number of rain days during MAM season in a given decade.
n= number of years in a decade.

$$\bar{x} = \frac{\sum y}{z} \quad \text{..} 2$$

Where **y**= amount of rainfall during MAM season in a given decade.
z= number of rain days during MAM season in a given decade.

Equation 3.1: Decadal rainfall analysis

The data captured in the questionnaires was cleaned for errors, coded and entered for analysis using the Statistical Package for the Social Sciences (SPSS) version 20 and Microsoft Excel for both the quantitative and qualitative data. Descriptive statistics were used to obtain the frequencies and percentages of the respondent’s perception on variations in climatic conditions as well as the distribution of the various adaptation strategies and then cross-tabulations was run and the results presented in respective charts and graphs. Inferential statistics using Multivariate

Logit regression tested the data for multi-colinearity for analysis on determinants of the respondents’ climate variability adaptation strategies and the results presented in relevant tables.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Rainfall patterns and trends

The study focused on the MAM rainfall season since it is a major determinant of livelihood in Senetwo location. Rainfall reliability during this season is 60% (KMD, 2009) and accounts for over 80% of food production in the entire West Pokot County.

The MAM seasonal rainfall showed an increasing trend but with marked year to year variations (Figure 4.1). Decadal analysis of rainfall trends revealed that the mean MAM seasonal rainfall rose from 203.2mm during the 1983 to 1992 decade to 229.7mm during the 1993 to 2002 decade and subsequently to 346.1mm during the 2003 to 2013 period. The increasing rainfall trend is an observation that was confirmed by 85% of the respondents who were asked if rainfall has been increasing in the area.

It is evident from Figure 4.1 that 1997/98 years experienced the highest amount of MAM rainfall in Senetwo location. This coincides with the *El Niño* rains experienced throughout the country during the same time. Similarly, Senetwo location experienced the lowest MAM rainfall in the year 2000 with only 60mm of rainfall collected (Figure 4.1). This is also the time during which the country experienced a major drought, the *La Nina* phenomenon (Shisanya *et al.*, 2011). Figure 4.1 further shows that low rainfall amount was recorded in the study area during 1984, 1990/91, 1994/95, 1999/2000, 2006 and during 2008/09; this were the same times when drought was recorded in the country (Shisanya *et al*., 2011). The 2000 and 2009 droughts were the worst in at least 60 years (Huho *et al.*, 2011), and between these two extreme years, several other rainy seasons have failed (Figure 4.1).

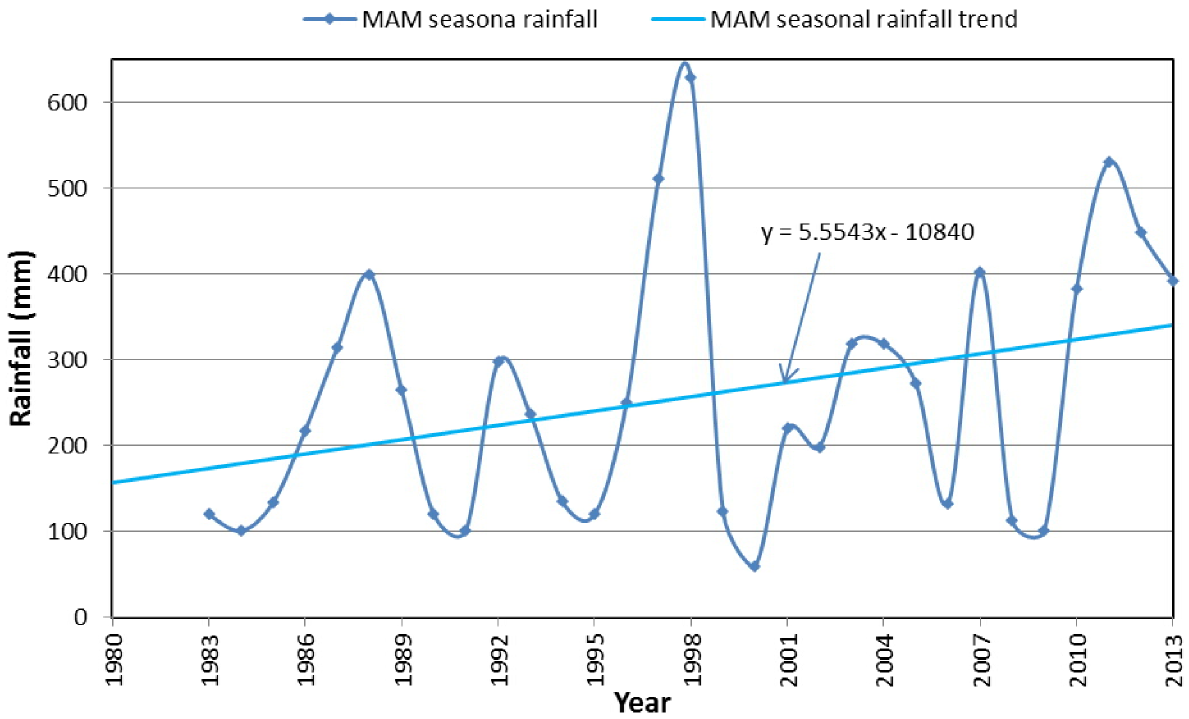

Figure 4.1: March, April and May (MAM) seasonal rainfall trend for Senetwo location for the period 1983-2013

It was also established from the analysis of the trend in number of rainy days that contrary to the increasing annual rainfall trend, the number of rainy days was declining (Figure 4.2).

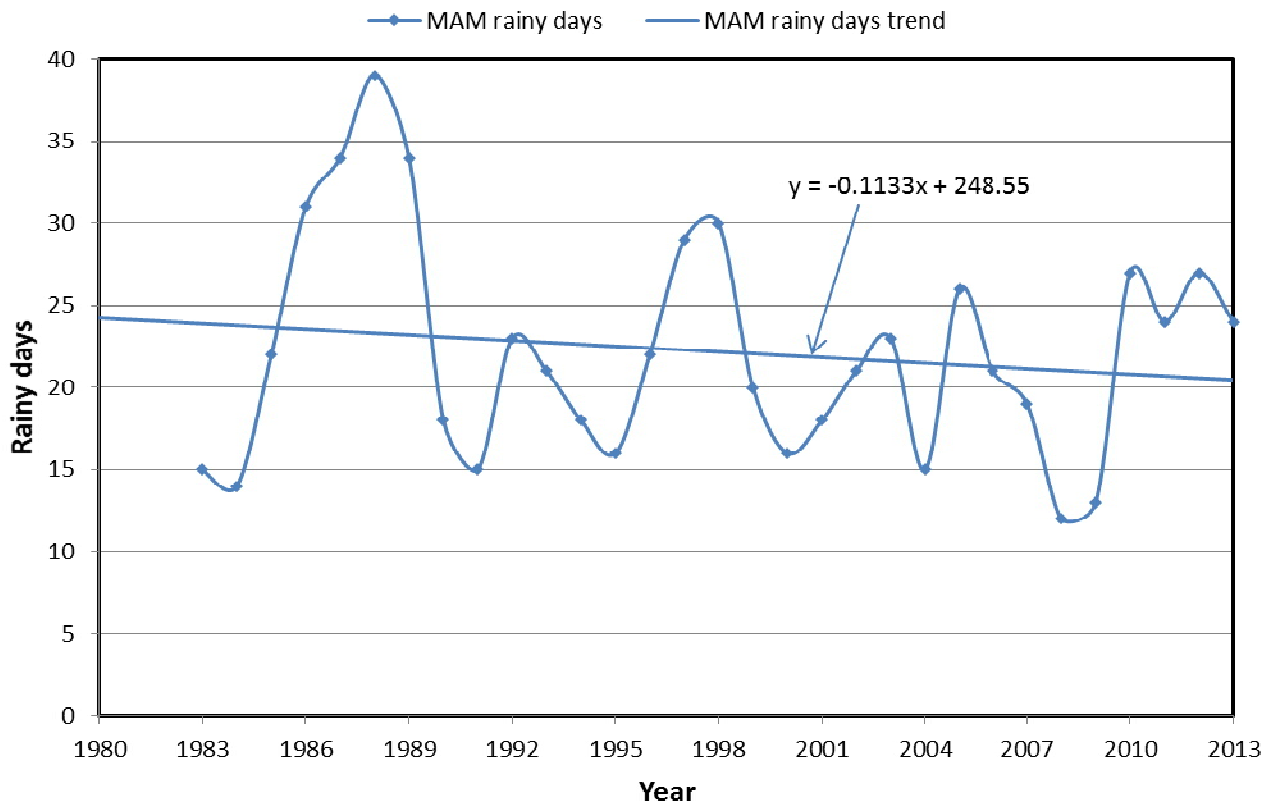

Figure 4.2: Trend in number of rainy days for Senetwo location during the MAM rainfall season

Table 4.1 shows analysis of daily rainfall data that revealed the number of rain days declined from an average of 25 rain days during the 1983 to 1992 decade to an average of 21 rain days during the 1993 to 2002 period and the least number of rain days was recorded during the 2003 to 2013 decade when Senetwo location recorded an average of 20 rain days.

