INTEGRATING INDIGENOUS AND CONVENTIONAL KNOWLEDGE-BASED CLIMATE FORECAST FOR FARMERS' ENHANCED ADAPTATION TO CLIMATE VARIABILITY IN THARAKA-NITHI AND KITUI COUNTIES

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DECLARATION

Candidate's Declaration

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

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Declaration by Supervisors

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

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DEDICATION

To my beloved parents Mr. Gerald Mugi and Mrs. Beatrice Wanjiku for their unfailing love, care and support; my husband Daniel Ngenga for the unending encouragement and to my siblings for the courage they instilled in me.

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ABBREVIATIONS AND ACRONYMS

ASALs	:	Arid and Semi-Arid Lands
CEEPA	:	Centre for Environmental Economics and Policy in Africa
FGDs	:	Focus Group Discussions
GOK	:	Government of Kenya
HH	:	Household
HHH	:	Household Head
IK	:	Indigenous Knowledge
IPCC	:	Intergovernmental Panel on Climate Change
KIs	:	Key Informants
KMD	:	Kenya Meteorological Department
LDCs	:	Less Developed Countries
LR	:	Long Rains
MNLR	:	Multinomial Logit Regression
MoA	:	Ministry of Agriculture
PCA	:	Principal Component Analysis
SPSS	:	Statistical Package for Social Sciences
SR	:	Short Rains
SSA	:	Sub- Saharan Africa
SSTs	:	Sea Surface Temperatures
UNEP	:	United Nations Environment Programme

ABSTRACT

Climate variability has a negative impact on crop productivity and has affected many small-holder farmers in the arid and semi-arid lands (ASALs). Small-holder farmers in the study area are faced with the constraint of climate variability and have consequently made effort at the local level to utilize indigenous knowledge (IK) in addition to conventional knowledge to mitigate the impacts of the variability. However, documentation of the IK indicators is limited. This study was therefore undertaken with the aim of identifying the IK and preparedness techniques employed in coping with climate variability by small-holder farmers, integrate the indigenous and conventional knowledge of climate forecasting and assess how the household's socio-economic factors influence the level of adaptation to climate variability. The study was conducted in Tharaka and Kitui-Central Sub-Counties in Tharaka-Nithi and Kitui counties, respectively and used both primary and secondary data. Data collected included: (i) Indigenous and conventional knowledge of climate forecasting employed by small holder farmers, (ii) Household demographic and socio-economic characteristics, (iii) Farmers' adaptation strategies to cope with climate variability, (iv) Rainfall and temperature data from Kenya Meteorological Department (KMD). Research design involved a triangulation approach to simultaneously collect both quantitative and qualitative data. Primary data was specifically gathered through the use of a survey. Sampling strategy involved random sampling and also a purposive sampling in combination with snow balling technique. Data was analyzed using descriptive statistics, multinomial and binary logistic regression, using variables produced through Principal Component Analysis (PCA). Results showed that there were significant differences in the use of indigenous strategies such as change in the sky (χ^2=14.631), moon (χ^2=7.851) and wind (χ^2=5.864) at $p<0.05$ in the two sub-counties. Majority (87%) of the farmers used change in the colour of trees' leaves as an indigenous strategy in weather forecasting. Results from the analysis of conventional data (rainfall and temperature) were found to conform to the information from small-holder farmers' perception on how climate has varied over the reference period. The study considered five strategies as measures of level of adaptation to climate variability; crop adjustment; crop management; soil fertility management; water harvesting and crop types; boreholes and crop variety factors. Average size of land under maize, farming experience, household size, household members involved in farming, education level, age, main occupation and gender of the household head were found significant ($p<0.05$) in predicting the level of adaptation to climate variability as being either low or medium relative to high. This study concludes that IK of weather forecasting is still in use today hence, effort should be put in place to document the indicators that are used in combination with conventional knowledge for use in future by small scale farmers. Furthermore, effort should be put in place to integrate the IK and the conventional knowledge. In addition, household socio economic factors that explain the level of adaptation should be considered in any efforts that aim to promote adaptation to climate variability in the agricultural sector among the smallholder farmers.

CHAPTER ONE:

INTRODUCTION

1.1 Background Information

Over 80% of the agriculture in Sub-Saharan Africa (SSA) is rain-fed and the bulk is under small-holder farming (Hulme *et al*., 2001; Barron *et al*., 2003). Not only are agricultural systems in the region diverse and vast but are often characterized by unreliable rainfall which is caused by climate variability (Parry *et al*., 2004; Matari *et al*., 2008). This has led to a wide recognition of adaptation as a fundamental and necessary response to the threats posed by climate variability (Adger *et al*., 2003; IPCC, 2007). Adaptation in this context includes all adjustments that reduce the vulnerability of farmers to conditions caused by climate variability (Smith *et al*., 1996; Smit *et al*., 2001; Tanner and Mitchell, 2008; van Aalst *et al*., 2008).

The conditions caused by climate variability have negative effects on agricultural productivity (Manneh *et al*., 2007; Laux *et al*., 2010) by introducing unfavourable growing conditions into the existing cropping calendar (Ziervogel and Calder, 2003; Dovers, 2009). The level of adaptation is influenced by many factors and varies among individuals and within communities, countries and regions (Ericksen *et al*., 2011). According to Ramphelle (2004) and UNEP (2007), such adaptive responses include among others indigenous knowledge (IK) that is passed on among local communities and helps them to predict disasters caused by climate variability and hence devise coping mechanisms to deal with this. The use of such knowledge has, however, not been properly documented in a way that can be of great help to small-holder farmers.

Recurrent and prolonged impacts of climate variability on agricultural production in Kenya are widely perceived to be due to farmers' over-reliance on rain-fed agriculture (Tanner and Mitchell, 2008; Maitima *et al*., 2009). This is because, agricultural production remains the main source of livelihood for most small-holder farmers in Kenya (IPCC, 2007) a scenario typical of the study area. Consequently, adaptation of the agricultural sector to these adverse effects becomes imperative so as to protect the livelihoods of farmers and also ensure food security.

A better understanding of how the small-holder farmers perceive climate variability and the ongoing adaptation measures is crucial in promoting their successful adaptation since they rely mainly on rain-fed agriculture (Smithers and Smit, 2009). This calls for comprehensive information on the impact of climate variability on agricultural systems as well as the effects on land use changes at household level (Manneh *et al*., 2007). This is so that reliable adaptation options can be targeted appropriately. Small-holder have tried to adapt to such conditions caused by climate variability such as drought through the use of indigenous approaches and preparedness techniques in combination with conventional approaches (Liebenstein and Marrewijk, 2000). However, the indicators are not quantified on any scale and are normally subjective, their documentation being quite limited. Also, there is no communication mechanism available for their transmission to the small holder farmers in future.

1.2 Problem Statement

Inhabitants of arid and semi-arid lands (ASALs) have been adjusting their livelihood strategies to large variations in climate (Nhemachena and Hassan, 2007). They have developed various coping strategies that enable them to survive the extreme climatic events (Cooper *et al*., 2008). These include preparedness techniques such as crop diversification and planting of varieties with varying susceptibility to climate variability (Salick and Byg, 2007). They have also generated a vast body of indigenous knowledge (IK) in addition to the conventional knowledge of climate forecasting to help cope with the situation by observing the activities around them. The knowledge is still in use at local level amongst small-holder farmers in the study area but its documentation is quite limited and it is within the preserve of the elderly people. Thus, this invaluable knowledge is not only at risk of being lost but its integration and mainstreaming with the conventional approaches is not clear. In view of this, the study sought to identify the indigenous coping strategies in use, integrate them with the conventional knowledge and determine the influence of socioeconomic characteristics on the level of adaptation to climate variability amongst small-holder farmers in Tharaka-Nithi and Kitui Counties.

1.3 Research questions

The study sought to answer the following questions:

1. What are the indigenous strategies and preparedness techniques employed by small-holder farmers in coping with climate variability in Kitui and Tharaka-Nithi Counties?
2. How can indigenous and conventional knowledge of weather forecasting be integrated in adapting to the impacts of climate variability in Kitui and Tharaka-Nithi Counties?
3. How do household socio-economic factors influence the level of adaptation to climate variability in Kitui and Tharaka-Nithi Counties?

1.4 Objectives

The overall objective was to assess the indigenous knowledge used in weather forecasting and how it can be integrated with conventional approaches of weather forecasting to enhance small-holder farmers' adaptation to climate variability in the study area.

To achieve this objective, the study sought to address the following specific objectives:

1. To identify the indigenous knowledge and preparedness techniques employed by small-holder farmers in coping with climate variability in Tharaka-Nithi and Kitui Counties
2. To integrate indigenous and conventional knowledge of weather forecasting for adaptation to climate variability in Tharaka-Nithi and Kitui Counties
3. To determine the influence of household socio-economic factors on the level of adaptation to climate variability in Tharaka-Nithi and Kitui Counties

1.5 Research Hypothesis

The study was guided by the following hypothesis:

1. There is a significant relationship between households' socio-economic factors and the level of adaptation to climate variability in Tharaka-Nithi and Kitui Counties

1.6 Significance of the study

The information generated from this study will enrich the knowledge of extension service providers as well as the small-holder farmers in regard to adapting to climate variability. This is after gaining a better understanding of how the small-holder farmers in the study area perceive climate variability and the ongoing adaptation measures. Since they rely mainly on rain-fed agriculture, identifying the IK of weather forecasting used and integrating it with conventional knowledge of climate forecasting was very crucial. This is because it is one of the adjustments that reduce the vulnerability of the small-holder farmers to conditions caused by climate variability, since such conditions have negative impacts on agricultural productivity. The knowledge is therefore envisaged to eventually improve the resilience of small holder farmers in the study area from the adverse effects of climate variability and the eventual increase in agricultural production.

1.7 Conceptual framework

Effectiveness of adapting to climate variability for small-holder farmers depends on many factors. Availability and use of indigenous and conventional knowledge of weather forecasting can influence the level of adaptation to climate variability. It also determines the possibility of integrating the two knowledge systems which influence on the adaptation level to climate variability. The level of adaptation to climate variability for small- holder farmers also depends on the socio-economic characteristics of a household. When smallholder farmers are well adapted to the effects of climate variability, they are able to increase their agricultural production and hence the general livelihood (Figure 1.1).

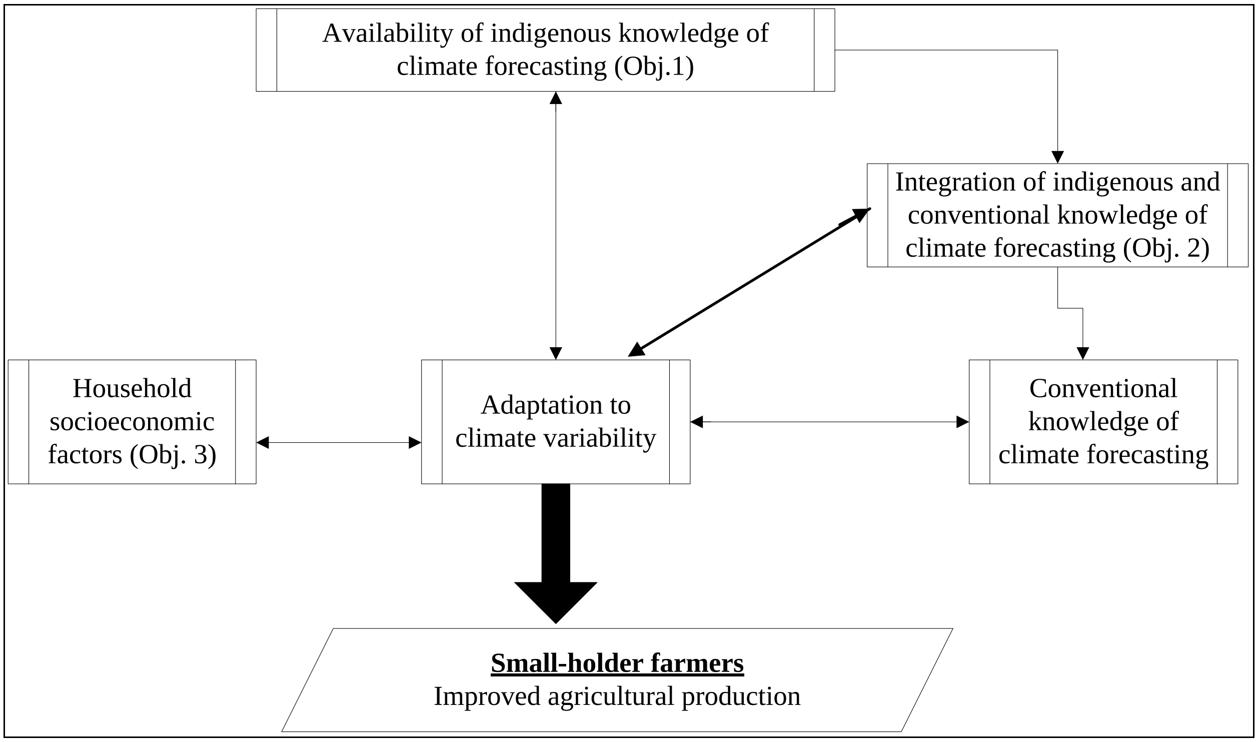


Figure 1.1: Conceptual framework showing the relationship among the objectives

1.8 Definition of terms

Adaptation: Adjustments in ecological, social and economic systems in response to the effects or impacts of climatic variability.

Climate variability: Fluctuations in climatic elements such as rainfall, temperature, wind flow patterns, ocean currents and air pressure on time scales of months, years, decades and centuries. It includes conditions such as droughts and floods.

Drought: A prolonged period of abnormally low or scanty rainfall, especially one that adversely affects growing or living conditions.

Household: Those members living under the same roof and whose labour, income and expenditures were considered as part of the household's economic conditions

Indigenous Knowledge: Wisdom, knowledge and practices of a group of local people living in close contact with nature, gained over time through experience and orally passed on from generation to generation. It covers all forms of knowledge (technologies, knowhow, skills, practices and beliefs) that enable the group of people to achieve stable livelihoods in their environment.

Principal Component Analysis: It is a multivariate method used for data reduction purposes. The basic idea is to present a set of variables by a smaller number of variables called principal components. These are chosen in such a way that they are uncorrelated and are therefore measuring different unrelated aspects or dimensions of the data.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

Africa is highly vulnerable to the negative impacts of climate variability and in particular, this has a negative impact on agricultural production in East African region because most of its agriculture is mainly rain-fed (Fugile, 2007; Thorton *et al*., 2009). Kenya has experienced the adverse effects of climate variability which has been found to include drastic changes in rainfall patterns leading to low agricultural productivity (Manneh *et al*., 2007). These drastic changes in rainfall patterns introduce unfavourable growing conditions into the existing cropping calendars thereby modifying growing seasons which subsequently reduce crop productivity (Thorton *et al*., 2009). This is even exacerbated when the situation extends over a prolonged period of time (Parry *et al*., 2004).

Anandaraja *et al*. (2008) noted that any technological management of climate variability requires medium to long-term climate prediction and information to be translated into early warning and response. With the threat of climate variability, the latest knowledge and capacities in climate science needs to be translated into operational products and services for stakeholders' use (Ngugi, 1999). This will enable countries to enhance their capacities in climate-related risk management (Adejuwon, 2002). In this context, integrating indigenous and conventional knowledge of climate forecasting can be seen as a way to improve the adaptation to climate related risks for small-holder. The adoption of various strategies used in adapting to climate variability by small-holder farmers are seen to be rather context specific (Nhemachena and Hassan, 2007).

2.2 Farmers' knowledge on indigenous strategies used in adapting to climate variability

Small holder farmers suffer the adverse effects of climate variability. This has had a negative impact on agricultural production and is attributed to the fact that most of their agriculture is rain-fed. These farmers have characteristically adopted indigenous strategies which have evolved over time in addition to the conventional strategies to help in reducing the overall vulnerability to climate variability shocks. Local perceptions of climate variability are deemed important since they reflect local concerns (Danielsen *et al*., 2005; Chang'a *et al*., 2010) and focus on the actual impacts of climate variability on people's lives (Laidler, 2006; Baumwell, 2008). Alessa *et al*. (2008) stress that local knowledge and perceptions influence people's decisions both in deciding whether to act or not. Small-holder farmers in marginal environments have characteristically adopted livelihood strategies which have evolved over time to help in reducing the overall vulnerability to climate variability shocks (Tschakert, 2007).