The Coefficient of variation (*Cv*) indicated that the number of rain days was more variable during the 1983 to 1992 decade at 37.9% compared to the 1993 to 2002 decade at 23.2% and the 2003 to 2013 period at 26.3% accordingly (Table 4.1). The increasing rainfall trend was attributed to the increase in high intensity rainfall rather than the number of rain days. Decadal rainfall intensity increased from an average of 8.5 mm during the 1983 to 1992 decade to 11.8 mm during the 1993 to 2002 decade, and a further increase to 14.8 during the 2003 to 2013 period (Table 4.1). The findings concur with the IPCC (2007) observation that under the climate change more extreme weather events such as severe storms will be experienced.

Table 4.1: Summary of decadal rainfall analysis since 1983 to 2013

TIME PERIOD	MAM Rainfall Intensity (mm)	MAM Mean Rainy Days	MAM C*v* (%)
1983-1992	8.5	25	37.7
1993-2002	11.8	21	23.2
2003-2013	14.8	20	26.3

Source: KMD data

As shown in Table 4.2, during the month of March (the start of the MAM rainfall season) the average number of rain days decreased from an average of 11 days to about 4 days between 1983-1992 and 2003-2013 periods respectively. Rainfall intensity increased to 9.3 mm during the 1993 to 2002 decade, from 5.4 mm the previous decade. Between 2003-2013 rainfall intensity rose to 10.6 mm during the month of March alone (Table 4.2). Overall, the month of March showed a significant increase in rainfall intensity and no increase in C*v*.

During the month of April, the number of rain days increased from an average of 7.1 days to 8.2 days during 1983-1992 and 2003-2013 periods; while rainfall intensity increased from 12.6 to 14mm between 1983 to 1992 and 1993 to 2002 and further increased to an average of 14.7mm during 2003-2-13 (Table 4.2). Coefficient of rainfall variation (C*v*) shows that the April rainfall was getting more variable. The C*v* increased from 52% during the 1983 to 1992 decade to 75.5% during the 1993 to 2002 decade but again became less variable between 2003 to 2013 period with a C*v* of 58.9% (Table 4.2). During the same period, the month of May experienced an increase in the number of rain days from an average of 7.4 to 9.5 days and an increase in rainfall intensity from 12 to 15.2 mm. The C*v* for the May rainfall increased from 57.7% during the 1983 to 1992 decade to 66.7% during the 1993 to 2002 decade. A decline in C*v* to 59.9% for May rainfall during 2003 to 2013 period was an indication that the May rainfall is decreasingly becoming consistent but reliable (Table 4.2).

Table 4.2: Summary of monthly rainfall intensity, mean rainy days and *Cv* for Senetwo location

TIME PERIOD	MARCH			APRIL			MAY		
	Rainfall Intensity (mm)	Mean Rainy Days	C*v* (%)	Rainfall Intensity (mm)	Mean Rainy Days	C*v* (%)	Rainfall Intensity (mm)	Mean Rainy Days	C*v* (%)
1983-1992	5.4	11.2	73.8	12.6	7.1	51.9	9.2	6.2	57.7
1993-2002	9.3	6.5	90.9	14	7.1	75.5	12	7.4	66.7
2003-2013	10.6	3.5	89.3	14.7	8.2	58.9	15.2	9.5	59.9

Source: KMD data

Coupled with declining number of rain days, the study established a shift in the onset of the MAM rainfall season, an observation ascertained by 88% of the respondents. Using the definition of the start of rain as the first occasion after the 1st of March with 20 mm or more in 1 or 2 consecutive days (Huho, 2011), the study established delayed onsets of the start of rains in the study area. Figure 4.4 shows the years when rainfall started in March and the trend for the start of rain date.

During the 1983 to 1992 decade Senetwo location experience significant variability in the dates that rain started falling signifying the begin of the MAM rainfall season, rainfall started falling mostly around the 23rd of March (Figure 4.4). It is in the year 1986 that rainfall delayed until the 26th of March and 1992 is the year when rain started the earliest of all the years up to date-when rainfall began on the 20th of March. Between 1993 and 2002 in Senetwo location, the start of rain date was less variable as rainfall started between 21st and 22nd of March. In Senetwo location, 2003 to 2013 decade was a highly variable season for the start of rainfall for the MAM season. In the year 2003, rainfall began falling on 22nd of March and by 2009 rainfall had delayed for up to 5 days when rain fell on the 27th of March. In the year 2011 rain fell earlier than expected on 23rd of March, but the years 2012 and 2013, rainfall delayed until 30th of March and 2nd of April respectively (Figure 4.4) The study thus established that despite the increasing rainfall amounts during the MAM season in the study area, the rainy season was getting shorter as climate became more variable (Figure 4.4). The observation was confirmed by 80% of the respondents who acknowledged that the climate in the area had changed.

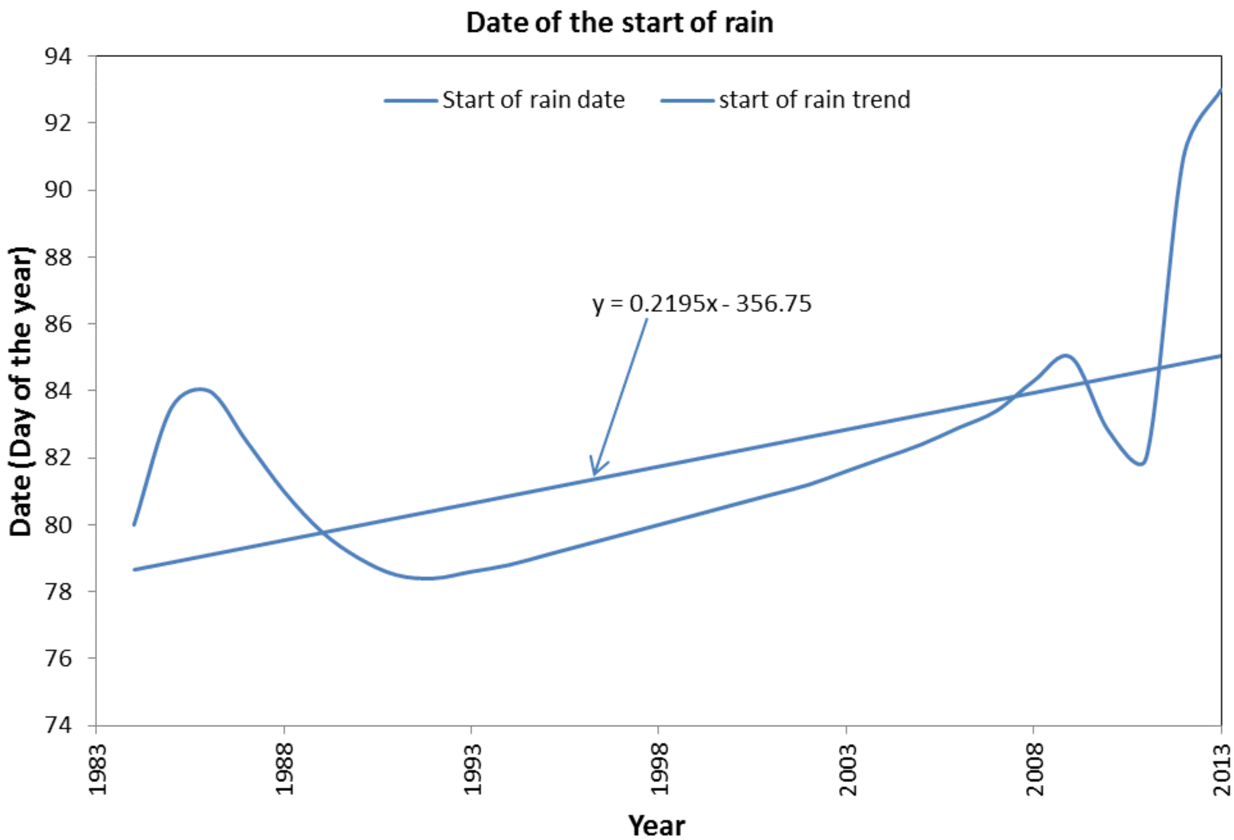

Figure 4.3: The trend for start of rain date during the month of March (1984 to 2013).

4.2 Effects of changing rainfall patterns on smallholder agriculture

Subsistence agriculture in the study area is a major livelihood option and depends entirely on rainfall performance. Although there are other factors such as high costs of production, poor market prices, reduced farm land sizes due to population pressure, which can also contribute to the decrease in agricultural production, changes in rainfall patterns plays the key role since agriculture in the study area is purely rain fed. Changes in rainfall patterns therefore alter farming activities with overall negative effects on agricultural activities and production. The study thus established the following effects.

4.2.1 Shortened growing period

Decline in the number of rain days and the increase in rainfall intensity during the MAM season was an indication that the length of the main growing season was shortening (Huho *et al.*, 2011). The study revealed in the analyses presented above that March rainfall amounts had declined

(Figure 4.3) and become more unreliable (Table 4.2). Thus the delayed onset of rains in March had forced some farmers to shift their planting dates to late March and others until mid-April in order to survive under an environment that is rapidly becoming arid. Shorter growing periods in the study area led to changes in crop varieties even to those with shorter maturity periods. Citing maize crop as an example, farmers stated that they had replaced hybrid maize of series H513, H614 and H629 which took longer durations (180 to 210 days) to mature with varieties such as Katumani Composite B; and Western Seed Company 402 and 503 which took shorter growing periods of between 120 and 150 days. However, farmers argued that H513, H614 and H629 varieties yielded more, had weightier grains, and were tastier compared to the new varieties. Thus farmers continued planting these varieties though in less quantities.

4.2.2 Poor yields due to ineffective rainfall

The MAM season seemed to have an overall increase in the rainfall (Figure 4.1), a condition suitable for rain-fed smallholder agriculture. However, increasing rainfall variability during the growing season led to droughts during the growing period. It was revealed by the divisional agricultural officers that early season droughts were common in Senetwo especially when planting was done in early March due to increase in "false rains". The officers argued that the rainfall that fell at the beginning of March were usually heavy giving a false impression of reliable start of the long rains prompting some farmers to begin planting. However the early March rains had become increasingly short-lived and were immediately followed by dry spells that sometimes extended up to two weeks causing poor germination of seeds. To cope with the uncertainty of the early March rains, farmers started planting with the rains that fell from mid-March onwards. The study attributed the occurrence of fewer mid-season droughts to the decreasing variability in April rainfall.

About 84% of the respondents were negative about obtaining good harvests due to late-season droughts, which had increased in the recent years. The respondents' assertion was confirmed by the analyzed May rainfall data which shows the number of rain days in May had been decreasing causing early cessation of the MAM seasonal rainfall. The increasing variation in May rainfall (C*v* for May) indicated that the rains were becoming more unreliable. In addition, increasing rainfall intensity during this month led to poor crop yields due to destruction of crop leaves and flowers of crops such as beans, if the rainfall had hailstones, and fell during the flowering and grain filling stages. The observed decline in crop yields (Figure 4.5) confirms the IPCC (2007) assertion that in some African countries climate change will exacerbate the deficiencies in rain-fed agricultural yield by up to 50% during the 2000 to 2020 period.

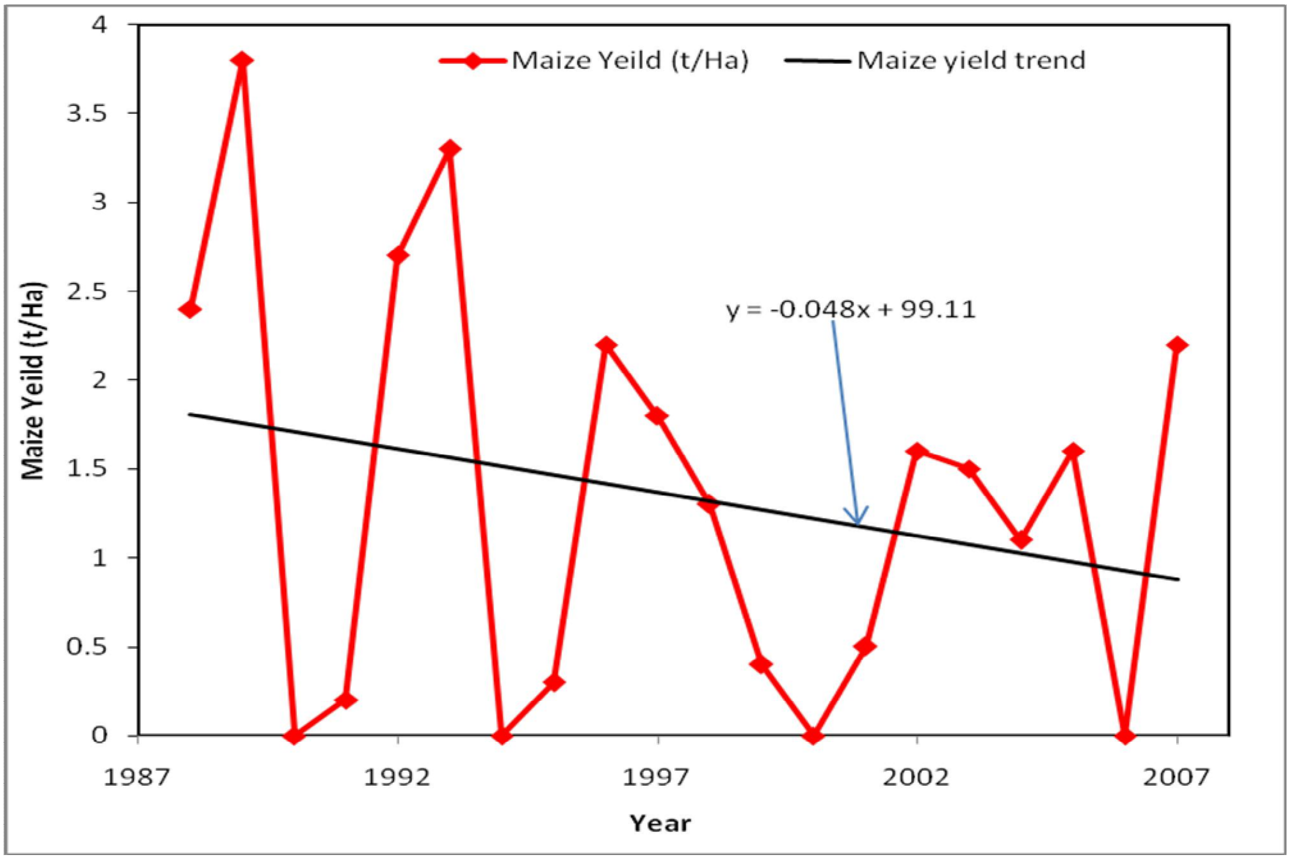

Figure 4.4 Annual maize yields in Senetwo location.

Due to the semi arid nature of the area, frequent occurrence of droughts hardens the top soil reducing its ability to absorb rain water when rainfall eventually comes (Huho *et al., 2011*). With hardened top soil, increased rainfall intensities served to increase surface runoff and in turn increased rate of soil erosion. This was evidenced by rills and gullies on the farmlands. According to IPCC (2007) climate change leads to greater soil erosion due to increased rainfall intensity.

4.2.3 Irregular planting dates

Increasing rainfall variability particularly in March made it difficult for farmers to plan for agricultural activities. Eighty four percent of the respondents stated that planting dates have increasingly become irregular with planting duration spanning from March to May (Figure 4.7).

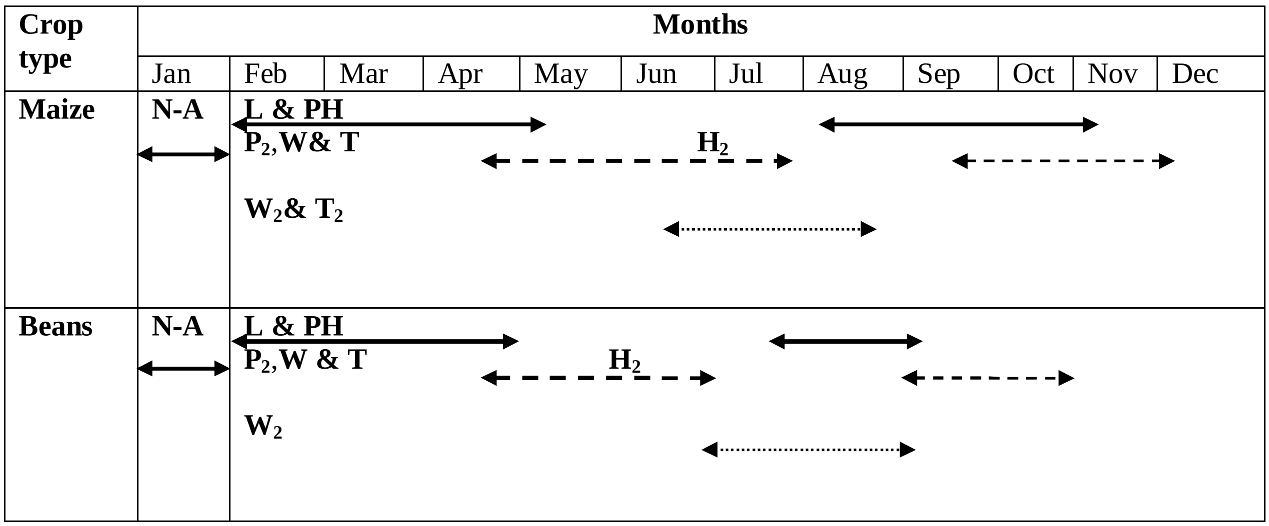

Figure 4.5: Irregular farming calendar in Chepareria Division: L= Land preparation for normal cropping cycle; P=Planting for first cropping cycle; P_2 =Planting for replanted cropping cycle; W = Weeding for normal cropping cycle; W2 = Weeding for replanted cropping cycle; T= Topdressing for normal cropping cycle; T_2= Topdressing for replanted cropping cycle; H = Harvesting for normal cropping cycle; H2 = Harvesting for replanted cropping cycle; and N-A = No Activity.