As observed by Anandaraja *et al*. (2008), these have included various indigenous ways in which future events can be foretold. For instance, an occurrence of a certain phenomena (biological, climatic or socio-economic) heralds the anticipation of an event (Aoki, 2003). Small-holder farmers are able to understand and incorporate such forecast information into their decision- making process (Luseno *et al*., 2003; Suarez and Patt, 2004; Lybbert *et al*., 2007). For instance, Mhita (2006) noted that presence of higher than normal flowering intensity of some trees in Tanzania during the month of July to November indicates that the upcoming season will have a good amount of well distributed rainfall, while a good fruit harvest from some other trees is a signal of impending climate variability in the upcoming season. Appearance of large swarms of red ants in September to November and occurrence of large swarms of butterflies is an indication of imminent rainfall onset and also indicates that the upcoming rainfall season would be good (Mhita, 2006).

In Kenyan, UNEP (2003) observed that indigenous communities recognize that to be able to cope with the natural disasters, they have to monitor the environmental conditions, including the weather, to be able to make meaningful prediction and take appropriate actions. Mbeere community in Mbeere Sub-County has designed ways of surviving persistent natural disasters through the use of traditional knowledge (Muriuki *et al*., 2009). In spite of all these benefits of IK, GOK (2004) noted that in many Kenyan communities the IK is likely to be lost due to limited documentation and condemnation of its ability in natural hazard management. In connection to this, the research study sought to identify the knowledge of small-holder farmers in the study area on indigenous technologies and preparedness techniques employable in coping with climate variability

2.3 Integration of indigenous with conventional knowledge of climate forecasting in adapting to climate variability

Climate variability has often been dealt with in a reactive manner rather than by applying a pre-emptive management approach that allows the effective use of all available information (Zorita and Tilya, 2002). Policy development related to national and regional management of climate variability is generally unsatisfactory and even lacking in most developing countries. A common understanding of climate variability and its effects is essential for its comprehensive management in an integrated approach (Kihupi *et al*., 2002) addressing the overall development goals and well being of the people living in prone areas, and involving the different sectors and stakeholders affected (Emery, 2000; Agrawal, 2008). Indigenous knowledge belongs to people local in an area and is in most cases absent in conventional knowledge. Such knowledge can be useful in providing information about local conditions and redirect empirical investigations to issues that have been overlooked by conventional knowledge. In addition, incorporating the IK into climate change policies can lead to the development of effective adaptation strategies that are cost effective, participatory and sustainable (Robinson and Herbert, 2001).

Conventional knowledge such as the use of remotely sensed data can be used to give an overview of the progress of a growing season in a region. Hutchinson (1998) argues that although vegetation estimates do not reflect the exact estimation of crop yields since it combines information from agriculture, fallow vegetation and trees into a single observation, it can still be useful to give a reasonably reliable estimate of the quality of the growing season and the ultimate yields expected in a season. This can be achieved by comparing a given season of the current year with known conditions from the previous years (Patt and Gwata, 2002). This kind of information can therefore be used to provide early warnings in an area and enable farmers to develop preparedness techniques since it reflects whether the cropping season will be better, worse or equal to the previous season (O'Brien and Vogel, 2003; Gissila *et al*., 2004; Johnston *et al*., 2004). There is need for calibration and validation of such information by crosschecking and identifying explanations based on scientific research results (Rengalakshmi, 2002). This can be achieved by interpretation based on IK in order to be relevant and sound (Kloprogge and Van, 2006; Rengalakshmi, 2010; Kalanda *et al*., 2011). There is therefore need for a better understanding of the scientific basis of climate variability (Ensor and Berger, 2009).

At the same time, the latest knowledge and adaptive capacities to climate variability in the study area need to be translated into operational products and services and should be widely shared and the capacity to apply such approaches built and developed (Brascoupe and Mann, 2001; West *et al*., 2008). Oluonko-Odingo (2009) noted that recognizing IK belonging to a community confirms to them that their knowledge is valuable and this gives them authority over the process of risk reduction. This in turn provides the enhanced capacity needed to respond to potential threats since local community members are the immediate responders. In this context, the study sought to integrate the indigenous practices with conventional knowledge systems in adapting to climate variability in the study area. This is envisaged to enable small-holder farmers to enhance their capacities in climate-related risk management.

2.4 Influence of household socio-economic factors on the level of adaptation to climate variability

The ability of small-holder farmers' to adapt to the effects of climate variability can be influenced by many factors including socio-economic characteristics of a household (Ericksen *et al*., 2011). For instance, the level of education of the household head influences the probability of adapting to climate variability (Deressa *et al*., 2009). Exposure through education increases farmers' ability to access, process and use information relevant to adaptation to the effects of climate variability (Nkonya *et al*., 1997). It has also been shown that more educated farmers are more exposed to understand new ideas and concepts related to climate variability (Nkonya *et al*., 1997).

Gender, especially of the household head, is also considered to influence the uptake of adaptation strategies (Nhemachena and Hassan, 2007). In respect to gender of the household head, Asfaw and Admassie (2004) argue that male headed households are more likely to access information on the availability of new technologies than female headed households. In addition to this, having a female heading a household may have negative effects on the adoption of coping strategies to climate variability such as soil and water conservation measures. This is due to the fact that women may have limited access to information, land and other resources due to traditional social barriers (Tenge and Hella, 2004). Contrary to these findings, Nhemachena and Hassan (2007) argue that female headed households are more likely to adapt to climate variability by taking up coping strategies because they are responsible for much of the agricultural work thus have greater experience.

Age also appears to be a significant determinant of the level of adaptation to climate variability conditions (Roncoli *et al*., 2001). The influence of age varies with some studies indicating that there is a positive relationship between age and the level of adaptation to the effects of climate variability. According to Ziervogel *et al*. (2008) and Ziervogel & Zermoglio (2009), older farmers are perceived to have more knowledge especially on indigenous methods of climate forecasting and high decision making autonomy thus giving them added advantage when it comes to adaptability. However, a study by Shiferaw and Holden (1998) showed a negative relationship between age and level of adaptation to the effects of climate variability, suggesting that older farmers may be less willing to take the risks associated with new technologies in regard to adaptation. Due to changes in the times, younger farmers also have access to education and exposure thus making them receptive to change (Roncoli *et al*., 2002 and Vogel & O’ Brien, 2006).

Household size is also a determinant of the level of adaptation to climate variability by small holder farmers. Tizale (2007) and Yirga (2007) found that households with large families may be forced to divert part of their labor force to off-farm activities in an effort to earn extra income so as to ease the consumption pressure that is known to be imposed by a large family. On the contrary, large family size is associated with a higher labor endowment which would enable a household to accomplish various agricultural tasks that would serve as coping strategies to climate variability since they have large pool of labor during peak times (Croppenstedt *et al*.,2003; Dolisca *et al*., 2006; Anley, 2007 and Nyangena, 2007). As such, the study endeavored to find out how socio-economic factors influence adaptation capacity to climate variability among small-holder farmers in the study area.

2.5 Summary of reviewed literature and research gaps

Small holder farmers suffer the adverse effects of climate variability. This has had a negative impact on agricultural production mainly because most of their agriculture is rain-fed. The farmers have characteristically adopted indigenous strategies which have evolved over time in addition to the conventional strategies to help in reducing the overall vulnerability to climate variability shocks. Indigenous knowledge is localized and is in most cases absent in conventional knowledge. Such knowledge can be useful in providing information about local conditions and redirect empirical investigations to issues that have been overlooked by conventional knowledge. However, in spite of all these benefits of IK, it is not well documented.

Local people's observations and conventional climate forecast techniques and approaches therefore play a great role in providing preparedness in regard to agricultural activities. A common understanding of climate variability and its effects is however limited. The understanding can be considered essential for its comprehensive management in an integrated approach. Consequently, there is need to translate such knowledge and adaptive capacities to climate variability into operational products and services by integrating the two knowledge systems.

Prediction of the influence of socio-economic factors on the level of adaptation to climate variability by small-holder farmers is seen to be rather context specific. However, information on the strategies used in adapting to climate variability and the factors that influence the level of adaptation by small-holder farmers in the study area is limited.

CHAPTER THREE

METHODOLOGY

3.1 Study area

The study was carried out in Tharaka and Kitui Central Sub-Counties in Tharaka-Nithi and Kitui Counties respectively (Figure 3.1)

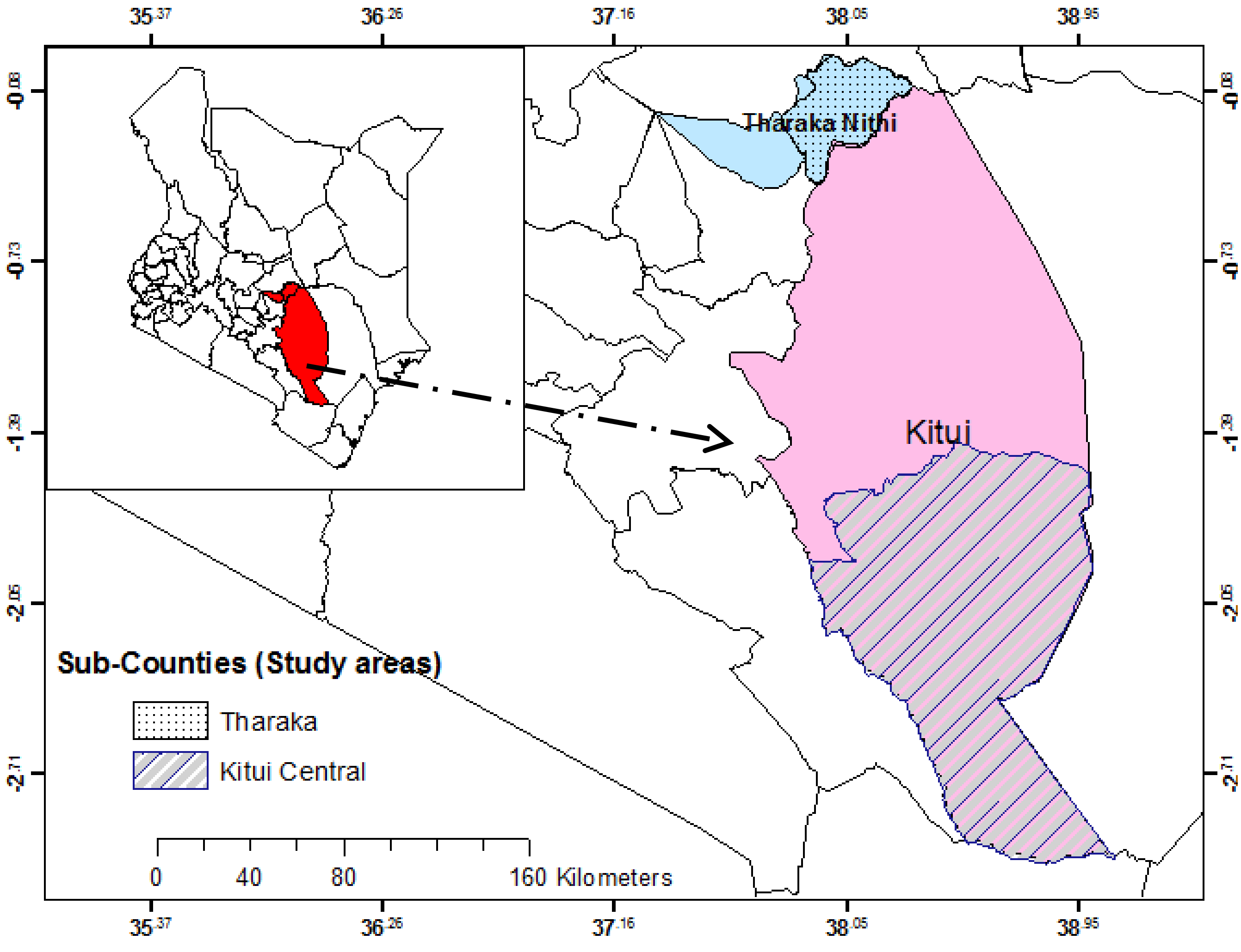


Figure 3.1: A map showing the study area where data was collected

Tharaka Sub-County (Figure 3.1) covers an area of 1,549.5 km^2 (GOK, 2010) and it lies in the Lower Midland 4 and 5 (LM 4 and 5) and Inner Lowland 5 (IL 5) agro-ecological zones (Jaetzold *et al*., 2006; Smucker and Wisner, 2008). The area experiences a bi-modal pattern of rainfall with average annual rainfall of 500 mm per annum. The area lies within an altitude of 350 to 1500 m above sea level and has a mean annual temperature of 11-25.9°C. During the 2009 population and housing census, Tharaka Sub-County had recorded a population of 130,098 people (GOK, 2010) and 27,393 households. The predominant soil type is ferralsols which is highly weathered and leached acid infertile soil (Jaetzold *et al*., 2006). The major crops grown are; millet (*Pennisetum glaucum*), cowpeas (*Vigna unguiculata*), pigeon peas (*Cajanus cajan*), green grams (*Vigna radiata*), sorghum (*Sorghum bicolor*), cotton (*Gossypium hirsutum*), cassava (*Manihot esculenta*), maize (*Zea mays*), beans (*Phaseolus vulgaris*), mangoes (*Mangifera indica*), pawpaw (*Asimina triloba*) and bananas (*Musa spp*.).

Kitui-Central Sub-County (Figure 3.1) covers an area of 7,616 km^2 (GOK, 2010) and lies in the Lower Midland 4 and 5 (LM 4 and 5) and Upper Midland 3 and 4 (UM 3 and 4) and Inner Lowland Ranching Zone (IL 6) agro-ecological zones (Jaetzold *et al*., 2006). The area experiences a bi-modal pattern of rainfall with average annual rainfall of 750 mm per annum. The area lies within an altitude of 400-1,800 m above sea level and experiences high temperatures throughout the year, ranging from 16°c to 34°c. It has a population of 447,613 persons with 38,377 households (GOK, 2010). The predominant soil types are acrisols, luvisols and ferralsols (Jaetzold *et al*., 2006). The soils are well drained, moderately deep to deep, dark reddish brown to dark yellowish brown in colour (Jaetzold *et al*., 2006). The climatic conditions of the Sub-County are suitable for ranching and subsistence farming. There are coffee plantations covering 20 hectares near Kitui town in the UM3-4 agro-ecological zone. According to Jaetzold *et al*. (2006), the main crops grown are cassava (*Manihot esculenta*), pigeon peas (*Cajanus cajan*), cow peas (*Vigna unguiculata*), maize (*Zea mays*), beans (*Phaseolus vulgaris*), green grams (*Vigna radiata*), finger millet (*Eleusine coracana*), cotton (*Gossypium hirsutum*), sunflower (*Helianthus annuus*), coffee (*Coffea Arabica*), mangoes (*Mangifera indica*), pawpaw (*Carica papaya*), avocado (*Persea americana*), oranges (*Citrus sinensis*) and bananas (*Musa spp*.).

3.2 Research design

Triangulation approach (O' Donoghue and Punch, 2003) was adopted in collecting both quantitative and qualitative data and merging the data. The results were used for in-depth investigation into the subject under study. The approach was used so as to serve as a vehicle for cross checking the authenticity and validity of the various generated data sets. This was achieved by using and cross checking information across both primary and secondary data sources. Primary data was obtained through a survey (household survey, key informant interviews and Focus Group Discussions (FGDs)). Secondary data was obtained by reviewing relevant literature. These included among others; journals, text books, annual reports and periodicals.

3.3 Sampling strategy

Several sampling procedures were used to select the required respondents for the household survey, key informant interviews and FGDs. Random sampling was used to select the specific wards where data was collected upon a purposive sampling of the two Sub-Counties (Tharaka- South and Kitui- Central) due to their high agricultural potential and their unique presence of the use of IK in climate forecasting. In Tharaka- Nithi County, Tharaka Sub-County, Tharaka-South constituency, the wards that were randomly sampled were; Kithino, Tunyai, Gakurungu, Nkarini and Chiakariga. In Kitui County, Kitui- Central Sub-County, Central constituency, the wards that were sampled were Township, Changwithia West, Tungutu, Mutuni and Mulundi.