The study established that delays in planting affected all other farming practices such as weeding, top dressing and harvesting. About 88% of the farmers stated that there have been observed shifting of the main rain season and thus the alteration of the farming calendar (Table 4.5). According to agricultural officers in working in Senetwo location, this has affected labour availability since the farmers depended on family labour especially their school-going children for weeding during school holidays in April. Shifts in weeding seasons to May or June meant shortage of farm labour because children were back in schools for their second term. In addition to inadequate labour, farmers also stated that the declining June rainfall led to mid or late season droughts leading to frequent crop failures.

4.3 Household characteristics

Socio-economic position of households in the study area was examined in order to understand how it influenced the response and adaptive capacity of households to climate variability. The variables studied include; gender, marital status and literacy levels of the respondents. Other variables such as household size, size of land and land tenure, household income and household livelihoods were also studied.

4.3.1 Gender and marital status of the respondents

The proportion of married people in the study area is relatively high consisting of about 88% as revealed by the respondents (Figure 4.7) and their households had both resident mother and father. Only a few of the households were found to be widowed (2.4%)and those that were found by the study to be single were nine young men and three ladies accounting for about 10% of the population (Figure 4.7), most of whom are in higher learning institutions in the country.

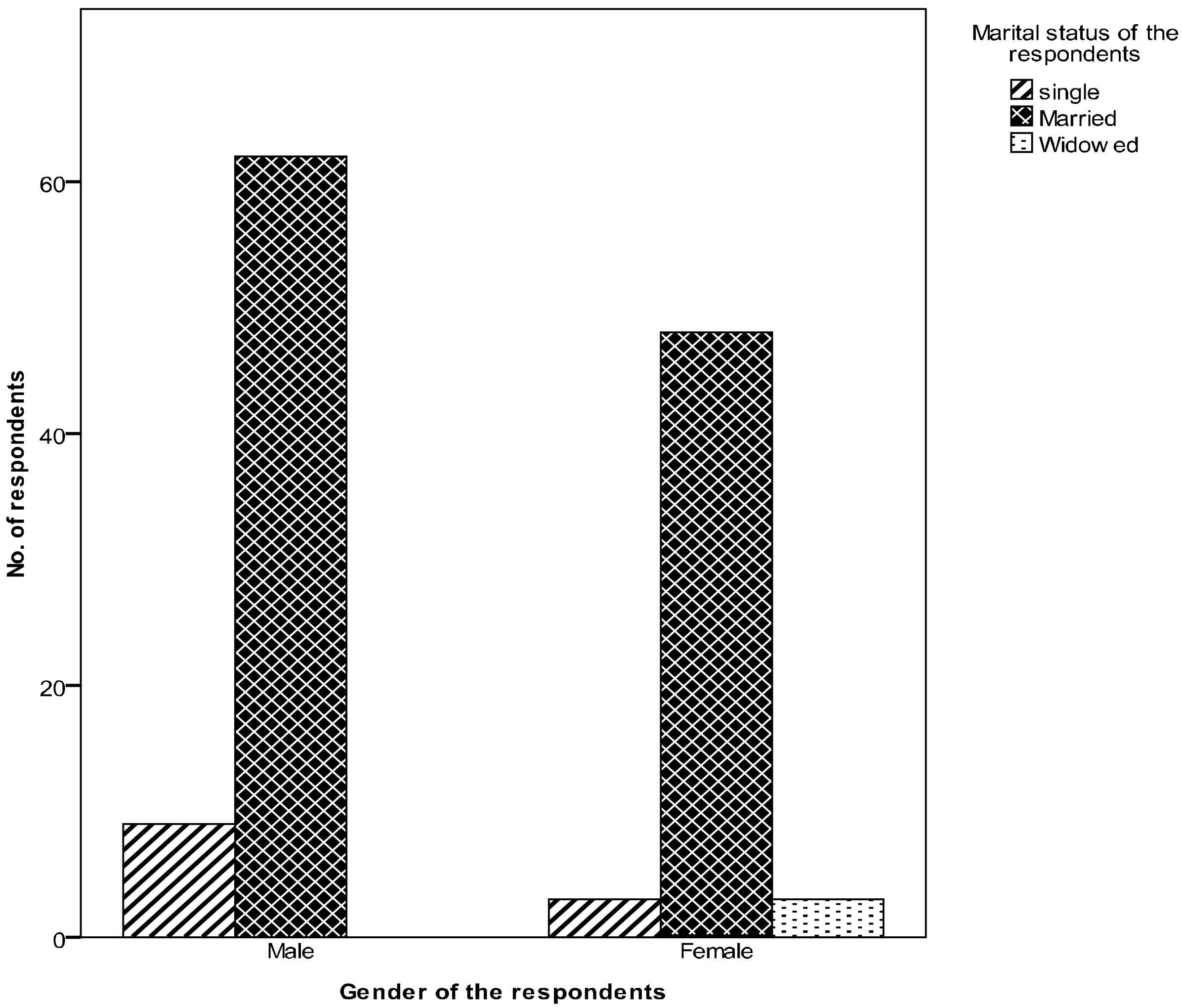

Figure 4.6: Gender and marital status of the respondents

Gender is believed to influence the decision to take adaptation measures. Female and male headed households in the study area differ significantly in their ability to adapt to climate variability because of major differences to critical resources (land, cash and labor). The male headed households were found to more be likely to adapt to climate variability by adjusting their planting period than using soil and water conservation method. This is consistent with the findings of Tenge De Graffe and Heller (2004) in which being a female head of household had negative effects on the adoption of soil and water conservation measures, because women have limited access to information, land and other resources due to traditional social barriers. According to De Groote and Coulibaly (1998) and Quisumbing et al. (1995) women have lesser access to critical resources (land, cash, and labor) which often undermines their ability to carry out labor-intensive agricultural innovations. On the other hand, Nhemachena and Hassan (2008), finds that female headed households are more likely to take up climate variability adaptation methods. In addition to this, Bekele, & Drake (2003) found that household head gender was not a significant factor influencing a farmers' decisions to adopt conservation measures.

4.3.2 Education level of the respondents

Literacy level in Senetwo location is very low (Figure 4.7). Fifty percent of all the respondents have primary level education, 17% no education, about 13% secondary level, 8% midlevel training and only 3% had attained a university degree (Figure 4.7 below).

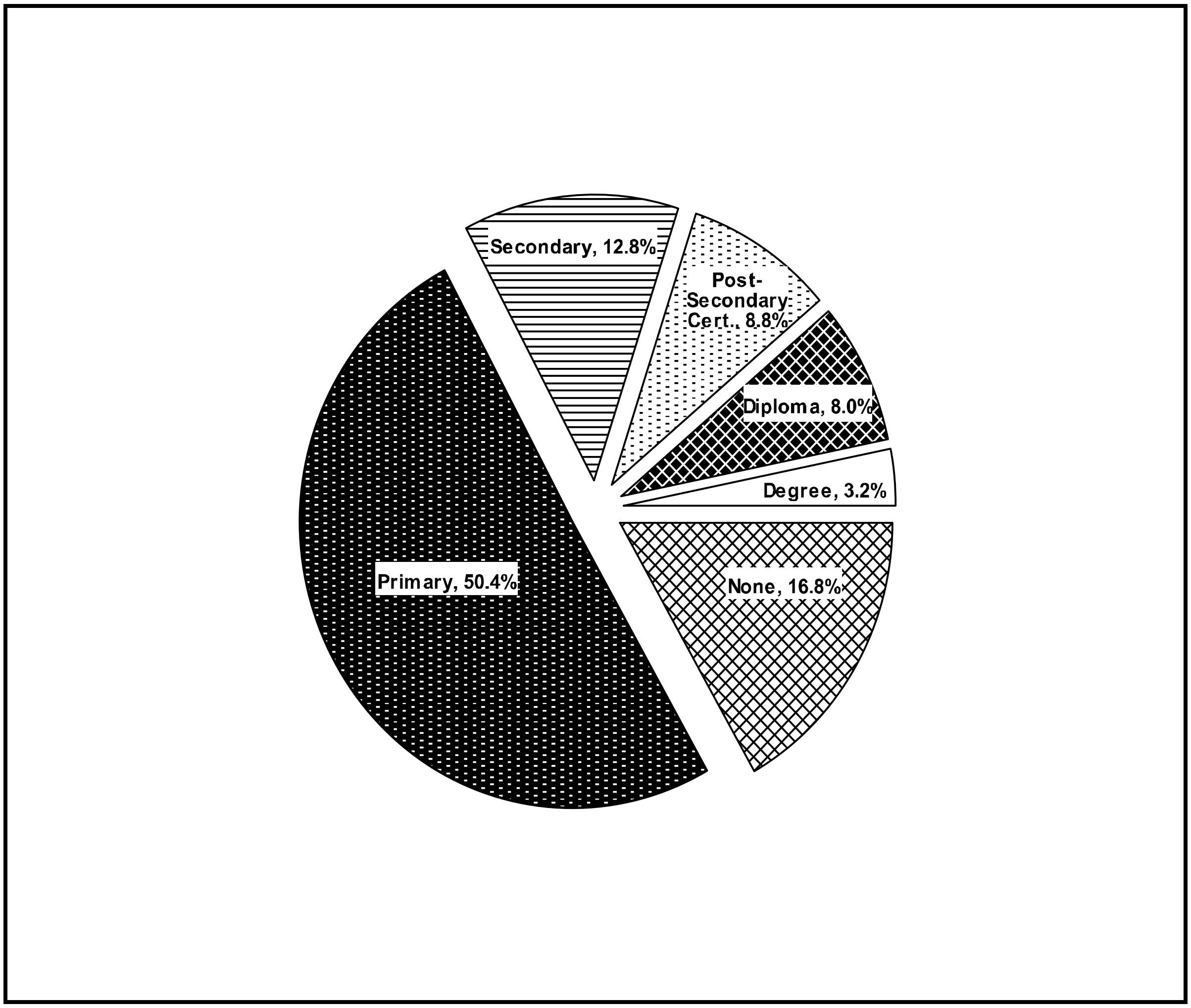

Figure 4.7: Level of education of the respondents (%)

The low literacy level in the study area is a worrying situation. Evidence from various sources indicates that there is a positive relationship between the education level of the household head and adaptation to climate change (Maddison, 2006). This implies that farmers with higher levels of education are more likely to adapt better to climate change. Education level is a significant factor in all households for the perception, analysis, interpretation and a better understanding of weather and climate variability information. Level of education is also critical for households to understand the impacts of climate variability, adaptation strategies and to make informed decision on how to adjust and respond positively to changes occurring in their natural environment. This is in support of Williams (1997) that reported that farmers “adoption of improved technology is influenced by their level of education, thus respondents level of education will assist them to seek information on climate variation.

4.3.3 Other household characteristics

The average number of household members was eight individuals in every household, although some households had as few members as three, but there were households with as many as 14 or 16 members (Table 4.3). Generally this is a high population to sustain in difficult time of famine especially for resource limited households. On the other side of the coin, many household members are good when it comes to distribution of labour in the family (Recha, 2008).

The average land size per household was found to be about 5 acres with some households having as much as 12 acres and others with as little as 0.8 of an acre. The land size allocated to crop farming was of about equal size to that allocated to livestock keeping at an average of 2.1acres and 2.5 acres respectively (Table 4.3). Mixed farming is widely practiced by households thus diversifying their livelihoods in order to obtain the maximum benefit from the small land sizes and a varying climate in the study area (Plate 4.1).

Table 4.3: Respondents household characteristics, with means

	Minimum	**Maximum**	**Mean**	**Std. Deviation**
Household size	1.0	16.0	7.53	2.99
Size of land of the household	0.8	12.0	4.80	2.89
Size of land for crop farming	0.0	8.0	2.12	1.32
Size of land for livestock keeping	0.0	8.0	2.52	1.97

Source: Survey data (2013)

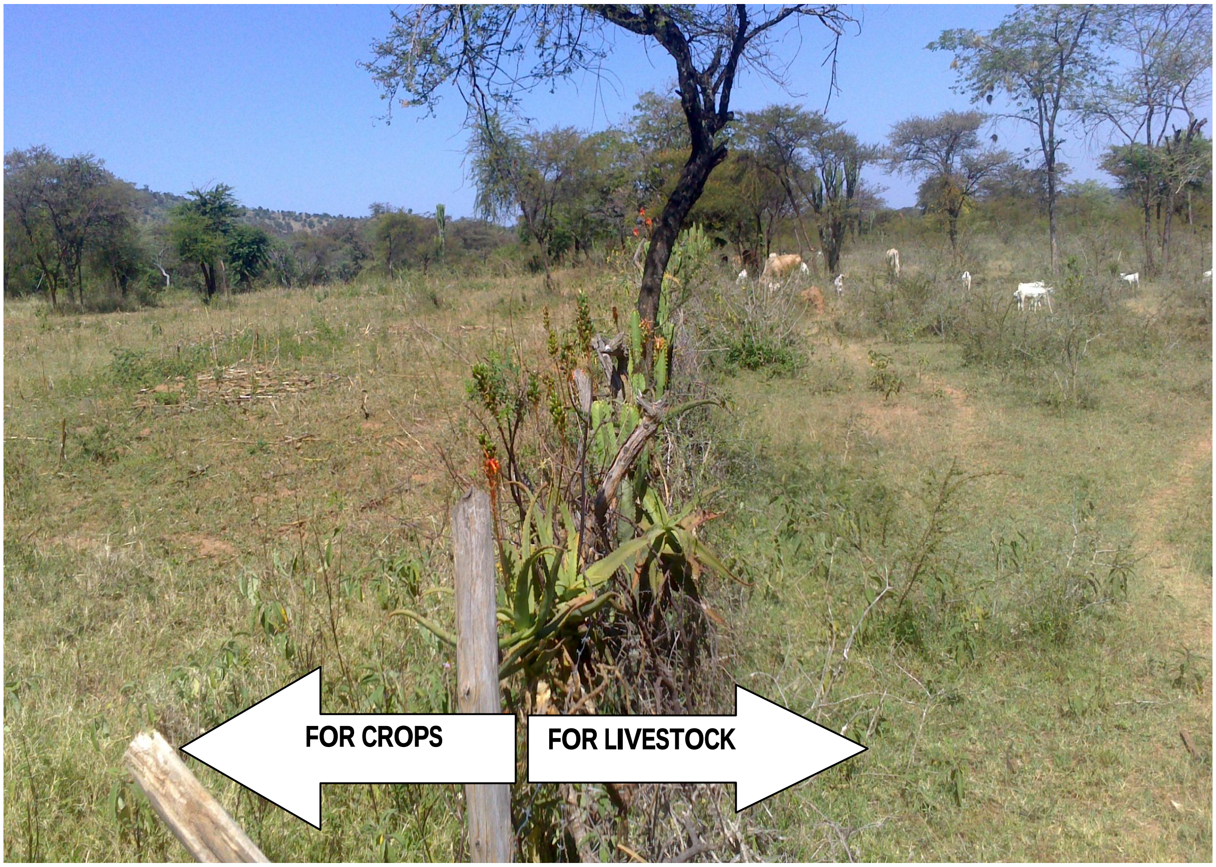

Plate 4.1: Farmer's land showing mixed farming in Senetwo location

4.4 Livelihoods of the respondents

Subsistence rain-fed mixed farming is the main source of livelihood in the study area with a response rate of 97.6%, with only a few 16.8% combining with some level of off-farm income sources such as businesses, government officials and school teaching (Table 4.4). The salaried members of the community had multiple sources of income, which act as a buffer to this group in times of extreme climate events, especially when the rains fail. The dominant crops grown are maize and beans and are planted by majority of the respondents also at 98.4%. Other crops grown include millet and sorghum 28%, bananas 11.2%, and cassava 5.6%. In the recent years the study revealed that most households have began re-introducing drought resistant crops. There is a significant increase in cultivation of millet, sorghum, cassava and sweet potatoes in Senetwo location. These crops were traditionally cultivated in the area up to early 1960s when maize and beans were introduced into the area as a commercial crop. Nevertheless cultivation of millet and sorghum was mainly for domestic purposes which were grinded and cooked mainly during ceremonies and other traditional functions.

The study was conducted in a community traditionally believed to be pastoralists and thus the study revealed that about 81% of respondents keep livestock in their farms (Table 4.4).

Table 4.4: Livelihoods of the respondents (%)

Income Activities	Percentage
Mixed farming	97.6
Crops only	0.8
Maize and Beans	98.4
Millet and Sorghum	28
Bananas	23.2
Cassava and other tubers	5.6
Keeping livestock only	1.6
Rearing and selling cattle	94.4
Rearing and selling goats	70.4
Rearing and selling sheep	79.2
Keeping and selling poultry	98.4
Off-farm Activities Percentage	
Business (apart from crops and animals)	9.6
Salaried employees	6.4
Informal sector	0.8

Source: Survey data (2013)

4.5 Respondents' knowledge and perception about climate variability

Respondents' perception of climate variability is the condition for their initiation of adaptation practices. As many African studies indicate a large number of agriculturalists already perceive that the climate has become warmer and the rains less predictable and shorter in duration (CEEPA, 2006). Such understanding is the main derive for smallholder farmers and policy-makers to initiate adaptation strategies.

Based on the household survey results in Table 4.5, the respondent's perceptions on changes in the major indicators of climate variability are presented. The summary statistics shows that a significant majority at about 80% of the respondents were of the opinion that there have been some changes in the climate over the years, with change in the amount of rainfall during the main season (96%), an increase in the amount of rainfall (84.8%), early timing of onset (61.6%), and an increase in temperature at 69.6% response rate (Table 4.5).