Random sampling of the households (HH) to be interviewed was done. Lists of all household heads were obtained from the Ministry of Agriculture (MoA) offices and random sampling was used to select the required sample size. A sample size of 100 households per Sub-County was arrived at using Equation 1(CRS, 2007).

$$S = \frac{Z^2 * (p) * (1 - p)}{c^2} \qquad \text{Equation 1}$$

Where: S is sample size, Z is Z value (e.g. 1.96 for 95% confidence level), P is percentage of picking a choice, expressed as decimal (0.5), C is confidence interval, expressed as a decimal (0.098= ±9.8%).

In order to select the target population to participate in key informant interviews and focus group discussions (FGDs), a purposive sampling was used to preferentially recruit elderly men and women (60 years and above) who are locally regarded to possess special knowledge on rainfall. This was also due to the well known truism that such people have a wealth of information regarding IK systems. This was used in combination with the snow balling technique (Hay, 2000). A snowball sample was achieved by asking opinion leaders with whom contact was already established to suggest people who could potentially participate in or contribute to the study. This technique was employed because this group of respondents represent a population that is not so common thus not easily accessible through probability sampling strategies. Stratification based on gender was also put into consideration to ensure proportionate representation of both genders. This assisted in eliciting information on climate variability. One FGD was conducted per Sub-County and 33 key informants (15 from Tharaka and 18 from Kitui- Central) were successfully interviewed. For the data from Kenya Meteorological Department, the choice of the rainfall station was informed by agro-ecological zones, percentage of missing data and length of the data available. Rainfall data was obtained from Tunyai and Ithokwe stations while temperature data was obtained from Machakos and Embu stations.

3.4. Pre –testing the research instruments

The research instruments used were first pre-tested then revised according to the suggestions made during pre-testing before the actual data collection exercise. This was achieved by conducting a pilot study to evaluate the competency of the research tools to be used in farmers' interviews. A sample of 10-15 farmers from Tunyai and Mulutu wards of Tharaka and Kitui- Central Sub-Counties, respectively were randomly selected and interviewed. The respondents who participated in the pre-test exercise were excluded in the actual survey.

3.5 Data collection

The actual data collection was preceded by an exploratory study in each of the two Sub-Counties which helped to enhance an understanding of climate variability issues and aid in designing of the data collection instruments. The kind of information collected during the exploratory study included; the IK that is deemed popular in the areas of study, the popular preparedness techniques employed by small-holder farmers and small-holder farmers' perception in regard to climate variability.

To gain a better insight into the subject under study, a survey (household survey, key informants interviews and FGDs) were conducted in an attempt to extract both quantitative and qualitative data in accordance to Newing (2011). Data on climate attributes (rainfall and temperature data from 1980 to 2012) were obtained from Kenya Meteorological Department (KMD). The data was used to produce trends on how rainfall and temperature varied over time in accordance to Patt *et al*. (2007). These were then compared with small-holder farmers' perception on how climate had varied.

The household survey was guided by a structured household survey interview schedule (Appendix 1) administered among 200 households. Key informant interviews were guided by key informant interview schedule (Appendix 2) while FGDs were guided by an FGD check list (Appendix 3). During the key informant interviews, seven key informants (60 years and above) were identified and interviewed on their knowledge of interpretation of the IK of climate forecasting (early warnings). They subsequently assisted in collecting real- time data upon careful monitoring of the events that they observed during the March-April-May season. The data was used in integration with the conventional data over the same period. The FGDs' checklists contained probing open-ended questions so as to get the maximum amount of data and information to help in clarifying the information collected through prior methods (Bryman, 2008). Data collected included indigenous and conventional knowledge of climate forecasting employed by small holder farmers, farmers' preparedness techniques to cope with climate variability and household demographic and socio-economic characteristics.

3.6 Data management and analysis

The first stage of data handling involved checking whether the interview schedules were consistently filled. Thereafter, the questions were numerically coded and responses stored in SPSS software (version 16) (Bryman and Cramer, 1999; Bryman, 2008) under assigned variable names. This was followed by data cleaning. After that, the data from household survey was subjected to descriptive statistics (frequencies, means and percentages) with the aim of displaying the data. In order to express the degree of correspondence between two random variables, chi square was used. Binary logistic regression model and multinomial choice model similar to the one used by Greene (2003) and Hassan & Nhemachena (2008) was fitted to the data from the survey of 200 households. This was done with the aim of determining how socio-economic factors influenced the level of adaptation to climate variability.

This was done upon subjecting the data to data reduction using Principal Component Analysis (PCA). The PCA was used to study the relationship among the various adaptation strategies. This was done by statistically grouping 10 adaptation strategies popularly used by small-holder farmers in the study area into 5 factors that represented the major adaptation strategies, similar to Barbier *et al*. (2009). Varimax rotation with Kaiser Normalization procedure was employed, similar to Mairura *et al*. (2007) and Ngetich (2012). The 5 factors were retained for subsequent analyses.

Data from FGDs and key informants interviews that was obtained by the use of open-ended questions was summarized according to key themes and illustrated by direct quotes, recounting particularly relevant experiences and views of smallholder farmers, essential for authenticity of findings in accordance to Newing (2011). Analysis of the data provided an insight into participants' perspectives on their living situations and climate variability.

Trends of rainfall and temperature data from KMD (1980 to 2012) were processed using MS Excel to show variation over time. Positive and negative anomalies for both rainfall and temperature over the same period were also computed to show long-term trends of annual and seasonal rainfall and temperature using Equation 2 and 3 below (Tilahun, 2006):

For Positive Anomalies

$$RAI = +3\left(\frac{RF - M_{RF}}{M_{H10} - M_{RF}}\right) \quad \text{Equation 2}$$

For Negative Anomalies

$$RAI = -3\left(\frac{RF - M_{RF}}{M_{L10} - M_{RF}}\right) \quad \text{Equation 3}$$

Where: RAI is rainfall anomaly index, RF is actual rainfall for a given year, M_{RF} is mean of the total Length of record, M_{H10} is mean of 10 highest values of rainfall of the period of record, M_{L10} is the lowest 10 values of rainfall of the period of record

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Socio-demographic characteristics of respondents

In Tharaka sub-county, out of the 100 respondents, there were 85% and 15% male and female headed households respectively, while in Kitui-Central, out of the 100 respondents, there were 63% and 37% male and female headed households, respectively (Table 4.1).

Table 4.1: Socio-demographic characteristics of the respondents in Tharaka and Kitui-Central Sub-Counties

Parameters	**Tharaka (n=100)**		**Kitui-Central (n=100)**	
Gender of HH head				
Male	85		63	
Female	15		37	
Marital status of HH head				
Single	3		10	
Married	84		60	
Divorced/separated & widowed	13		30	
Education level				
None	23		20	
Primary	59		55	
Post-Primary	18		25	
Main occupation of HH head				
Full time farmer	89		81	
Part time farmer	11		19	
	Mean	**SD**	**Mean**	**SD**
Age (years)	55.1	15.1	51.5	16.1
HH size (members)	7	3.0	6	2.3
Farming experience (years)	27	14.1	24	14.1
Total land size owned (acres)	10.2	10.1	4.4	3.7
Average area under maize crop (acres)	1.4	2.0	1.5	1.6

The higher percentage of male headed households in Tharaka and Kitui Central Sub-Counties was attributed to the fact that culture in the region dictates that men should be the heads of the household. In addition, men have a better access to land, assets, education and other critical services such as credit, technology and input supply. This therefore qualifies them to be the main decision makers in the household (FAO, 2010). The average age of the HH heads was 55.1 and 51.5 in Tharaka and Kitui-Central Sub-Counties, respectively and a relatively high number of them were fully involved in farming (89% and 81% in Tharaka and Kitui-Central Sub-Counties, respectively). In terms of implementation of adaptation strategies, such a population is likely to be more willing to access information on such strategies and take up even more labour intensive ones as compared to their elderly counterparts (Onu, 2007).

All the household heads were involved in farming for over 20 years (27 and 24 years) of farming experience in Tharaka and Kitui-Central Sub-Counties, respectively. They are therefore expected to have a better adaptation to climate variability owing to the fact that experienced farmers are expected to have more knowledge and information about climate variability (Maddison, 2006). Family size in Tharaka Sub-county was 7 members while in Kitui-Central Sub-county was 6 members (Table 4.1). This implies that family sizes were large and as was noted by Nyangena (2007), large family size is expected to be an enabling factor for farmers to take up labour intensive adaptation strategies. This is however contradicted by Tizale (2007) who noted that large family sizes might be forced to divert part of their labour into other off-farm activities so as to generate extra income.

Majority (84%) of the household heads in Tharaka sub-county was married and the minority (3%) was unmarried. Similarly, in Kitui Central Sub-County, majority was married (60%) while minority was single (10%). Education attainment was high on basis of the number of HH heads who had attained primary education and above (77% and 80% in Tharaka and Kitui-Central Sub-Counties, respectively) compared to those who had no formal education (Table 4.1). This implies that majority of household heads in the study area can be regarded as being educated. Average farm sizes were higher in Tharaka Sub-county, 10.2 acres (4.08 hectares) compared to Kitui-Central Sub-county which was 4.4 acres (1.76 hectares). Despite the significant difference in farm sizes in the two sites, average area under maize cultivation was 1.5 acres (0.6 hectares) in Kitui Central and 1.4 acres (0.56 hectares) in Tharaka (Table 4.1).

4.2: Indigenous strategies and preparedness techniques employed by small-holder farmers in coping with climate variability in Tharaka-Nithi and Kitui Counties

4.2.1: Indigenous strategies employed by small-holder farmers in weather forecasting

Majority of the surveyed farmers were aware of the indigenous knowledge of weather forecasting (91% in Tharaka and 97% in Kitui-Central). They indicated different indigenous strategies of weather forecasting. These included observing changes in trees, sky, moon, wind and behavior of animals (Table 4.2). The use of these strategies varied between Tharaka and Kitui- Central Sub Counties (Table 4.2).

Table 4.2: Indigenous strategies of weather forecasting employed by small-holder farmers in Tharaka and Kitui-Central Sub Counties

Indigenous strategies (Changes in ;)	**Sub-County name**			**χ^2 P-Value**
	Tharaka (n=100)	**Kitui (n=100)**	**Total**	
Tree leaves' colour	83 (83)	91 (91)	174 (87)	NS
Behaviour of animals	79 (79)	74 (74)	153 (77)	NS
Sky colour	64 (64)	87 (87)	151 (76)	0.001
Moon size/ shape	66 (66)	83 (83)	149 (75)	0.005
Wind direction	65 (65)	80 (80)	145 (73)	0.015

Values in parenthesis are in percentages

There was a significant association between the use of change in sky (χ^2=14.631, p<0.001), moon (χ^2=7.851, p=0.005) and wind (χ^2=5.864, p=0.015) and the Sub-Counties (Table 4.2). Checking the changes in sky color was a strategy employed by 87%

of the small-holder farmers in Kitui Sub-County while in Tharaka Sub-County 64% of the farmers used the strategy. On checking change in the moon, 83% of the small-holder farmers interviewed were employing the strategy while Tharaka Sub-County had 66% of the small-holder farmers using the strategy. Change in wind direction was a strategy employed by 80% of the interviewed small- holder farmers from Kitui Sub-County while in Tharaka Sub-County, 65% of the respondents used the strategy. These results confirm findings by Egeru (2012) that the indigenous prediction practices of using moon characteristics, tree phenology and particular animal behaviour patterns are still being utilized.

4.2.2: Preparedness/adaptation strategies used by small-holder farmers to cope with climate variability

The farmers employed different adaptation strategies to counteract the impact of climate variability. These included changing of planting dates, crop varieties, crop spacing and crop types, increasing the use of manure/ fertilizer, water harvesting, digging boreholes/ water pans, agro-forestry, crop rotation and storing food in stores to be used later (Table 4.3). The most commonly used adaptation strategies used by over 80% of the small-holder farmers were storing food in stores to be used later (89%) and changing of planting dates (88%). The least used strategy was digging of boreholes/ water pans (55%) (Table 4.3).

Table 4.3: Adaptation strategies used by small-holder farmers when planning for maize production in Kitui Central and Tharaka Sub-counties

Preparedness Techniques	**Sub-County**		**Total**	**Chi-Square (χ^2) P Value**
	Tharaka	**Kitui-Central**		
Changing of planting dates	92 (92)	83 (83)	175 (88)	NS
Changing of crop varieties	79 (79)	81 (81)	160 (80)	NS
Changing of crop spacing	40 (40)	83 (83)	123 (62)	0.001
Changing of crop types	81 (81)	72 (72)	153 (77)	NS
Increasing the use of manure/ fertilizer	71 (71)	83 (83)	154 (77)	NS
Water harvesting	32 (32)	91 (91)	123 (62)	0.001
Digging boreholes/ water pans	14 (14)	95 (95)	109 (55)	0.001
Agroforestry	48 (48)	75 (75)	123 (62)	0.001
Crop rotation	99 (99)	59 (59)	158 (79)	0.001
Storing food in stores to be used later	87 (87)	90 (90)	177 (89)	NS

Values in parenthesis are in percentages.

There was a significant association between the use of changing of crop spacing as a strategy (p<0.001) and small-holder farmers in the two Sub-Counties with 83% of the interviewed farmers in Kitui-Central Sub-County using the strategy while only 40% of the farmers in Tharaka Sub-County used the strategy (Table 4.3). This implies that farmers in Kitui are more likely to use change of planting spacing more than those in Tharaka. The explanation of this according to the farmers in Kitui Central was that they had received numerous trainings from extension officers in the area on the importance of spacing. In Tharaka, the minimal use of crop spacing as a strategy was attributed by the farmers to lack of knowledge on the importance of spacing such that small-holder farmers in the area do not use a specified spacing but mainly broadcast their seeds.

Use of water harvesting as a strategy was significantly associated with farmers in the two Sub-Counties (p<0.001) with 91% of the interviewed farmers in Kitui-Central Sub-County using it while only 32% of the interviewed farmers in Tharaka Sub-County used the strategy (Table 4.3). Farmers attributed this to the fact that Kitui region lacks piped water and therefore farmers have to look for strategies to ensure water availability at all times. This lack of piped water in Kitui-Central further explains the significant association in the use of digging boreholes/water pans as a strategy in the two Sub-Counties ($p<0.001$) with 95% of the interviewed farmers in Kitui-Central Sub-County using it while only 14% of the farmers in Tharaka Sub-County were using the strategy. According to the interviewed small-holder farmers, this was also contributed by the many projects dealing with boreholes and water pans that have previously been implemented in Kitui Central.

There was a significant association ($p<0.001$) between the use of agro forestry and the Sub-Counties with 75% of the interviewed farmers in Kitui- Central Sub-County using the strategy while only 48% of the farmers in Tharaka Sub-County used the strategy (Table 4.3). This implies that farmers in Kitui Central were more likely to practice agro forestry than those in Tharaka. The explanation for this observation was that small-holder farmers in Kitui valued agro-forestry for multiple benefits and its contribution to soil fertility was said to override the others. They also added that Kenya Forestry Research Institute (KEFRI) had put a lot of effort in promoting agro-forestry in the area. Additionally, this can be supported by Jaetzold *et al*. (2006) in that, since fertilizing alone will only increase yields in the short term, means of obtaining a stable agro-biological system with continuous production, such as agro forestry becomes inevitable.

Crop rotation strategy was also significantly ($p<0.001$) associated with the Sub-Counties with more farmers in Tharaka Sub-County likely to use crop rotation than farmers in Kitui Central (Table 4.3). This greater use of crop rotation as an adaptation strategy in Tharaka was associated with the lower expense associated with the strategy and also by the availability of large pieces of land in the region (Jaetzold *et al*., 2006; Smucker and Wisner, 2008).