Table 4.5: Knowledge and perception of respondents regarding the variable climate in Senetwo location

Perception indicators	**Yes (%) n=125**	**No (%) n=125**
Is there any change in amount of rainfall during main rain season	96	4
Is rainfall increasing in amount during main rain season in the past 10 years?	84.8	15.2
Is the timing of onset of rain in main rain season shifting?	88	12
Is rain starting early than normal?	61.6	38.4
Is planting date changing due to change in onset of rain?	67.2	32.8
Does the planting date change apply to most crops?	96	4
Is the amount of precipitation sufficient for full cropping during short rains?	1.6	98.4
Is the temperature changing in the past 10 years?	71.2	28.8
Is the temperature is increasing in the past 10years?	69.6	30.4
Is diversity of crops changing in the past 10 years?	48.8	51.2
Encountered complete crop fail in the past 10 years?	83.2	16.8

Source: Survey data (2013)

Moreover, the table above also reveals that significant majority of the respondents perceive the consequences of these changes in the rainfall pattern in cropping systems, temperature and livestock health situations in the last ten years. Indeed this perception is in line with the finding of CEEPA (2006) that rainfall declined by 0.39% in Ethiopia in the period 1948–2001 which created problems of seasonal flooding, new invasive plants affecting crop and pasture land, problems of livestock health, increased frequencies of crop failure and extreme temperature problems were visible for majority of the sample households.

For instance, 83.2% of households have encountered at least one time complete crop failure in the last ten years (Figure 4.8). An increase in the problem of livestock health related to climate change (86.4 %) and a problem of new invasive plants that affect crop and pasture land (46.4 %) is also well perceived (Figure 4.8). Weather and climate directly influence crop growth, development and yields, water needs of both plants and animals, fertilizer requirements and indirectly influence the incidence of pests and diseases, (WMO, 2010). According to the IPCC (2007), in the Fourth assessment report, climate change contributes to the global burden of diseases and premature deaths in both animals and humans. However, Lelenguyah (2010) noted that there was no significant relationship existing between rainfall variability and cases of Trypanosomiasis, Babesiosis, Anaplasmosis and East Coast Fever (ECF).

Increased occurrences of hail has been experienced by about half (49.6%) of the households in the study area mostly when heavy rains occur. Seasonal flooding has only been realized by 8.8% of the respondents especially by those households leaving nearby rivers or streams that burst their banks during the rainy season (Figure 4.8).

These problems brought about by climate variability in Senetwo location have a great deal in influencing the choice of livelihood options which form the suitable adaption strategies employed by households.

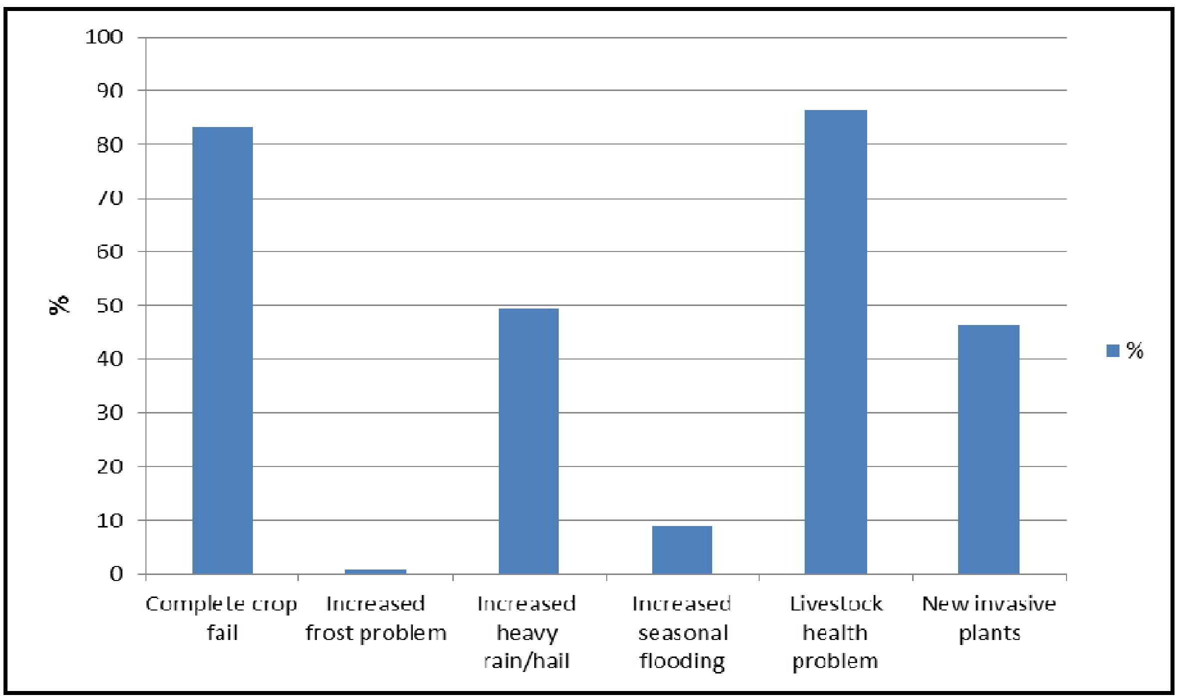

Figure 4.8: Problems related to climate variability in Senetwo location.

4.6 Smallholder farmers' coping and adaptation strategies to climate variability in Senetwo location

In the study area the respondents have adopted different strategies to cope up with the consequences of climate changes and thus manage future changes in climate variability. The residents of Senetwo location have made significant changes to their farming practices due to changes in the agro-climatic factors. Some of these changes are presented in Table 4.6 and include, planting of different crops with more (82.4%) focused on short maturing ones, and different crop varieties different planting dates, better farm-level management of soil and water, and increased number of trees planted.

Different adaptation practices are employed in all farming practices by households in the study area (Table 4.6). The specific crops cultivated in Senetwo location are maize, beans, millet and sorghum. Only about 10% of the respondents have resorted to different crops which are fast maturing and also drought tolerant such as cassava, sweet potatoes, ground nuts, bananas and mangoes on a small scale (Plate 4.1). About 17% of the respondents have also used different crop varieties and animal breeds in order to cope with climate variability in the study area (Table 4.6). According to agricultural officers in Senetwo location, it is only different maize varieties that farmers have widely opted for in order to cope with the variable climate. This is due to farmers' limited information regarding yields and reliability of other new crop types and varieties.

Animal husbandry in Senetwo location has seen tremendous changes in the last 10 years. Rearing and sale of cattle, goats, sheep and poultry, were the main sources of income from livestock with 94.4%, 70.4%, 79.2% and 98.4% of the respondents respectively. According the livestock officers working in Senetwo location, more farmers (26.8%) have improved their livestock breeds (see plate 4.1) in order to fetch higher returns from the sale of their animals. This gives them a competitive advantage in the market compared to farmers with inferior breeds. Livestock breed improvement is mainly attributed by the presence of a government livestock improvement centre at Naskuta within the study area. This centre has been offering livestock extension services since its inception in the early 1970s as well as making high breed sheep, goats, poultry and most recently cattle. The Gala goat, Zebu and Sahiwal cows and bulls and the doper sheep are available at subsidized prices for farmers. Naskuta livestock improvement centre offers veterinary services also at subsidized prices to farmers.