Basically, the significant associations between the use of the strategies and the Sub-Counties can be attributed to the difference in agro-ecological zonations (Jaetzold *et al*., 2006). The use of the various adaptation strategies is in line with Recha *et al*. (2011) who reported that small-holder farmers need to adopt different cropping systems and farm management strategies to curb the negative effects of climate variability. Their use can be attributed to the fact that natural hazards associated with climate variability such as droughts and floods greatly impact on small-holder farmers' agricultural productivity (Slegers, 2008). This has therefore necessitated the farmers to devise a variety of adaptation strategies to enable them survive the adverse effects of climate variability (Bradshaw *et al.*, 2004; Maddison, 2006; Nhemachena and Hassan, 2007; Hassan and Nhemachena, 2008; Kurukulasuriya and Mendelsohn, 2008; Deressa *et al*., 2009). Furthermore, such kinds of hazards invariably cause famine, food insecurity and poverty, hence adaptation becomes inevitable.

The use of changing of planting dates by majority (88%) of the farmers was attributed to the unpredictable nature of rainfall thus the need of taking advantage of every drop of rain. Recha *et al*. (2011) noted that change in planting dates is necessitated by variations in rainfall patterns so as to take advantage of every available drop of rain, failure to which a significant amount of rainfall would end up being missed and consequently affect the crop performance. Farmers attributed the use of storing food in stores by majority of them to the fact that droughts were rampant in the regions thus necessitating prior planning in order to ensure availability of food for an extended period of time. The fact that digging of boreholes/ water pans was the least practiced strategy at household level was attributed by farmers in the study area to the need for more capital that is associated with establishment of the strategy. In addition, water from these boreholes/ water pans was said to be inefficient for irrigation due to its salty nature.

4.3: Integration of Indigenous and Conventional Knowledge of weather forecasting for adaptation to climate variability in Tharaka-Nithi and Kitui Counties

4.3.1: Indigenous Knowledge indicators used when planning for various activities in maize production

In planning for the various activities in maize production, small-holder farmers in the study area were found to make use of the IK differently. The main activities in which the IK indicators were used in maize production were found to be land preparation and determination of planting time with over 40% of the small-holder farmers using it when planning for the two activities. Only 10% of the farmers used the IK indicators to determine when to carry out weeding, harvesting and storage activities in the maize production process (Table 4.4).

Table 4.4:The IK indicators and their level of use (%) while planning for various field management and activities in maize production in the study area

IK Indicators	**Activities in maize production**				
	Land preparation (%)	**Planting (%)**	**Weeding (%)**	**Harvesting (%)**	**Storage (%)**
Behaviour of plants	73	77	3	7	1
Behaviour of animals	60	69	1	9	1
Behaviour of sky	48	64	6	8	2
Behaviour of moon	46	57	9	7	2
Behaviour of wind	44	57	1	4	1

Farmers in Kitui and Tharaka-Nithi reported that in the past, traditions and beliefs were also said to have played a role in climate forecasting in addition to the use of the IK indicators. This is a case where shrines were used as places of performing rituals. The rituals were mainly performed by specialized people commonly referred to as the rainmakers. Key informants were able to recall how such ceremonies were performed especially after a long period of rainfall failure. For example, John Mugambi (87 years) from Tharaka explained that;

> *"………in case of a long period with no rains, we would get a black goat together with two kids (male and female) and take them to our shrine. We could then sing songs as the rainmaker repeatedly shouted that we wanted rains moving round and round. We could then slaughter the goats, roast the meat as we continued calling to our God and by the time the event was concluded, a lot of rain could be experienced. In 1942, a memorable event occurred in that, after such a ceremony was performed, torrential rains occasioned by heavy hailstones were experienced and ended up killing livestock".*

In another acoount, Makau Mutuku (86 years) from Kitui explained that;

> *"……….in case of a prolonged period with no rains, we would organize a feast to appease our gods and we could go to the shrines and slaughter a goat of one colour (any colour). Only old people were allowed to go to the shrines for the sacrifice but the rest of the people would be invited later to feast on the roasted meat as we danced "kilumi", a popular dance among the Kamba community during those days so as to continue appeasing and provoking our gods. By the time we left the shrine, heavy rains fell. We also had beliefs that entailed a specialized person (a seer) being requested to foretell the quality of a season and the seer could dream and then communicate the results of the dream to the rest of us by advising on the most appropriate crops to grow in that particular season".*

This involvement of the rainmakers was related to Mhita (2006) who noted that elders in the African communities undertook the responsibility of predicting disasters and guiding the people on the actions to take to mitigate disasters. Through the key informants' discussions, it was observed that the ceremonies were no longer applicable in the current days and attributed this to the advanced technology and Christianity which has dominated the local culture. This concurs with Egeru (2012) who noted that diviners among the Teso community have lost their central role in community affairs due to rise in Christianity, modernity and education. The farmers also indicated that failure to perform such ceremonies had played a role in the recent rainfall failures they had been experiencing in the region.

4.3.2 Small-holder farmers' perception of climate variability

Results from household survey on farmers' perceptions of rainfall and temperature variations in the study area showed that all the interviewed farmers noticed variations in rainfall patterns and temperature over the past 30 years (Figure 4.1).

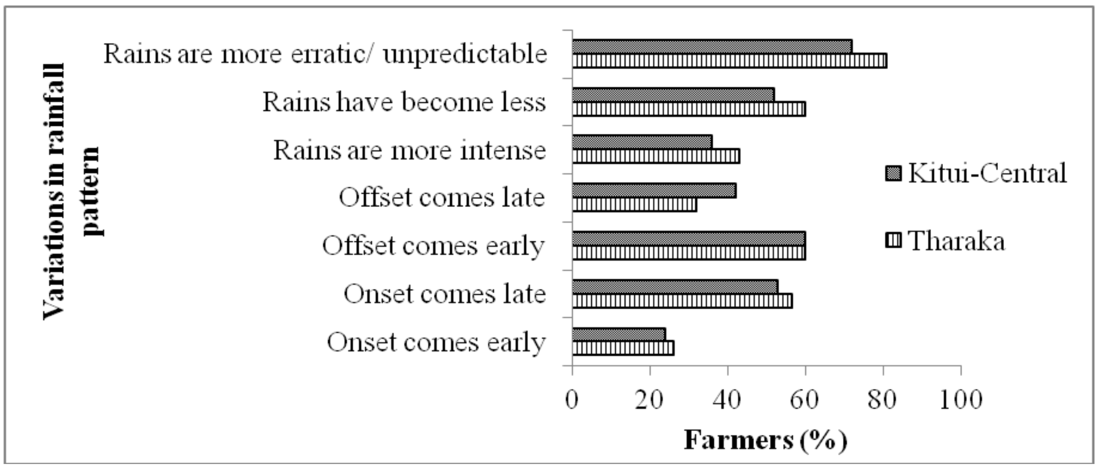


Figure 4.1: Variations in rainfall pattern as perceived by small-holder farmers over the past 30 years

This observation concurs with the findings by Maddison (2007) and Mertz *et al*. (2009) that rainfall and temperature has been fluctuating in the recent past. The farmers were found to perceive the changes differently. The changes identified in rainfall patterns included; early rainfall on-set, late rainfall onset, early rainfall offset, late rainfall offset, more rainfall intensity, rainfall reduction and more erratic/unpredictable rainfall (Figure 4.1), similar to the changes highlighted by Bryan *et al*. (2010).

The perception that rains had become more erratic/ unpredictable was the change perceived by majority of the small-holder farmers (81% and 72% in Tharaka and Kitui-Central Sub- Counties, respectively). This perception concurs with the findings of

CEEPA (2006) that in Africa, rains have become less predictable. The change that was perceived by the least number of farmers (26% and 24% in Tharaka and Kitui-Central, respectively) was that the rains onset came early (Figure 4.1). Their perception of how rainfall and temperature was changing was considered crucial in anticipating the effects of climate variability. This is due to the fact that only farmers who perceive a problem will adapt to it (Nhemachena and Hassan, 2008). Key informants were able to recall variations that they had identified in climatic patterns from 1980s and they were asked if they had experienced any variations in climate over the period. All of the key informants from both sites recognized that climate had varied over time, in line with Maddison (2007) and Mertz *et al*. (2009). The major climatic parameters that were reported to have varied were rainfall and temperature patterns, in line with the findings by CEEPA (2006).

Similar to Gissila *et al.* (2004) and IPCC (2007), rainfall pattern were observed to have varied in such a way that it had become insufficient thus tampering with the cropping pattern. The kind of rains experienced were said to be of torrential nature and then cessation comes at an earlier stage than what was experienced in the past where the rains were quite systematic. Such kind of rains was said not to take maize (the staple crop in the study area) to maturity stage thus resulting to frequent crop failure. This concurs with Recha *et al*. (2011) that rainfall in the region varies a lot leading to frequent crop failure.

Spatial distribution of rainfall was also reported to have changed in such a way that rains were being experienced in one area and failed in a neighbouring locality, similar to Ovuka and Lindqvist (2000). This variability in SR and LR can be associated with El Nino/Southern Oscillation Index (ENSO) and related sea surface temperatures (Odingo *et al*., 2002; Chambers, 2003; Yasunaka and Hanawa, 2005). The variations can also be linked to the recent abrupt decline in the East African rains (Ogallo, 1989; Camberlin *et al.,* 2001; Schreck and Semazzi, 2004; Lyon and Dewitt, 2012). The studies linked the variability of SR to increased tropical Atlantic or Indian Ocean Sea Surface Temperatures (SSTs) while variability in LR was linked to large scale SST changes mainly in the tropical Pacific. Increasing SSTs in tropical Atlantic or Indian Ocean region are said to favour a local enhancement of precipitation with the resultant latent heating altering regional wind and moisture flux patterns, ultimately reducing LR precipitation (Funk *et al*., 2008) leading to the shorter growing period.

The small-holder farmers also identified events when rainfall has been higher than normal since 1980s. Results showed that such events were experienced in the year 1989/1990 and 1997/1998. The event in 1997/1998 was identified as the worst in the living memory and was referred to as EL-Niño, during which buildings and roads were destroyed thus hampering the day to day activities. This abnormally wet period similar to what was noted by Camberlin *et al*. (2001) destroyed crops especially in Tharaka Sub-County. However, in Kitui Central Sub-County, there was a bumper harvest as a result of the excess rainfall though the farmers were concerned that poor post-harvest handling resulted to maize being affected by aflatoxin. Majority of the small-holder farmers (over 80%) perceived temperatures to have increased in the recent years (Figure 4.2) as compared to what was experienced in the past.

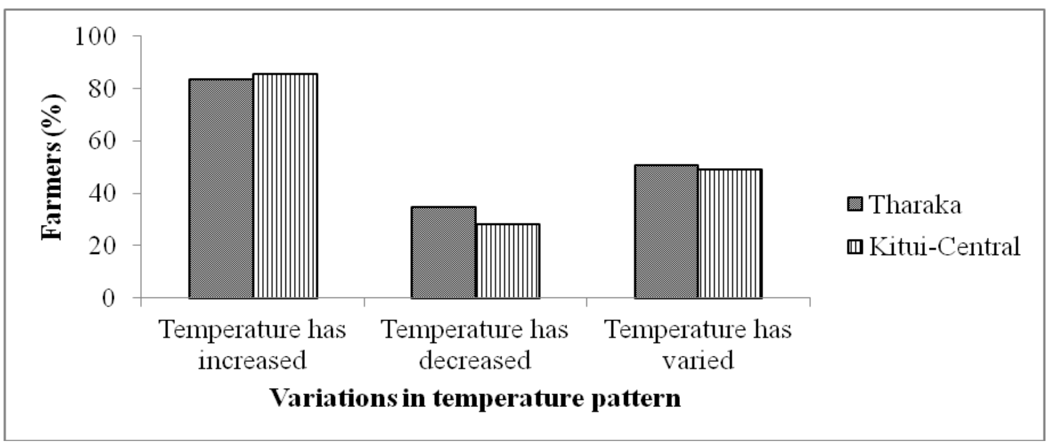


Figure.4.2: Variations in temperature pattern as perceived by small-holder farmers in Tharaka and Kitui-Central

The temperatures were also said to be varying in such a way that they increase and decrease unexpectedly. This increase in temperature can be supported by the fact that temperatures are projected to increase by 2.8^{o}C until 2060 and by 4.5^{o}C until 2090 (IPCC, 2007). Events where temperatures have been found to be higher than normal were identified. These were 2009 in Tharaka Sub-County and 1983/1984, 2005, 2012 in Kitui Central Sub-County. Events of temperatures being higher than normal combined with rainfall failure were said to result to drought conditions. This corroborates with Few *et al*. (2006) who noted that the trends of increasing temperatures coupled with less reliable rainfall increases the likelihood of droughts in Kenya. Respondents were able to recall events when droughts have been experienced and results of the most extreme droughts from 1980 are shown in Table 4.5.

Table 4.5: Droughts experienced since 1980 in Tharaka and Kitui

Sub-County	**Local name of the drought**	**Year when the drought was experienced**	**Description of the drought**
Tharaka	*Ngakua ngwete (will die with money on my hands)*	1983/1984	Rivers dried up. People traded with Kikuyu community to get food because there was nothing to buy in their locality; they had money but there was nothing to buy, thus the drought name.
	Githukio (approximation)	1991	Crops dried up and as livestock also began to die, the only option was to slaughter them. There was no meat inspection or weighing and meat could be sold by approximating the weight by lifting it on the hand, thus the drought name and a large piece could go for as low Ksh. 10. There were cracks on the ground, wide enough to accommodate a five shilling coin
Kitui-Central	*Nikwa ngwete (will die with money on my hands)*	1984	There was crop failure. There was money but no food to buy and this led to people travelling to as far as Rift valley and Central regions to purchase food and livestock fodder.
	Katongelele (yellow maize)	1987	Crops dried up and relief food was supplied in form of the yellow maize, popularly known as "*Katongelele"* thus the drought name

This occurrence of droughts was found to be in line with Anyamba and Tucker (2005). The study identified that in the analysis of Sahelian vegetation dynamics using Normalized Difference Vegetation Index (NDVI), the period between 1982 and 1993 was characterized by below average NDVI and persistent droughts. Also, Bryan *et al*. (2010) noted an increasingly prolonged periods of droughts over the past 20 years in some Kenyan regions.

4.3.3 Evidence of climate variability and trends from conventional knowledge

Based on the findings, the perceptions of small-holder farmers in regard to climate variability using their experiences from rainfall and temperature variability in the study area were traced back to the 1980s. Results from analysis of rainfall and temperature data from KMD traced from the same period supported the small-holder farmers' perceptions on the years of occurrence of abnormal events in regard to rainfall and temperatures. Illustration of the trends of rainfall (Figure 4.3) and temperature data from KMD (1980 to 2012) showed variations over time.

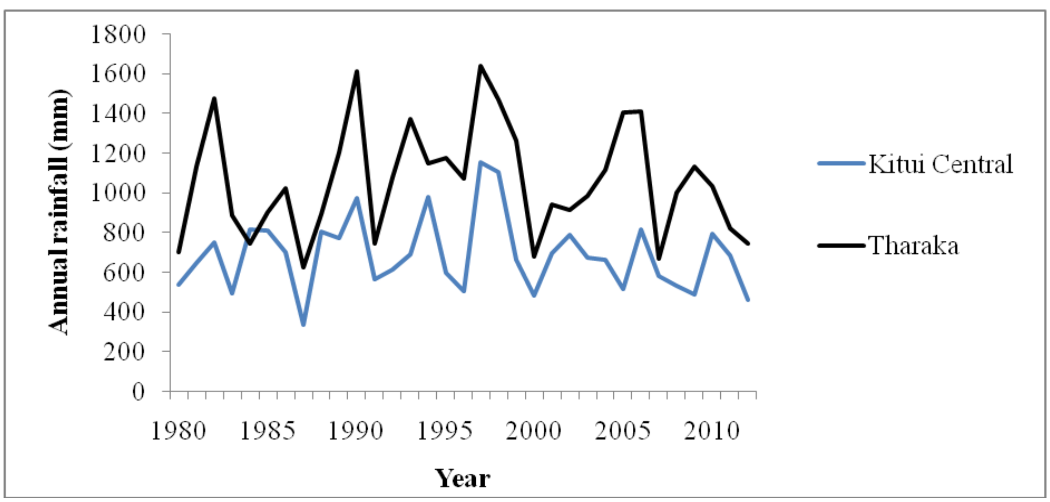


Figure 4.3: Annual rainfall series and linear trends for Tharaka and Kitui Central Sub-Counties from 1980 to 2012

In Figure 4.3, the erratic/unpredictable nature of rainfall is shown by the variations in rainfall patterns and the fact that the rains have reduced in the recent past is evident for the entire study area thus supporting small-holder farmers' perception. The trends were similar to the findings by Hulme *et al* (2005) who noted that inter-annual rainfall variability is large over most of Africa. Also, Christensen *et al*. (2007) and McSweeney *et al*. (2008) projected that there would be an increase in rainfall variability in Kenya.

It was also observed that 1989/1990 and 1997/1998 seasons had higher rainfall thus confirming farmers' observation of such events as El Nino that was said to have been experienced in 1997/1998. This was well reflected by the highly variable temporal rainfall pattern depicted by the rainfall anomalies (Figure 4.4) during the reference period.

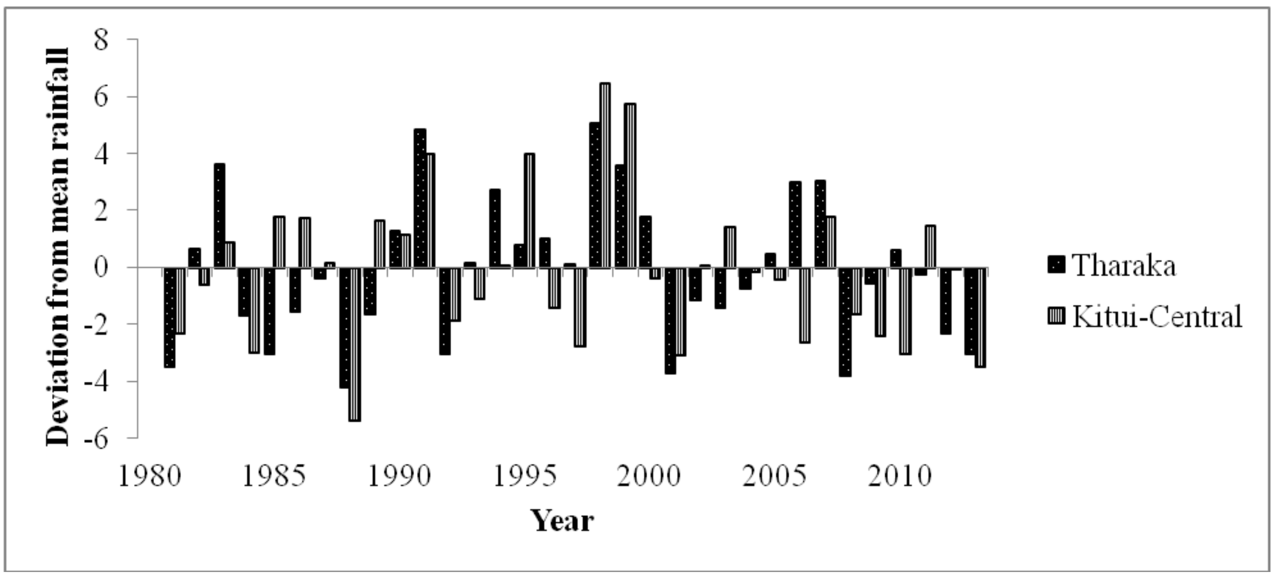


Figure 4.4: Annual Rainfall anomalies for Tharaka and Kitui Central Sub-Counties from 1980 to 2012

The droughts from the small-holder farmers' memory experienced in 1983/1984, 1987 and 1991 were well marked by negative anomalies in Figure 4.4. Similar to the rainfall data, the temperature data was found to support the small-holder farmers' observations. Information from the farmers that temperatures have increased in the recent years as compared to the past is confirmed in Figure 4.5 by a positive or increasing trend during the reference period (1980 to 2012).

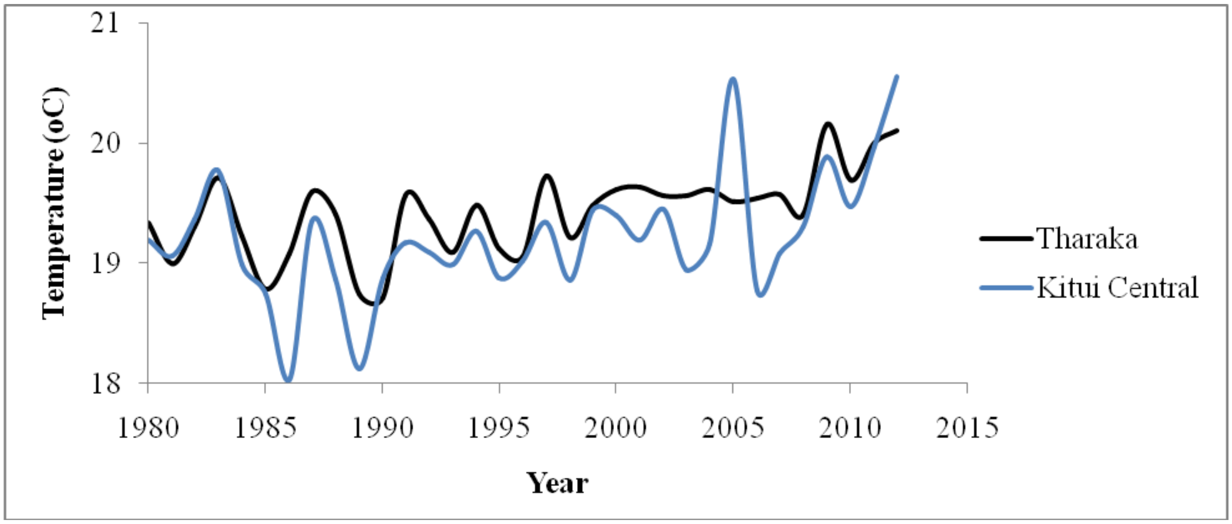


Figure 4.5: Mean annual temperature series and linear trend for Tharaka and Kitui Central Sub-Counties from 1980 to 2012

The variation reported by the farmers was also evident from the trends and the anomalies on temperature which shows events of fluctuations in temperature throughout the reference period (Figures 4.5, 4.6 and 4.7). The fact that temperature has been increasing recently was also clearly reflected by the anomalies. The observed minimum temperatures (Figure 4.6) reflected more positive anomalies in the recent years (from the year 2000).

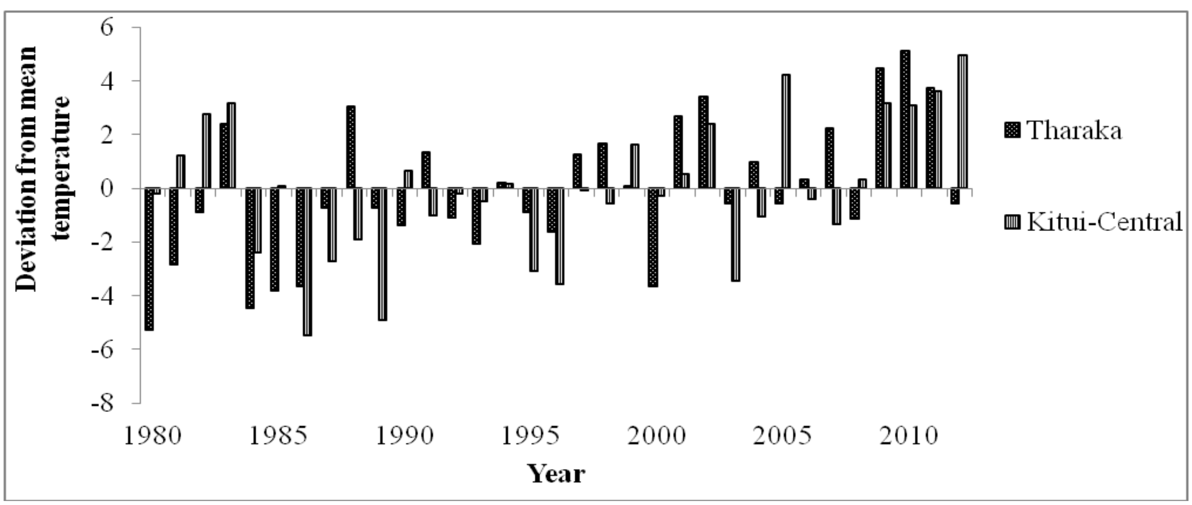


Figure 4.6: Annual mean minimum temperature anomalies for Tharaka and Kitui Central Sub-Counties from 1980 to 2012

Similarly, the observed maximum temperatures (Figure 4.7) reflected more positive anomalies in the recent years (from the year 2000).

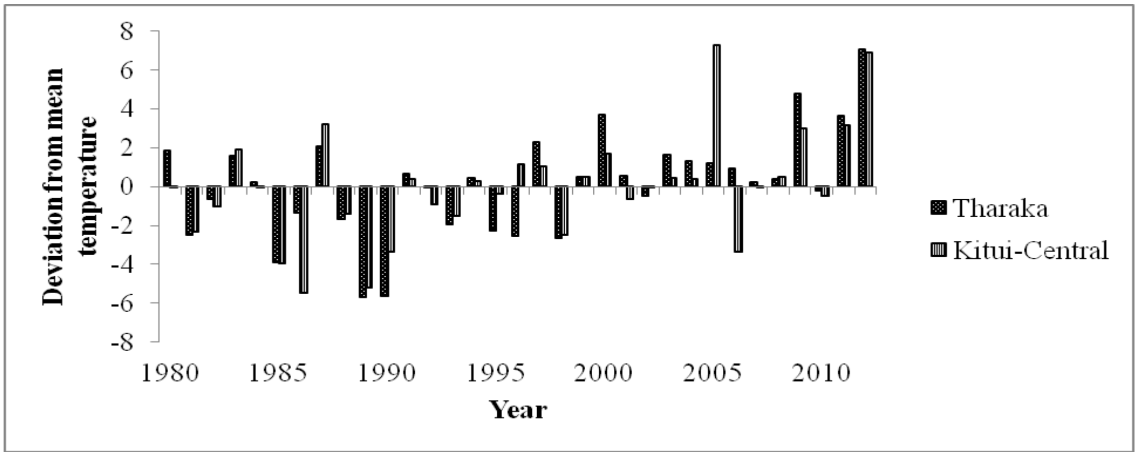


Figure 4.7: Annual mean maximum temperature anomalies for Tharaka and Kitui Central Sub-Counties from 1980 to 2012

4.3.4: Integration of conventional and indigenous knowledge of weather forecasting

An overview of small-holder farmers' experience on the use of the knowledge on local indicators based on a combination of trees, animals, sky, wind and moon was given. On observing change in behaviour of these strategies, the small-holder farmers were able to predict the local weather and then interpret based on the implication of the changes in regard to weather forecasting. These were said to help them prepare accordingly in regard to their agricultural activities. For instance, changes in the phenology of specific trees was used as indicators in prediction of weather. Likewise, changes in the behaviour and movement of animals such as cattle, snakes, bees, specific insects and birds were observed and interpreted accordingly. The behaviour of the sun, wind and appearance of the sky and moon were also used in forecasting.

Based on real time data from the long rains season, it was observed that the IK is still in use today. Small-holder farmers reported that they made several observations that enabled them to prepare accordingly for the season. In Kitui Central, the observations they made included change in the colour of leaves of a tree locally referred to as "*Githumura*" from green to reddish brown and insects commonly referred to as "*Ivandaathano*" were seen jumping up and down for a prolonged period of time. Similarly, birds commonly referred to as "*Thugururu*" were spotted flying in groups towards the same direction. A very strong wind blowing in a circular motion repeatedly was also experienced (Table 4.6).

Table 4.6: Specific indigenous indicators used in weather forecasting in Kitui Central

Indicators (general term)	**Specific indicators**	**Observation**	**Prediction**	**Implications**
Trees	"*Githumura*"	Changes from green to reddish-brown	Wet conditions approaching	Start land preparations in the field
Animals	Insects- "*Ivandaathano*"	Jumping up and down for a prolonged period (a day or two)	Wet conditions Approaching	Land preparations in the field should start
	Birds- "*Ivulu*"	Walking along rivers	Rains will resume after a break	Start weeding the crops
	Birds- "*Thugurururu*"	Flying in groups towards one direction	Rains expected in the next 1 or 2 days	Prepare accordingly
	Cattle	Running all over	More rains expected	Prepare accordingly
	Snakes	Invading their homesteads	Persistence of a dry spell	Danger of an agricultural drought
Sky	Sky	3-5 stars seen appearing on the sky	More rains expected	Prepare accordingly
Wind	Wind	A very strong wind blowing in circles and repeatedly for some days	Rains are just about to begin	Prepare seeds in readiness for planting

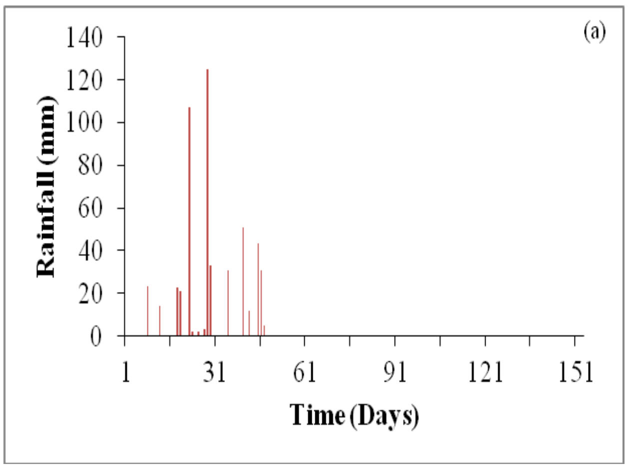
In Tharaka, the observations they made included re-growth of the leaves of fig tree (*mugumo)*, acacia (*mugaa*) and baobab (*muramba*) having been shed previously. At the same time, insects commonly referred to as "*Miunjur*i" were seen jumping up and down for a prolonged period of time. Similarly, glaring sun with much heat was also experienced (Table 4.7).

Table 4.7: Specific indigenous indicators used in weather forecasting in Tharaka

Indicators (general term)	**Specific indicators**	**Observation**	**Prediction**	**Implications**
Trees	-Fig tree (*Mugumo*), Acacia (*Mugaa*) and Baobab (*Muramba*)	Re-growth	Onset of rains	Land preparation in the fields
Animals	Insects (*Miunjuri*)	Jumping up and down but very close to the ground for a prolonged period	Rains will begin	Prepare accordingly and start planting
Sky	Sky	Clear during full moon	Low rainfall to drought conditions	Early planting would be beneficial. Also planting of drought tolerant crops
Moon	Moon	When the moon is slightly tilted to the west and the crescent is facing down during the months of September and October	Imminent rainfall	Intercrop and plant even crops that do well only when there are enough rains.
	Sun	Glaring sun and very hot	Rains will begin	Prepare lands to plant
Sun	Sun	Glaring sun with no much heat	Inadequate rains	Plant drought resistant crops
	Sun	Its movement towards the *Kianjege* mountain observed very early in the morning (5 am). If it passes a point called *kirikuyu* and goes beyond it,	Long dry spell expected	Plant drought resistant crops such as cassava and pigeon peas

All these observations (in Table 4.6 and 4.7 above) were made during the first week of March 2013 and gave a signal that rains were about to start. Consequently, farmers prepared their lands in readiness for planting. These local indicators used to predict the weather in the study area were found to be similar to those highlighted by Chang'a *et al*. (2010) and Kijazi *et al*. (2012) in Tanzania.

Conventional data from KMD showed that the onset of the long rains was 8th and 13th March 2013 in Kitui Central and Tharaka Sub-Counties respectively (Figure 4.8). This therefore concurred with the observations made by the small-holder farmers in the first week of March.