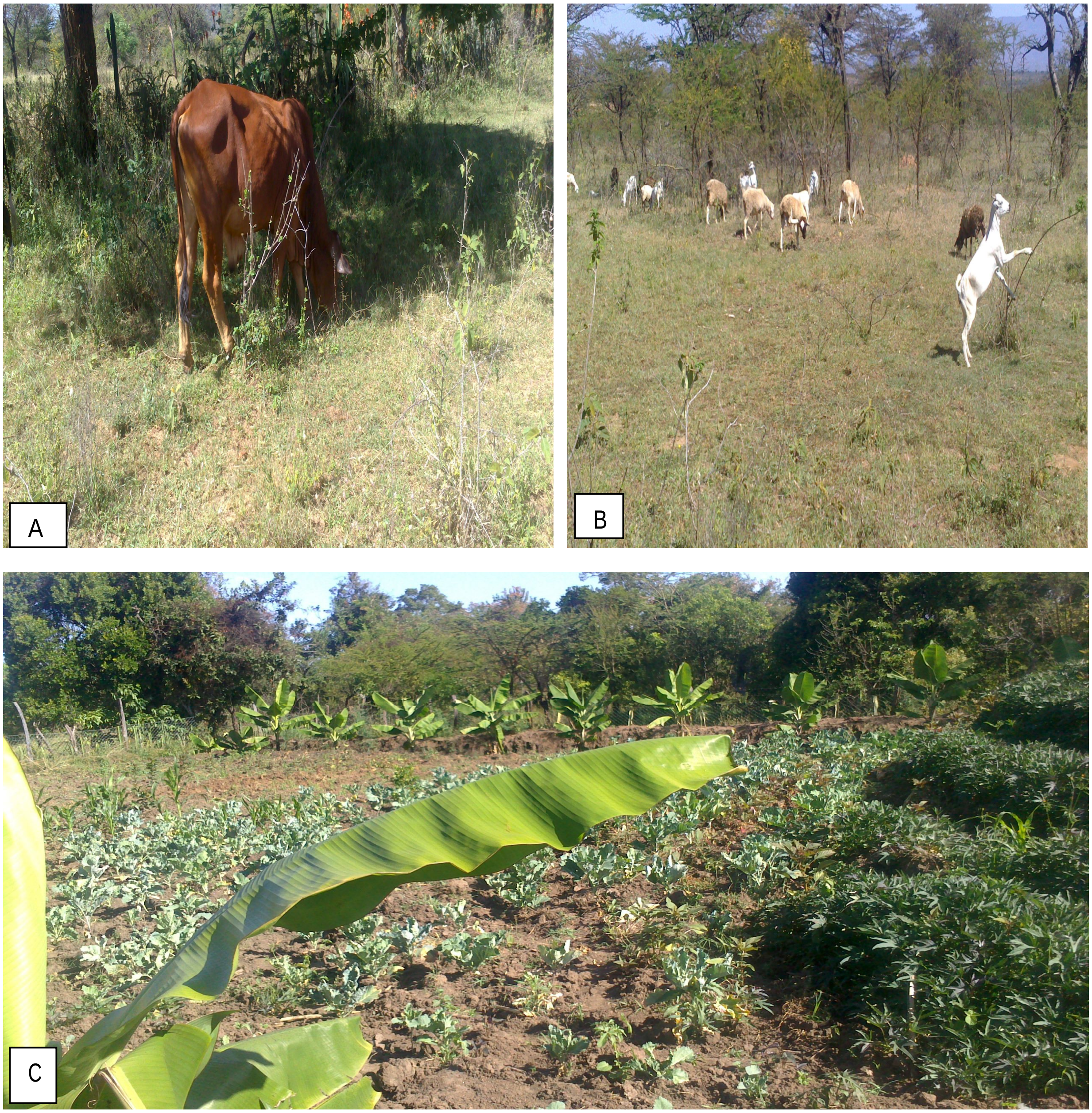

Plate 4.2: Coping and adaptation measures in Senetwo location

A. Improved cattle breed
B. Improved goats and sheep breeds
C. Different crops

Poultry keeping in Senetwo location is a major adaptation strategy employed by majority of the residents in this area at 98.4%. This is because of the favourable climate; it is not labour intensive; and it is a low capital investment since it is free range. This livelihood option is also adopted widely by farmers in the study area because of the ready market for the chicken and its products (eggs). Majority of the farmers involved in livestock keeping also sell their animals during harsh economic times in order to buy food, pay for medical expenses and pay school fees for their school going children. The intensity of labour use in the farming systems have also increased in about 58% of the sample households. Some of the residents stated that alteration of the farming calendar during weeding affected labour availability especially the households that are dominated by school going children for school holidays in April. Shifts in weeding seasons to May or June meant shortage of farm labour because children were back in schools for their second term. For instance 67% of the farmers increased the use of soil and water conservation at household-level and about 53 % of the households surveyed have increased the number of trees planted on their private land (Table 4.6).

Table 4.6: Main livelihood coping and adaptation strategies in the study area

Adaptation	**Percentage**
Different crops	9.6
Different crop varieties	16.8
Different livestock breeds	26.8
Short growing crop varieties	82.4
Rearing and selling cattle	94.4
Rearing and selling goats	70.4
Rearing and selling sheep	79.2
Keeping and selling poultry	98.4
Increased commercial fertilizer use	66.5
Increased labour force at farm	58.4
Use of soil and water conservation at farm level	67.2
Plant more trees at farm	53.4

Source: Survey data (2013)

Soil and water conservation practices and rain water harvesting structures are evident on communal and individually owned farms. These rain water harvesting structures are designed and implemented by the government of Kenya through the Department of Land Reclamation. These land reclamation projects in the area are only on a limited scale considering the huge capital investment required to implement which cannot be afforded by all the area residents. The soil and water conservation structures that are evident in Senetwo location include; water pans for livestock trapezoidal bunds and contour bunds for crop and grass farming (Plate 4.1).

Plate 4.3: Soil and water conservation techniques in Senetwo location (Photos by author, 2014)

A. Water pan before rain in February; **B. Water after rain in May;**

C. Contour bund **D. Trapezoidal bund**

4.6.1 Attributes and indicators of adaptive capacity

A multivariate Logit regression analysis on the determinants of farmers' climate variability adaptation strategies was carried out (table 4.7) to determine their adaptive capacity.

Table 4.7: The Multivariate Logit regression of Determinants of climate variability adaptation measures

Variable	**Different crops**	**Different crop varieties**	**Short growing crops varieties**	**Increased external fertilizer use**	**Increased labour input**	**Use soil and water conservation at farm level**	**Plant more trees at farm level**
Gender	0.446	-0.034	0.007	0.624	**0.449**	0.076	-0.226
Age	-0.058	-0.056	-0.015	-0.045	-0.028	0.011	**0.051**
Education level	**0.337**	**0.485**	-0.424	0.260	0.538	-0.030	0.462
HH size	0.247	0.181	-0.098	0.091	**-0.036**	-0.124	-0.059
Land size	0.092	0.034	**0.001**	0.080	-0.281	-1.000	**0.348**
Land for crops	-0.871	-0.058	**0.224**	-0.825	0.622	**0.466**	-0.241
Change in temperature	0.719	0.608	**0.017**	0.050	0.622	**0.279**	0.566
Access to credit	**0.716**	0.306	0.056	**-0.351**	0.972	-0.300	-0.199
Access to extension services	-0.338	-0.313	-0.048	**0.648**	-0.079	**-0.224**	**-0.438**
Access to climate information	-0.050	0.315	0.386	-0.080	0.140	**0.447**	**0.612**

Note: * significant at 1% level, ** significant at 5% level, and * significant at 10% level**

In Senetwo location, Multivariate Logit regression model revealed that access to agricultural extension service (0.302; p≤0.01), large farms (0.341; p≤0.1), access to climate change information (0.326; p≤0.05), access to credit (0.311; p≤0.01) and perceived change in temperature (0.117; p≤0.1) have been identified to have positive and significant impact on adaptation to climate variability.

The households that have access to climate information and have had access to agricultural extension services are found to promote adaptation in soil and water conservation. Institutional factors often considered in the literature to influence adoption of new technologies are access to information via extension services (climate information and production technologies) and access to credit (Nhemachena and Hassan, 2008). Extension education was found to be an important factor motivating increased intensity of use of specific soil and water conservation practices (Bekele and Drake, 2003). In deed of the many sources of information available to farmers, agricultural extension is the most important for analyzing the adoption decision. Those households usually have better knowledge and information on climate (and weather) changes and agronomic practices that they can use to cope with variability in climate and other socioeconomic conditions. This suggests that consistent awareness creation of the potential benefits of soil and water conservation in the adaptation to climate variability is an important policy measure for stimulating farm-level climate adaptation.

Access to climate change information, positively and significantly affect the decision to take up climate variability adaptation measures in the study area. It increases the probability of using different crop varieties, use of commercial fertilizer, use of soil and water conservation measures and planting more trees at plot level. Access to climate forecast information has potential to reduce impacts of climate variability and enhance households' adaptive capacity (Recha, 2008).

It was surprising that none of the respondents mentioned extension officers as sources of forecast information. Recha (2008) notes that despite the current structure of forecast dissemination through the Ministry of Agriculture and Office of the President, Special Programs (ASAL Department) (Odingo *et al.* 2002). Extension officers offer a better opportunity to accurately interpret forecasts to farmers during their field visits. Alternatively, it might perhaps be of greater importance if Kenya Meteorological Department (KMD) packages forecast information in a manner easily understood by farmers and directly send it to the increasing vernacular radio stations across Kenya. It is therefore, important for governments, NGOs and donor communities to raise awareness of the climate variability using appropriate media available to farm households.

Access to credit was found to be significant and negatively relating to the use of different crop varieties but the table above also shows a positive influence on increased use of external fertilizers. Credit is found to relax the financial constraint brought about by farming inputs and thus would be expected to have a positive influence on farm-level climate risk adaptation. However, this is only as far as the profitability of the technology supersedes other investment alternatives available to the farmer. In reality a farmer must make a choice between farming and other alternative investment options. The area being environmentally fragile due to erratic rainfall makes farming more risky than other business opportunities and this may lead to farmers allocating a higher proportion of their capital to other investment opportunities. Access to credit, especially from banks and co-operative movements are non-existent in the study area. The most common source of credit is *Merry-go-round* in which members make weekly or monthly contribution to one another on rotational grounds. In some cases, a part of the contribution is saved to enable members to borrow when in need. According to Recha, 2011, Limited access to credit can be explained by two factors. To smallholder farmers ASALs, borrowing money for farming does not make economic sense as the chances of crop failure are much higher than those of success. Secondly majority of the smallholder farmers are poor and therefore lack collateral, including lack of land title deeds.