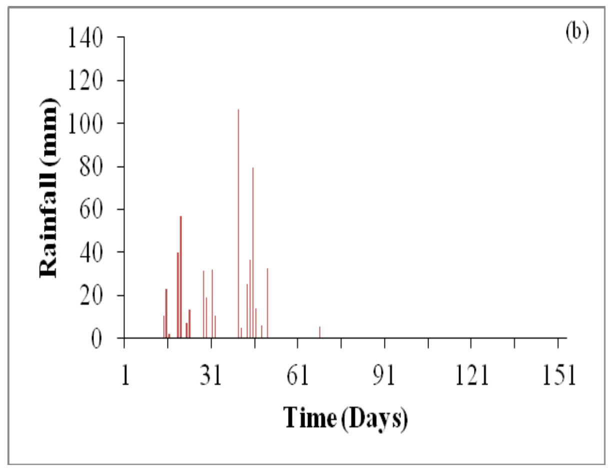


Figure 4.8: Rainfall distribution during the study period for (a) Kitui Central and (b) Tharaka Sub-Counties

Note: Day 1 represents 1st March

Farmers reported that by mid April, fig tree *(mugumo)* began shedding the leaves and they were signaled that cessation of the rains was approaching. Conventional data indicated that cessation of the rains during the long rain season was 16th and 18th in Kitui and Tharaka respectively (Figure 4.8) meaning that the two knowledge systems (conventional and IK) gave similar results. Thereafter, a period of no rains followed in the subsequent months of the season (Figure 4.8). The findings from IK were found to converge with those from conventional knowledge and according to Hansen and Indeje

(2004), they are key in making decisions regarding agricultural production since they dictate the right time to begin land preparation in readiness for planting.

4.4: Influence of household socio-economic factors on the level of adaptation to climate variability in Tharaka-Nithi and Kitui Counties

4.4.1: Farmers' level of adaptation to climate variability

Farmers' level of adaptation was measured by the extent of use of the various adaptation strategies in Tharaka and Kitui Central Sub-Counties. Factor analysis indicated a significance of 0.001 and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of 0.76, a clear indication that the solution was statistically viable. Five factors were identified to represent the 10 adaptation strategies popularly employed by the small-holder farmers to adapt to climate variability. The 5 identified factors had a total explained variance of 64.3% indicating that the percentage of the original data that was explained and had Eigen values that were greater than 1 (Table 4.8).

The factor loadings and communalities for the reduced components are shown in Table 4.8 and the first factor had high positive loadings on the extent of use of crop rotation (0.73) and changing of planting dates (0.70). As a result, the factor was identified as the *crop adjustment factor*. The second factor had high positive loadings on the extent of use of changing crop spacing (0.77) and storing food in stores to be used later (0.71). Consequently, the factor was identified as the *crop management factor* because it was composed of strategies that ensured good management of the crop both in the field and during the post-harvest phase. The third factor had high positive loadings on the extent of use of agro forestry (0.79) and increasing the use of manure/fertilizer (0.64) and was consequently identified as the *soil fertility management factor*. This was because the factor comprised of strategies that minimized soil degradation and enhanced use of manure and fertilizers.

Table 4.8: Extent of utilization of climate variability adaptation strategies (indicating level of adaptation) by small-holder farmers on maize crop in the study area

	Component (Factor)					Communalities (%)
Parameters	1	2	3	4	5	
Extent of use of crop rotation	0.73					60
Extent of use of changing planting dates	0.70					54
Extent of use of changing crop spacing		0.77				63
Extent of use of storing food in stores to be used later		0.71				55
Extent of use of agro forestry			0.79			74
Extent of use of increasing the use of manure/fertilizer			0.64			65
Extent of use of water harvesting				0.81		74
Extent of use of changing crop types				-0.60		72
Extent of use of digging boreholes/water pans					0.80	74
Extent of use of changing crop varieties					-0.64	53
Eigen Values	**1.5**	**1.3**	**1.3**	**1.2**	**1.1**	
%Explained variance	**15.3**	**13.3**	**13.2**	**11.7**	**10.8**	
% Cumulative variance	**15.3**	**28.6**	**41.8**	**53.5**	**64.3**	

Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization; Kaiser-Meyer-Olkin Measure of Sampling Adequacy (0.76, Chi-square=107.5, Sig=0.001); Cut point for loadings and communalities=0.5

The fourth factor comprised of the extent of use of water harvesting and changing crop types and had high positive loadings on the extent of use of water harvesting (0.81) and a high negative loading on the extent of use of changing crop types (-0.60). The factor was identified as *water harvesting and crop types factor* because the use of the two strategies had a negative correlation in such a way that small-holder farmers who do water harvesting do not change crop types and do not make use of most of the other popular strategies. The fifth factor comprised of extent of use of digging boreholes/ water pans and changing crop varieties and had high positive loadings on the extent of use of digging boreholes/ water pans (0.74) and a high negative loading on the extent of use of changing crop varieties (-0.64). It was therefore identified as *boreholes and crop variety factor* because the use of the two strategies had a negative correlation in such a way that small-holder farmers who dig boreholes/ water pans do not change crop varieties and they do not make use of most of the other popular strategies. The strategies in factor 4 and 5 (with negative correlations) can be collectively referred to as *tactical management strategies* because decisions for their use calls for a foresight and were made based on the expected or forecasted weather conditions.

The 5 extracted factors explained percentages of variance in the popularly used adaptation strategies by small-holder farmers in the study area. These were, 60% in the extent of use of crop rotation, 54% in changing planting dates, 63% in changing crop spacing, 55% in storing food in stores to be used later, 73% in agro forestry, 64% in increasing the use of manure/fertilizer, 73% in water harvesting, 72% in changing crop types, 73% in digging boreholes/water pans and 53% in changing crop varieties as indicated by their communalities (Table 4.8).

This section also presents descriptive statistics, the estimated *p*-levels of the predictor variables from the Multinomial Logit Regression (MNLR) and Binary Logistic Regression model at statistical significance of 5% probability level. The estimation of the MNLR model for this study was undertaken by normalizing one category (the reference/base category) as being the third category (high adaptation to climate variability) and therefore all results were explained in reference to this category. This was in respect to the level of use of crop adjustment factor, crop management factor, soil fertility management factor and water harvesting & crop types factor.

4.4.2 The extent of use of crop adjustment factor

Both descriptive statistics and the MNLR revealed that two socio-economic factors (education level of the household head and average area of land under maize) were significantly associated with the extent of use of *crop adjustment* factor (extent of use of crop rotation and extent of use of changing planting dates) (Table 4.9). However, gender, marital status, main occupation, age of the household head, household size, household members involved in farming, farming experience and total land size owned had no significant association with the extent of use of the strategies contained in the crop adjustment factor (Table 4.9).

Table 4.9: Socio-economic factors influencing the extent of use of crop adjustment factor in Tharaka and Kitui Central Sub- Counties

Independent variables		Adaptation level			χ^2 P value
		Low	**Medium**	**High**	
HH Gender					
	Male	14 (10)	69 (47)	65 (44)	NS
	Female	5 (10)	26 (50)	21 (40)	
HH Marital Status					
	Single	2 (15)	6 (46)	5 (39)	NS
	Married	14 (10)	67 (47)	63 (44)	
	Divorced/Separated & Widowed	3 (7)	22 (51)	18 (42)	
HH Education Level					
	None	1 (2)	22 (51)	20 (47)	0.012
	Primary	15 (13)	52 (46)	47 (41)	
	Post-Primary	3 (7)	21 (49)	19 (44)	
HH Main Occupation					
	Full-time farmer	14 (8)	84 (49)	72 (42)	NS
	Part-time farmer	5 (17)	11 (37)	14 (47)	
		Mean	**Mean**	**Mean**	**t-test**
Age		48.89	52.89	54.78	NS
HH size		5.79	6.35	7.01	NS
HH members in farming		3.42	3.66	3.47	NS
Farming experience		22.95	25.57	25.73	NS
Total land size owned		3.3	7.2	8.3	NS
Average land under maize		1.4	1.5	1.6	0.036

N=200, ∗association significant at α = 0.05

Values in parenthesis are in percentage

Multinomial Logistic Regression model revealed that education level of the household head was found to be a significant positive predictor (β=0.560, *p*=0.029) of whether the adaptation level of the farmer is low as related to high adaptation level (Table 4.10).

Table 4.10: Socio-economic factors influencing the extent of use of crop adjustment factor in Tharaka and Kitui-Central Sub-Counties

	Low adaptation level					**Medium adaptation level**				
Independent variables	**B**	**S.E.**	**Wald**	**Sig.**	**Exp(β)**	**B**	**S.E.**	**Wald**	**Sig.**	**Exp(β)**
Intercept	3.013	2.656	1.287	0.257	_	1.396	1.482	0.886	0.346	_
Gender of HH head	-0.577	0.687	0.705	0.401	0.562	-0.053	0.449	0.014	0.906	0.949
Marital status of HH head	-0.470	0.562	0.699	0.403	0.625	0.038	0.381	0.010	0.920	1.039
Education level	0.560^*	0.530	1.117	0.029	0.571	-0.162^*	0.259	0.147	0.050	1.105
Main occupation	0.742	0.727	1.044	0.307	2.101	-0.522	0.480	1.184	0.277	0.593
Age	-0.028	0.028	0.976	0.323	0.972	-0.017	0.015	1.164	0.281	0.984
HH size	-0.137	0.137	1.006	0.316	0.872	0.099	0.074	4.789	0.701	0.850
HH members in farming	0.141	0.174	0.651	0.420	1.151	0.192	0.098	3.834	0.150	1.211
Farming experience	0.023	0.033	0.491	0.484	1.023	0.018	0.016	1.250	0.264	1.019
Total land size owned	-0.632	0.232	7.403	0.237	0.532	-0.010	0.023	0.207	0.649	0.990
Average land under maize	0.057^*	0.391	7.310	0.007	2.877	-0.015	0.104	0.021	0.885	0.985

Reference category is High adaptation level

This implies that less educated farmers are more likely to have low adaptation relative to high adaptation to climate variability in regard to the extent of use of crop adjustment factor. This agrees with Deressa *et al*. (2009) who found that education level of the household influenced the probability of adapting to climate variability, in that the lower the educational attainment, the low the level of adaptation to climate variability.

Average size of land under maize was a significant positive predictor (β=0.057, p=0.007) of whether the adaptation level of the farmer was low as related to being high level of adaptation (Table 4.10). This implies that having low level of adaptation relative to high adaptation level is associated with large farm sizes of land under maize crop which is the main crop in the study area. Farmers attributed this to the fact that large area of land under maize can become overwhelming in terms of the extent of use of the adaptation strategies in the crop adjustment factor.

Education level of the household head had a strong negative influence (β=-0.162, *p*=0.050) on the probability of having a medium relative to high adaptation to climate variability (Table 4.10). This implies that medium level of adaptation relative to high level of adaptation is associated with low level of education and agrees with Nkonya *et al*. (1997) in that less educated farmers are less exposed to understanding new ideas and concepts related to climate variability, which in this context refers to new ideas related to the adaptation strategies in the crop adjustment factor.

4.4.3 The extent of use of crop management factor

Univariate results revealed that the socio-economic factors that had a significant association with the extent of use of strategies that entailed management of the crop while in the field and out of the field (extent of use of changing crop spacing and extent of use of storing food in stores to be used later); *crop management* factor were household size, gender of the household head and average area of land that is normally put under maize crop (Table 4.11). Marital status, education level, main occupation, age of the household head, members involved in farming, farming experience and total land size owned had no significant association with the extent of use of strategies in the crop management factor (Table 4.11).

Table 4.11: Socio-economic factors influencing the extent of use of crop management factor (Univariate analysis)

Independent variables		Adaptation level		χ^2 P value
	Low	Medium	High	
HH Gender				
Male	23 (16)	76 (51)	49 (33)	0.016
Female	5 (10)	24 (46)	23 (44)	
HH Marital Status				
Single	2 (15)	6 (46)	5 (39)	NS
Married	23 (16)	74 (51)	47 (33)	
Divorced/Separated & Widowed	3 (7)	20 (47)	20 (47)	
HH Education Level				
None	8 (19)	23 (54)	12 (28)	NS
Primary	16 (14)	54 (47)	44 (39)	
Post-Primary	4 (9)	23 (54)	16 (37)	
HH Main Occupation				
Full-time farmer	24 (14)	88 (52)	58 (34)	NS
Part-time farmer	4 (13)	12 (40)	14 (47)	
	Mean	**Mean**	**Mean**	**t-test**
Age	54.71	53.45	52.61	NS
HH size	7.50	6.23	6.71	0.003
HH members in farming	3.93	3.34	3.71	NS
Farming experience	27.11	24.57	25.86	NS
Total land size owned	9.4	7.9	5.7	NS
Average land under maize	2.0	1.6	1.1	0.021

N=200, ∗association significant at $\alpha = 0.05$

Values in parenthesis are in percentage

The MNLR model revealed that three predictor variables: gender of the household head, household size and average size of land under maize were found to be significant in explaining whether the farmer's adaptation level was low relative to high level of adaptation in regard to the use of adaptation strategies in the crop management factor. Gender of the household head was found to be a significant negative predictor (β=-0.571, p=0.038) of whether the adaptation level of the farmer is low relative to being highly adapted (Table 4.12) in regard to the use of crop management factor.

Table 4.12: Socio-economic factors influencing the extent of use of crop management factor

	Low adaptation level					Medium adaptation level				
Independent variables	**β**	**S.E.**	**Wald**	**Sig.**	**Exp(β)**	**β**	**S.E.**	**Wald**	**Sig.**	**Exp(β)**
Intercept	2.975	2.278	1.705	0.192	_	2.561	1.529	2.807	0.094	_
HHH gender	-0.571*	0.661	0.746	0.038	0.565	-0.359	0.456	0.620	0.431	0.699
HHH marital status	-0.734	0.552	1.769	0.184	0.480	-0.115	0.389	0.088	0.767	0.891
HHH education level	-0.822	0.434	3.576	0.604	0.440	-0.243	0.277	0.772	0.380	0.784
HHH main occupation	-0.074	0.687	0.012	0.914	0.928	-0.662	0.478	1.915	0.166	0.516
HHH age	0.000	0.025	0.000	0.990	1.000	0.016	0.016	0.916	0.339	1.016
HH size	-0.052*	0.100	0.268	0.005	1.053	-0.080	0.078	1.034	0.309	0.923
HH members in farming	-0.107	0.141	0.584	0.445	0.898	-0.115	0.102	1.272	0.259	0.891
Farming experience	-0.013	0.026	0.235	0.628	0.987	-0.024	0.018	1.838	0.175	0.976
Total land size owned	0.021	0.036	0.339	0.560	1.021	0.031	0.028	1.237	0.266	1.031
Average land under maize	0.222	0.179	1.538	0.245	1.249	0.170*	0.147	1.351	0.021	1.186

Reference category is High adaptation level

This implies that the male headed households from the study area were more likely to have low level of adaptation in relation to being highly adapted in regard to the use of the strategies in the crop management factor. This is similar to Nhemachena and Hassan (2007) who argued that male-headed households were less likely to take up climate variability adaptation methods and attributed this to the fact that men are not responsible for much of the agricultural work in line with the adaptation strategies in the crop management factor therefore have less experience in regard to the use of the strategies in adaptation to climate variability.

Household size was a significant negative predictor (β=-0.052, p=0.005) of whether the adaptation level of the farmer is low relative to high level of adaptation to climate variability (Table 4.12) in regard to the use of strategies in the crop management factor. This implies that smaller household sizes are related to low use of the crop management factor as related to the high use of the factor in adaptation. Small- holder farmers attributed this to the fact that smaller household sizes do not require a lot of food thus such households do not lay emphasis on storage of food. This was in regard to storing food to be used during the lean periods as a strategy in the crop management factor.

Average land under maize was found to be a significant positive predictor (β=0.170, p=0.021) of whether the adaptation level of the farmer was medium in relation to high adaptation level (Table 4.12). This implies that farmers who have smaller sizes of land being put under maize crop are more likely to have medium relative to high level of adaptation to climate variability in regard to the extent of use of the adaptation strategies in the crop management factor, thus agreeing with Deressa *et al*. (2009).

4.4.4: The extent of use of soil and water conservation factor

Results from the univariate analysis indicated that gender, education level and main occupation of the household head were the factors that had a significant association with the extent of use of soil and water conservation factor (agro-forestry and use of manure/ fertilizer) adaptation strategies (Table 4.13). Total land size owned, average size of land normally put under maize, household size, household members involved in farming, farming experience, marital status and age of the household head did not have a significant association with the extent of use of soil and water conservation factor (Table 4.13).

Table 4.13: Socio-economic factors influencing the extent of use of soil and water conservation factor

Independent variables		Adaptation level		χ^2 P value
	Low	Medium	High	
HH Gender				
Male	42 (28)	74 (50)	32 (22)	0.029
Female	21 (40)	22 (42)	9 (17)	
HH Marital Status				
Single	3 (23)	6 (46)	4 (31)	NS
Married	41 (29)	73 (51)	30 (21)	
Divorced/Separated & Widowed	19 (44)	17 (40)	7 (16)	
HH Education Level				
None	18 (42)	20 (47)	5 (12)	0.044
Primary	38 (33)	53 (47)	23 (20)	
Post-Primary	7 (16)	23 (54)	13 (30)	
HH Main Occupation				
Full-time farmer	53 (31)	84 (49)	33 (19)	0.038
Part-time farmer	10 (33)	12 (40)	8 (27)	
	Mean	**Mean**	**Mean**	**t-test**
Age	54.51	54.22	49.41	NS
HH size	7.0	6.59	5.9	NS
HH members in farming	3.92	3.37	3.41	NS
Farming experience	29.05	24.90	20.94	NS
Total land size owned	7.5	8.4	4.5	NS
Average land under maize	1.3	1.7	1.3	NS

N=200, ∗association significant at $\alpha = 0.05$

Values in parenthesis are in percentage

The MNLR model showed that two predictor variables: gender and main occupation of the household head, were significant in explaining whether the farmer's adaptation level was low relative to high in regard to the use of adaptation strategies in the soil and water conservation factor. The rest of the variables were not significant in determining if the level of adaptation to climate variability is low in relation to high in regard to the use of the adaptation strategies in the soil and water conservation factor (Table 4.14)

Table 4.14: Socio-economic factors influencing the extent of use of soil and water conservation factor

Low adaptation level						Medium adaptation level				
Independent variables	**B**	**S.E.**	**Wald**	**Sig.**	**Exp(β)**	**β**	**S.E.**	**Wald**	**Sig.**	**Exp(β)**
Intercept	-0.735	2.005	0.135	0.714	_	-0.394	1.801	0.048	0.827	_
HHH gender	-0.616*	0.593	1.079	0.035	1.851	0.414	0.526	0.620	0.431	1.513
HHH marital status	0.248	0.496	0.249	0.618	1.281	0.062	0.435	0.020	0.887	1.064
HHH education level	-0.140	0.372	2.312	0.226	0.568	0.060*	0.315	0.036	0.024	0.942
HHH main occupation	-0.498*	0.591	0.709	0.040	1.645	-0.354	0.554	0.409	0.523	0.702
HHH age	-0.040	0.023	3.063	0.180	0.961	0.008	0.018	0.199	0.655	1.008
HH size	0.101	0.107	0.887	0.346	1.107	0.090	0.100	0.820	0.365	1.094
HH members in farming	0.025	0.134	0.035	0.852	1.025	-0.167	0.128	1.695	0.193	0.846
Farming experience	0.053	0.025	4.469	0.299	1.054	0.004	0.021	0.036	0.849	1.004
Total land size owned	0.189	0.063	4.949	0.128	1.150	0.138	0.061	5.094	0.624	1.148
Average land under maize	-0.268	0.203	1.743	0.187	0.765	-0.118	0.183	0.420	0.517	0.888

Reference category is High adaptation level

Gender of the household head was found to be a significant negative predictor (β=-0.616, *p*=0.035) of whether the adaptation level of the farmer is low relative to high (Table 4.14) in regard to the use of soil and water conservation factor. This implies that the male headed households from the study area were more likely to have low level of adaptation relative to high level of adaptation in regard to the use of the strategies in the crop management factor than the female headed households. This concurs with Bayard *et al*. (2007) that households headed by female farmers are more likely to take up adaptation strategies in regard to climate variability.

The main occupation of the household head was a significant negative predictor (β=-0.498, *p*=0.040) of whether the adaptation level of the farmer is low relative to high

(Table 4.14) regarding the use of strategies in the soil and water conservation factor. This implies farmers who are not fully into farming were more likely to have a low adaptation to climate variability in relation to high adaptation in regard to the use of the strategies in soil and water conservation factor. This could be attributed to the fact that part time farmers have other things to attend to and might end up over-looking the need to use strategies in the soil and water conservation factor thus end up having a low adaptation relative to high adaptation to climate variability in regard to the use of this factor.

For the medium level of adaptation in relation to high level of adaptation to climate variability in regard to the extent of use of the adaptation strategies in the soil and water conservation factor, education level of the household head was found to be significant in determining the adaptation level. Education level of the household head was found to be a significant positive predictor (β=0.060, p=0.024) of whether the adaptation level of the farmer is medium relative to high (Table 4.13) in regard to the use of soil and water conservation factor. This implies that farmers who have low level of education are more likely to have a medium level of adaptation to climate variability relative to the high level of adaptation, considering the extent of use of soil and water conservation factor. This means that less educated farmers are not adequately exposed to understand new ideas and concepts related to climate variability thus ending up being less adapted to climate variability in relation to more educated farmers who in most cases are more exposed to understand new ideas and concepts related to climate variability thus being highly adapted (Nkonya *et al*., 1997).

4.4.5: The extent of use of water harvesting and crop types factor

The socio-economic factors that had a significant association with the extent of use of water harvesting and extent of use of changing crop types were average size of land under maize, farming experience, age and main occupation of the household head (Table 4.15). The rest of the socio-economic factors studied (total land size owned, household members involved in farming, household size, marital status and education level of the household head) did not have a significant association with the extent of use of water harvesting and changing crop types factor (Table 4.15).

Table 4.15: Social-economic factors influencing the extent of use of water harvesting and change of crop types factor

Independent variables		**Adaptation level**		**χ^2 P value**
	Low	**Medium**	**High**	
HH Gender				
Male	61 (41)	61 (41)	26 (18)	NS
Female	19 (37)	28 (54)	5 (10)	
HH Marital Status				
Single	3 (23.)	8 (62)	2 (15)	NS
Married	59 (41)	61 (42)	24 (17)	
Divorced/Separated & Widowed	18 (42)	20 (47)	5 (12)	
HH Education Level				
None	23 (54)	17 (40)	3 (7)	NS
Primary	42 (37)	52 (46)	20 (18)	
Post-Primary	15 (35)	20 (47)	8 (19)	
HH Main Occupation				
Full-time farmer	70 (41)	74 (44)	26 (15)	0.032
Part-time farmer	10 (33)	15 (50)	5 (17)	
	Mean	**Mean**	**Mean**	**t-test**
Age	55.14	52.5	51.1	0.029
HH size	6.8	6.4	6.87	NS
HH members in farming	3.7	3.4	3.7	NS
Farming experience	26.1	24.74	25.1	0.041
Total land size owned	8.1	6.5	7.6	NS
Average land under maize	1.4	1.3	2.3	0.013

N=200, ∗association significant at $\alpha = 0.05$

Values in parenthesis are in percentage

The MNLR had two predictor variables: main occupation of the household head and farming experience being significant in explaining whether the farmer's adaptation level was low as related to high level of adaptation in regard to the use of adaptation strategies in the water harvesting and crop type factor. The rest of the variables were not significant in determining if the level of adaptation to climate variability is low in relation to high in regard to the use of the adaptation strategies in this factor (Table 4.16).

Table 4.16: Socio-economic factors influencing the extent of use of water harvesting and crop type factor

Low adaptation level						**Medium adaptation level**				
Independent variables	**β**	**S.E.**	**Wald**	**Sig.**	**Exp(β)**	**β**	**S.E.**	**Wald**	**Sig.**	**Exp(β)**
Intercept	-0.068	2.137	0.001	0.974	_	0.098	2.080	0.002	0.963	_
HHH gender	0.368	0.751	0.240	0.624	1.445	1.122	0.701	2.563	0.109	3.070
HHH marital status	0.085	0.654	0.017	0.896	1.089	-0.429	0.602	0.508	0.476	0.651
HHH education level	-0.174	0.359	0.236	0.627	0.840	-0.054	0.356	0.023	0.879	0.947
HHH main occupation	-0.056*	0.645	0.003	0.035	0.965	0.241	0.620	0.152	0.697	1.273
HHH age	0.028	0.024	1.385	0.239	1.029	0.024*	0.024	0.952	0.032	1.024
HH size	-0.012	0.101	0.015	0.901	0.988	-0.027	0.101	0.071	0.790	0.973
HH members in farming	0.027	0.134	0.041	0.839	1.028	-0.025	0.134	0.036	0.849	0.975
Farming experience	-0.033*	0.026	0.978	0.026	0.975	-0.018	0.026	0.459	0.498	0.983
Total land size owned	0.061	0.045	1.792	0.181	1.063	0.048	0.046	1.114	0.291	1.049
Average land under maize	-0.297	0.149	3.960	0.324	0.743	-0.324*	0.163	3.959	0.047	0.723

Reference category is High adaptation level

Main occupation of the household head was found to be negatively significant (β=-0.056, *p*=0.035) in predicting whether the adaptation level of the farmer is low relative to high (Table 4.16) in regard to the use of water harvesting and crop type factor. This implies that households whose heads are partly involved in farming are more likely to have a low adaptation to climate variability in relation to high level of adaptation in regard to the extent of use of water harvesting and crop type factor. This was attributed to the fact that part time farmers are involved in other activities thus may not be in a position to realize every other requirement in the farm in regard to the use of water harvesting and crop type factor.

Farming experience was found to be negatively significant (β=-0.033, p=0.026) in predicting whether the adaptation level of the farmer is low in relation to high (Table 4.16) in regard to the use of water harvesting and crop type factor. The implication of this is that farmers who have not been involved in farming for many years are more likely to have a low adaptation in relation to high adaptation to climate variability regarding the extent of use water harvesting and crop type factor. This is supported by Maddison (2006) in that less experienced farmers are expected to have less knowledge and information about climate variability and the adaptation strategies that they can use in response to this.

In reference to medium level in relation to high level of adaptation to climate variability in regard to the extent of use of the adaptation strategies in the water harvesting and crop type factor, age of the household head and average size of land under maize were found to be significant in determining the adaptation level.

Age of the household head was found to be a significant positive predictor (β=0.024, p=0.032) of whether the adaptation level of the farmer is medium relative to high (Table 4.16) in regard to the use of water harvesting and crop type factor in adaptation. This implies that farmers who are much older are more likely to have a medium level in relation to high level of adaptation to climate variability. This concurs with Shiferaw and Holden (1998) that older farmers may be less willing to take the risks associated with new technologies in regard to adaptation to climate adaptation. In addition, older farmers are said to still hold to traditional practices and therefore have a lesser likelihood of willingness to access information on new adaptation strategies (Onweremadu and Matthews, 2007).

Average land under maize was found to be negatively significant (β=-0.324, p=0.047) in predicting whether the adaptation level of the farmer was medium relative to high adaptation level (Table 4.16) in regard to the use of water harvesting and crop type factor.

This implies that farmers who have smaller sizes of land allocated to maize which is the staple crop in the study area are more likely to have a medium level relative to high level of adaptation to climate variability considering the extent of use of water harvesting and crop type factor. This was attributed to the fact that having a smaller area of land under maize crop is not a satisfactory incentive to using the adaptation strategies in the water harvesting and crop type factor at a higher level as related to having a larger area allocated to the staple crop which would consequently call for higher extent of use of the strategies in the factor.

4.4.6: The extent of use of boreholes and crop variety factor

Results of the Univariate analysis of socio-economic variables showed that three variables were significant in explaining the adaptation level in regard to the use of boreholes and crop variety factor as an adaptation strategy. These variables were the number household members involved in farming, gender and age of the household head (Table 4.17). However, total land size owned, average area under maize, farming experience, household size, education level, main occupation and marital status of the household head did not have a significant association with the extent of use of the strategies (Table 4.17).

Table 4.17: Socio-economic factors influencing the extent of use of boreholes/ water pans and changing crop varieties factor

Independent variables		Adaptation level		χ^2 P value
		Low	High	
HH Gender				
	Male	11 (1)	137(7)	0.004
	Female	3 (0)	49 (6)	
HH Marital Status				
	Single	2 (0)	11(15)	NS
	Married	10 (1)	134 (7)	
	Divorced/Separated/Widowed	2 (0)	41(5)	
HH Education Level				
	None	3 (7)	40 (93)	NS
	Primary	5 (4)	109 (96)	
	Post-Primary	6 (14)	37(86)	
HH Main Occupation				
	Full-time farmer	11 (7)	159 (94)	NS
	Part-time farmer	3 (10)	27 (90)	
		Mean	**Mean**	**T-test**
Age		33.0	53.43	0.013
HH size		6	6.58	NS
HH members in farming		2	3.56	0.013
Farming experience		13	15	NS
Total land size owned		5	7.3	NS
Average land under maize		0.85	1.49	NS

N=200, ∗association significant at $\alpha = 0.05$

Values in parenthesis are in percentage

Binary Logistic Regression model was significant at $p<0.05$ and correctly predicted 93% of the small holder farmers with high and low levels of adaptation to climate variability in regard to the use of boreholes and crop variety factor (Table 4.18). Three variables (gender, age of the household head and number of household members involved in farming) were found to be significant in explaining the adaptation level in regard to the use of boreholes/ water pans and crop variety factor.

Table 4.18: Socio-economic factors influencing the extent of use of boreholes and crop variety factor

Independent variables	**β**	**S.E.**	**Wald**	**Sig.**	**Exp(β)**
HHH gender	0.098*	0.760	0.001	0.019	0.981
HHH marital status	-0.285	0.606	0.222	0.638	0.752
HHH education level	0.224	0.446	0.251	0.116	1.251
HHH main occupation	0.118	0.747	0.025	0.874	1.126
HHH age	0.026*	0.033	0.651	0.050	0.974
HH size	0.165	0.122	1.825	0.177	1.180
HH members in farming	0.069*	0.171	0.064	0.014	0.933
Farming experience	-0.011	0.036	0.091	0.762	0.989
Total land size owned	-0.044	0.065	0.464	0.496	0.957
Average land under maize	0.106	0.188	0.320	0.572	1.112

N=200, *Significant at 5% probability level

Age of the household head was found to be significant (β=0.026, p=0.050) in influencing the level of adaptation to climate variability in regard to the use of boreholes/water pans and crop varieties factor. This implies that households headed by more elderly people were more likely to have a high level of adaptation to climate variability in regard to the extent of use of boreholes/ water pans and changing crop varieties factor. This is supported by Ziervogel *et al*. (2008) and Ziervogel & Zermoglio (2009), who noted that older farmers were perceived to have more knowledge especially on indigenous methods of climate forecasting and high decision making autonomy thus giving them added advantage when it comes to adaptability

Gender of the household head was found to be significant (β=0.098, p=0.019) in influencing the level of adaptation to climate variability in regard to the use of boreholes/ water pans and crop varieties factor. This implies that male headed households were more likely to have a high level of adaptation to climate variability in regard to the extent of use of boreholes/ water pans and changing crop varieties factor. The results concur with Asfaw and Admassie (2004) who noted that male headed households were more likely to access information on the availability of new technologies than female headed households. This is due to the fact that women may have limited access to information, land and other resources due to traditional social barriers (Tenge and Hella, 2004).

The number of household members involved in farming was found to be a significant positive predictor (β=0.069, p=0.014) of adaptation level of the small-holder farmers to climate variability in regard to the use of boreholes/water pans and changing crop varieties factor (Table 4.18). This implies that households with a large number of members involved in farming are more likely to have a high level of adaptation to climate variability in regard to the extent of use of boreholes/ water pans and changing crop varieties factor. This was explained in regard to labour availability in that households with more members being involved in farming activities are associated with a higher labour endowment, which would help a household in accomplishing various tasks associated with the strategies in the boreholes/ water pans and changing crop varieties factor since the strategies calls for adequate labour availability. This can be supported by Croppenstedt *et al*. (2003) that households with a larger pool of labour are more likely to adopt agricultural technology and use it more intensively because they have more labour at peak.