Perceived change in temperature has also quite significant effect in the likelihood of employing climate variability adaptation strategies. Perceived change in temperature did seem to explain in the cultivation of more crop varieties (at 5 % level of significance), use of short growing crop varieties (at 1 % level of significance) and use of soil and water conservation measures (at 1 % level of significance). Households that perceive the change in temperature can link their perception with decreases in water resources (surface and ground), and high evapotranspiration rates. This leads them to take various responses. For instance, farmers tend to use drought – resistant crops or varieties; use short growing crop varieties and use of soil and water conservation techniques to conserve the little rain that is received in the area.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study sought to quantify rainfall variability and examine the adaptive capacity to climate variability of smallholder farmers living in the ASALs of Senetwo location, Chepareria division, West Pokot County. The study thus revealed that:

- Changes in rainfall patterns have been identified by the smallholder farmers in Senetwo location. These changes are evidenced by the declining number of rain days between March and May, increasing rainfall intensity and variability. Shifts in timings of rainfall onset has led to altered planting dates and shortened growing periods with the overall effect on yields.

- In an attempt to cope with rainfall variability, only a small proportion of farmers are diversifying cropping by mainly considering other crop types such as sorghum, millet, cassava, sweet potatoes, bananas and mangoes which are either fast maturing and/or drought resistant. However, much progress has been made in livestock husbandry with more farmers having improved and commercialized their livestock breeds in a move to combat climate variability.

- Access to agricultural extension service, access to climate change information and access to credit have been identified to have positive and significant impact on adaptation to climate variability.

5.2 Recommendations

- It is crucial for private and public institutions to come up with a strategy (policies and programs) that address the underlying causes of climate variability vulnerability in Senetwo location. The strategy should be an institutional framework based on science-policy-practice communication in the quest for enhancing adaptation to climate variability in Senetwo location.

- Emphasis should be put on the need to strengthen and build capacity of extension services. Measures and programs on training of extension agents in the use, interpretation, strength and weaknesses of climate forecast information, soil and water conservation measures, and alternative forms of livelihoods that are more adapted to climate variability in Senetwo location.

- There is need for further social-scientific research in the area of suitability and potential of alternative cropping and coping mechanisms such us green houses, bee keeping in the wake of the observed climate variability in Senetwo location.

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APPENDICES

APPENDIX ONE: QUESTIONNAIRE FOR THE HOUSEHOLDS HEADS

I am a student of Egerton University in the Department of Environmental Science. I am conducting a research on the assessment of the***impacts of climate variability on smallholder farmers' livelihoods in Senetwo location, Chepareria division.*** This is an academic study and thus your participation is **VOLUNTARY** and you are assured that the information you provide will be treated with utmost **CONFIDENTIALITY** and used for sole purpose of this research. Your support is highly appreciated and you are requested to provide the researcher with accurate information for the success of this study.

Section A: general information

1. Name of Respondent: ……………………………………………………………..
2. Area of residence: (i) Sub-location: ………………………...........................

   (ii) Village: ………………………………………………………..
3. Gender: i. Female ☐ ii. Male ☐
4. Age of respondent (in years): …………..
5. Marital status (*please tick one*)

   i. Single ☐ ii. Married ☐ iii. Widowed ☐ iv. Divorced ☐
6. Highest level of education (***please tick one only***)

   i. None ☐

   ii. Primary ☐

   iii. Secondary ☐

   iv. Post secondary ☐ specify: ………………………………………

   ………………………………………………………………………………

Section B: Household livelihood characteristics

7. How many dependants do you have with whom you have been living with for the last one year?

Household members	Number
Men (adult(s))	
Women (adult(s))	
Children	

8. What are your household's main on-farm sources of income? (**please tick appropriately**)

   i. Food crop farming ☐

   List crops grown ………………………………………………………………

   ………………………………………………………………………………..

   ii. Livestock keeping ☐

   List livestock reared ……………………………………………………………..

   ……………………………………………………………………………….

   iii. Others (specify)

   …………………………………………………………………………………

   ………………………………………………………………………………..

9. Are you involved in any off-farm income generating activity?

   Yes ☐ No ☐

   If yes, specify and give reason(s)……………………………………………………….

   ………………………………………………………………………………………………

   ………………………………………………………………………………………………

   …………………………………………………………………………………………….

10. (a)Are you a member of any community group/organization?

   Yes ☐ No ☐

   (b) If yes, give reasons for joining the group (**please tick on that is most appropriate**)

i. Collective production ☐
ii. Group marketing ☐
iii. Purchase of inputs ☐
iv. Training ☐
v. Group lending ☐

11. What is the size of your land? .... (**Acres**)

12. What size of land is allocated to:

i. Crop farming?…………………………(Acres)
ii. Livestock rearing?……………………(Acres)
iii. Others (specify)?……………………..(Acres)

13. (a) Do you have access to credit services?

Yes ☐ No ☐

(b) If yes, what was your reason for borrowing?

i. To cater for farming activities . ☐
ii. To cater for production inputs ☐
iii. Medical bills ☐
iv. School fees ☐
v. Others ☐

(specify)……………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………

14. (a) Do you have access to agricultural extension services?

Yes ☐ No ☐

(b) If yes, what information did you obtain that influenced your farming activities?

i. ……………………………………………………………………………………
……………………………………………………………………………………….
ii. ……………………………………………………………………………………
……………………………………………………………………………………….
iii. ……………………………………………………………………………………
………………………………………………………………………………………..

15. (a) Do you have access to climate information?

Yes ☐ No ☐

(b) If yes, where do you get this information?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………….

16. Are you likely to continue crop farming in the future?

Yes ☐ No ☐

What are your reasons? ....

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………..

Section C: Climatic conditions and impacts for the last ten (10) years

17. When do main rain season occur? ....
18. Is there change in the amount of rainfall during main rain season?

    Yes ☐ No ☐
19. Is rainfall increasing in amount during main rain season?

    Yes ☐ No ☐
20. Is the timing of the onset of rain in the main season shifting?

    Yes ☐ No ☐
21. Is the rain starting: 1) Early ☐ 2) Late ☐ 3) Normal ☐
22. Is your planting date changing due to change in the onset of rain?

    Yes ☐ No ☐
23. Does the planting date apply to most crops?

    Yes ☐ No ☐
24. Is the amount of precipitation sufficient for full cropping during short rains?

    Yes ☐ No ☐
25. Do you feel the temperature of the area is changing?

    Yes ☐ No ☐

    If yes, is the temperature: 1) hotter ☐ 2) colder ☐ 3) normal ☐

26. Is the diversity of crops and livestock changing?

Yes ☐ No ☐

27. Is diversity of your crops and livestock increasing?

Yes ☐ No ☐

28. Have you encountered:

i. Complete crop fail?

Yes ☐ No ☐

ii. Increased problem of frost?

Yes ☐ No ☐

iii. Increased problem of heavy rain/ hail?

Yes ☐ No ☐

iv. Increased problem of seasonal flooding?

Yes ☐ No ☐

v. Increased problem of livestock health related to climate change?

Yes ☐ No ☐

vi. Increase in new invasive plants affecting pasture land?

Yes ☐ No ☐

Section D: adaptation and coping strategies

29. Have you received any support from the government or non-governmental organization(s) in farming and livestock keeping in the last one year?

Yes ☐ No ☐

If yes, what kind of support?

☐ Training

☐ Farm inputs

☐ Cash (specify amount) …………………….. (Kshs)

Other

…………………………………………………………………………………………………

……………………….………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

30. Have you changed the types of crops and livestock you keep on your farm in the last 5 years? Yes ☐ No ☐
31. Do you use different varieties of crops and livestock in your farm since the last 5 years?
    Yes ☐ No ☐
32. Do you plant short growing varieties in your farm since the last 5 years?
    Yes ☐ No ☐
33. Do you use external fertilizer in you farm?
    Yes ☐ No ☐
    If yes, has the use of the fertilizer in the last 5 years:
    Increased? ☐ Decreased? ☐ Unchanged? ☐
34. Has the labour you use in your farm in the last 5 years:
    Increased? ☐ Decreased? ☐ Unchanged? ☐
35. Do you use soil and water conservation practices in farm?
    Yes ☐ No ☐
    If yes, list those practices
    i. ……………………………………………………………………………………
    ii. ……………………………………………………………………………………
    iii. ……………………………………………………………………………………
    iv. …………………………………………………………………………………….
    v. ……………………………………………………………………………………
    vi. ……………………………………………………………………………………
    vii. ……………………………………………………………………………………
    viii. …………………………………………………………………………………..
36. Have you planted trees in your farm since five years ago?
    Yes ☐ No ☐
    If yes, has the tree planting:
    Increased? ☐ Decreased? ☐ Unchanged? ☐