Studying the factors that influenced the level of adaptation to climate variability was necessitated by the fact that small-holder farmers' responses to climate variability are dictated by a host of socio economic factors. Household characteristics for instance are known to influence the day to day farm operations and decision making. Knowledge of key socioeconomic factors influencing farmers' adaptability to climate variability can play a role in policy formulation to mitigate the effects of climate variability on small-holder agriculture (Deressa *et al*., 2009). The study also states that knowledge of these socioeconomic factors can play a role in assisting policy makers to strengthen adaptation through investing on these factors.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study dealt with integration of Indigenous knowledge (IK) and conventional knowledge-based climate forecasts for farmers' enhanced adaptation to climate variability in Tharaka-Nithi and Kitui Counties. The study was based on a survey of 200 households randomly selected from two Sub-Counties (Tharaka and Kitui Central). The first objective of the study was to identify the indigenous strategies and preparedness techniques employed by small-holder farmers in coping with climate variability. The study clearly brought out the vast IK and preparedness techniques employed by small-holder farmers. Results showed that the popular IK employed by small-holder farmers in the study included strategies like observing the behaviour of trees, animals, sky, moon and wind. The use of these strategies varied between the two Sub Counties.

The second objective was to integrate indigenous and conventional knowledge of climate forecasting in the study area. Results on farmers' perceptions of rainfall and temperature changes showed that they had noticed changes in the rainfall patterns and temperature over the past 30 years. The changes identified in rainfall patterns included; on-set comes early, onset comes late, offset comes early, offset comes late, the rains are more intense, the rains have become less and the rains are more erratic and unpredictable. Results from the analysis of data on rainfall and temperature from KMD were found to be in line with the information from small-holder farmers' perception on how climate has varied over the reference period. The IK was also identified as an enabler to the small-holder farmers in determining the right time to perform their farming activities and to prepare accordingly in regard to an approaching natural hazard. This was because the interpretation of IK indicators observed by the farmers over the study period was found to be in agreement with conventional data over the same period.

The third objective was to determine the influence of household socio-economic factors on the level of adaptation to climate variability in regard to the extent of use of five factors containing different popular strategies employed by small-holder farmers in the study area. The five strategies were: crop adjustment factor; crop management factor; soil fertility management factor; water harvesting and crop types' factor; boreholes and crop variety factor. Results showed that in regard to the extent of use of the adaptation strategies in the five factors, several significant factors were likely to influence whether adaptation level to climate variability is low or medium relative to high. These were education level, age, gender and main occupation of the household head, average size of land allocated to maize crop, household size, farming experience and household members who are actively involved in farming.

These results therefore imply that IK is popularly utilized by small-holder farmers in Tharaka and Kitui-Central as a method of weather forecasting in their quest to adapt to climate variability, thus the need to document the use of this IK for the sake of the future generation. The use of the popular preparedness/ adaptation techniques revealed that the most utilized preparedness techniques were crop rotation and digging of boreholes/ water pans in Tharaka and Kitui Central Sub-Counties respectively. These adaptation strategies were therefore found to be the best option for the small- holder farmers as coping strategies to climate variability. Indigenous knowledge was indeed found to be vital in assessments of climate variability since it is identified by farmers within a cultural context and the knowledge base follows specific language, belief and process. Therefore, both IK and conventional knowledge should be used concurrently since perceiving such a knowledge base (IK) can act in facilitating social interaction and acceptance among the farmers. In addition, since small- holder farmers' responses to climate variability are dictated by a host of socio economic factors, studying these factors becomes inevitable. It is also evident that knowledge of these socioeconomic factors can play a role in policy making to strengthen small-holder farmers' adaptation to climate variability.

5.2 Recommendations

Based on the findings of this study, in order to ensure small-holder farmers' enhanced adaptation to climate variability in the study area:

- Effort should be put in place to document the IK indicators that are used in addition to conventional knowledge in adapting to climate variability for the sake of the future generations.
- In Tharaka Sub-County the preparedness technique that can be envisaged to give the best results is crop rotation while digging of boreholes/ water pans is the preparedness technique that would be expected to give the best results in Kitui Central Sub-County. The strategies can therefore be recommended for use by small-holder farmers in the respective regions.
- There is need to consider IK during product development at national meteorological departments by using the IK in scientific forecasts. This basically means integration and harmonization of conventional products with IK and can only be achieved through interaction among the stakeholders of climate forecasts (users, producers, and communicators).
- The household and socio-economic factors found significant in influencing the level of adaptation considering the five factors (crop adjustment; crop management; soil fertility management; water harvesting and crop types; boreholes and crop variety) should be taken into consideration in any efforts to promote adaptation to climate variability by smallholder farmers.

5.3 Further Research

Further studies are recommended in:

- Studying the indicators of IK through close monitoring and then using climate modelling to integrate the IK to the conventional data over the same period the monitoring of the IK was done.

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APPENDICES

APPENDIX 1: HOUSEHOLD SURVEY INTERVIEW SCHEDULE

I am a Master of Science student at Kenyatta University pursuing a degree in Environmental Studies (Agro-forestry and Rural Development). My study focuses on aspects to do with climate variability. The information you provide will be treated with utmost **CONFIDENTIALITY. Your assistance in answering the questions will be highly appreciated.**

Thank you

Enumerator's Name: ________________________________ Date of interview: ____/____/____

Time when the interview started: ______:_____ Household number__________

GPS coordinates: S: ______°.______'._______"

E: ______°.______'._______"

Altitude (meters above sea level) ___________

No.	Variable label	Variables	Skip rules, information, remarks
Identifying variables			
1.	County	1=Tharaka-Nithi, 2=Kitui	
2.	Sub-County	1=Tharaka- South, 2=Kitui-Central	
3.	Division	1=Tharaka- South, 2=Central	
4.	Location		

	…………………………………………..		
5.	Sub-location …………………………………………		
6.	Name of household head (**main decision maker**) ……………………………………………		
Household demographic and socio-economic characteristics			
7.	Gender of household head ……………………	1= male, 2= female	
8.	Name of the respondent ……………………………………		
9.	Relationship of the respondent to household head ………………	1=household head, 2= spouse to the household head, 3= own child, 4= relative, 5= other (specify)	
10.	Age of household head (years) ………………..		
11.	Marital status of household head ……………….	1= single, 2= monogamously married, 3=	

		polygamously married, 4= divorced/ separated 5= widowed	
12.	Education level of household head ………………….	1= none, 2= primary, 3= secondary, 4= tertiary	
13.	Main occupation of the household head ………………………	1=full-time farmer, 2=part-time farmer	
14.	No. of members of the household (family size) ……………………		
15.	Of the members mentioned above, how many are actively involved in day to day farming? ……………………….		
16.	Total land size **owned**		(In acres)
17.	How many years has this household been involved in farming?		Give the number of year e.g 20
18.	Area under **crops** (in the current season)		(In acres)
19.	Area under **pasture** (in the current season)		(In acres)
20.	**Main** source of labour in the household	1= family labour, 2= hired labour, 3=other (specify)	

Climate variability			
21.	Which date and month of the year is considered the onset of **short rains** in normal circumstances? ……………………………..	1=1st-5th March, 2=6th-10th March, 3=11th-15th March, 4=16th-20th March, 5= 21st-25th March, 6= 26th-31st March, 7=other (specify)	
22.	Which date and month of the year is considered the onset of **long rains** in normal circumstances? ……………………………..	1=1st-5th October, 2=6th-10th October, 3=11th-15th October, 4=16th-20th October, 5= 21st-25th October, 6= 26th-31st October, 7=other (specify)	
23.	Over the past **30 years**, have you noticed any long-term change in the rainfall pattern? ………………………………	0= no, 1=yes	If yes, ask question 24. If no, skip to question 25

24.	What changes have you noticed in the rainfall pattern?		Tick all that apply
a)	The on-set comes early [ ]		
b)	The on-set comes late [ ]		
c)	The off-set comes early [ ]		
d)	The off-set comes late [ ]		
e)	The rains are more intense [ ]		
f)	The rains have become less [ ]		
g)	The rains are more erratic/unpredictable[ ]		
h)	Other (specify) [ ]		
25.	Over the past **30 years**, is there a time when rainfall was far much higher than normal?	0= no, 1=yes	If yes, ask question 26. If no, skip to question 27
26.	Which years was the rainfall higher than normal? ……………………………….		List all the years when the rainfall was higher than normal
27.	Over the past **30 years**, have you noticed any long-term change in temperature? …………………………….	0= no, 1=yes	If yes, ask question 28. If no, skip to question 29
28.	What changes have you noticed in	1= increased,	

	temperatures?	2=decreased, 3=varied	
29.	Which years did you notice the temperature being higher than normal? ……………………………………		List all the years when temperature was higher than normal
30. a) b) c) d)	How has the above changes in rainfall and temperature affected your agricultural activities? Decrease in crop yields/ crop failure [1……...2……...3………4………5] Increase in crop diseases [1……...2……...3………4………5] Increase in crop pests [1……...2……...3………4………5] Increase in weeds [1……...2……...3………4………5]		Circle the number that represents the level of severity

e)	Death of livestock [1……...2……...3………4………5]		
31.	Are you using the following preparedness techniques to adapt to the changes?		
a)	Changing of planting dates	0= no, 1=yes	
b)	Changing crop varieties	0= no, 1=yes	
c)	Changing crop spacing	0= no, 1=yes	
d)	Changing crop types	0= no, 1=yes	

e)	Increasing the use of manure/ fertilizer	0= no, 1=yes	
f)	Water harvesting	0= no, 1=yes	
g)	Digging boreholes/ water pans	0= no, 1=yes	
h)	Agroforestry	0= no, 1=yes	
i)	Crop rotation	0= no, 1=yes	
j)	Storing food in stores to be used later	0= no, 1=yes	
32. a) b)	Kindly score the effectiveness and rate the extent of use of the following preparedness techniques on **maize** crop Changing of planting dates 1……2……3……4……5 L…M…H Changing crop varieties		**N.B**: First rate the **effectiveness** followed by the **extent**. For effectiveness, circle on the scale; 5 being the most effective and 1 being the least effective. For extent of use, indicate by circling whether Low (L),

	1……2……3……4……5 L…M…H		Medium (M) or High (H) **e.g.** 2……3……4 M L……......H
c)	Changing crop spacing		
	1……2……3……4……5 L…M…H		
d)	Changing crop types		
	1……2……3……4……5 L…M…H		
e)	Increasing the use of manure/ fertilizer		
	1……2……3……4……5 L…M…H		
f)	Water harvesting 1……2……3……4……5 L…M…H		
	Digging boreholes/ water pans		
g)	1……2……3……4……5 L…M…H		
h)	Agroforestry 1……2……3……4……5 L…M…H		
i)	Crop rotation		
j)	1……2……3……4……5 L…M…H		
	Storing food in stores to be used later		

	1……2……3……4……5 L…M…H		
33.	Are you aware of the traditional knowledge of weather forecasting?	0=no, 1=yes	
34.	Do you use the traditional weather and climate forecasting to plan for your agricultural activities? ………………………..	0=no, 1=yes	
35.	Which of the following traditional knowledge of weather forecasting do you use to help in adapting to the varying climatic conditions?		
a)	Behaviour of Trees	0=no, 1=yes	
b)	Behaviour of Animals	0=no, 1=yes	
c)	Behaviour of Sky	0=no, 1=yes	
d)	Behaviour of Moon	0=no, 1=yes	
e)	Behaviour of Wind	0=no, 1=yes	

f)	Other (specify)		
36.	On which activities do you use the traditional weather and climate forecasting information?		Circle appropriately. **Can have more than one choice**
a)	Behaviour of Trees	1=land preparation, 2=planting, 3=weeding, 4=harvesting, 5=storage, 6=other (specify)	
b)	Behaviour of Animals	1=land preparation, 2=planting, 3=weeding, 4=harvesting, 5=storage, 6=other (specify)	
c)	Behaviour of Sky	1=land preparation, 2=planting, 3=weeding, 4=harvesting, 5=storage, 6=other (specify)	
d)	Behaviour of Moon	1=land preparation, 2=planting,	

e)	Behaviour of Wind	3=weeding, 4=harvesting, 5=storage, 6=other (specify) 1=land preparation, 2=planting, 3=weeding, 4=harvesting, 5=storage, 6=other (specify)	
37.	Kindly rate the accuracy of traditional weather and climate forecasting? 1………2………3………4………5		Circle appropriately
38.	Are you aware of scientific weather forecasts information?	0=no, 1=yes	
39.	What source of scientific forecasts information are you aware of **MAINLY**?	1=radio, 2= television, 3=newspaper, 4=relatives/ friends, 5=ministry of agriculture official, 6=other (specify)	
40.	Do you use the scientific weather forecast information to plan for your agricultural activities and adapt to the conditions caused by climate variability such as droughts?	0=no, 1=yes	If no, ask question 41. If yes, skip to question 42

41.	Why don't you use scientific weather forecast information? ……………….	1= lack of access to timely weather forecasts, 2=lack of credit facilities, 3=other (specify)	Only for those who do not use
42. a) b) c) d) e)	On which activities do you use the scientific weather and climate forecasting information? Land preparation [ ] Planting [ ] Weeding [ ] Harvesting [ ] Storage [ ]		Tick appropriately
43.	Kindly rate the accuracy of scientific weather and climate forecasting? 1………2………3………4………5		Circle appropriately
44.	Have you experienced drought in the past **30 years**? ……………………	0=no, 1=yes	
45.	How many droughts have you experienced in the last **30 years**?	0=none, 1= less than three, 2= more than three	Only if has ever experienced

	……………….		
46.	Which years have you experienced the drought conditions?		List the years. Can be as many years as possible
47.	Of the above listed years of drought conditions, which one do you consider the worst in the living memory/ which one was most severe?		List the year that had the worst drought
48.	Which crop has been affected more by climate variability?	1=maize, 2=pigeon peas, 3=cow peas, 4=beans, 5=bananas, 6=millet, 7= sorghum, 8= green grams, 9=other (specify)	Get the main one
49.	Which crop has not been affected at all by climate variability?	1=maize, 2=pigeon peas, 3=cow peas, 4=beans, 5=bananas, 6=millet, 7= sorghum, 8= green grams, 9=other (specify)	Get the main one
50.	Which livestock type has been affected	1= poultry,	Get the main one

	more by climate variability?	2=goats, 3=cattle, 4=other (specify)	
51.	Which livestock type has not been affected by climate variability?	1= poultry, 2=goats, 3=cattle, 4=other (specify)	Get the main one

Time the interview ended: _______: _______

THANK YOU

APPENDIX 2: KEY INFORMANTS INTERVIEW SCHEDULE

I am a Master of Science student at Kenyatta University pursuing a degree in Environmental Studies (Agro-forestry and Rural Development). My study focuses on aspects to do with climate variability. The information you provide will be treated with utmost **CONFIDENTIALITY. Your assistance in answering the questions will be highly appreciated.**

Thank you

No.	Variable label	Variables	Skip rules, information and remarks
Identifying variables			
1.	Name of respondent		
2.	Gender	1=male, 2=female	Circle appropriately
3.	Age		In years
4.	Date of interview		Date format: dd/mm/yy
5.	County		
6.	Sub-County		
7.	Division		
8.	Location		
9.	Sub-location		
10.	Village		
Climate variability			
11.	What is your understanding of climate variability?		

12. a) b) c) d) e)	Which of the following have had a change in their patterns over the past 30 years or so? Rainfall [ ] Temperature [ ] Wind [ ] Insects [ ] Vegetation [ ]		Tick appropriately
13.	For those whose patterns have changed, please give a brief description of the changes		
14.	What were the onset dates and month of the		Date format: dd/mm/yy

	following over the past 30 years or so? Short rains Long rains	____/_____/____ ____/_____/____	
15.	How has the onset dates and month changed with the varying climate now? Short rains Long rains	____/____/_____ ____/____/_____	Give dates
16.	Are there incidences when rainfall has been too much than normal?	0=no, 1=yes	If yes ask the next question. If no, skip to question **18**
17.	What were the effects?	1=bumper harvests, 2=flooding, 3=increased crop pests, 4= increased crop diseases, 5=destruction of crops, 6=other (specify)	Can have more than one choice
18.	Have there been incidences of climate variability conditions such as droughts over the past 30 years or so?	0=no, 1=yes	If yes ask the next question. If no, skip to question **20**
19.	Give a brief history pertaining to this		

20.	What coping strategies do farmers in this area employ to reduce the impact of such conditions with respect to agricultural activities?	1=change of crop varieties, 2=change of planting dates, 3=planting early maturing crops, 4=water harvesting, 5=storage of harvested crops to be used during the lean period, 6= other (specify)	Can have more than one choice
21.	What constraints are faced in an effort to change the patterns of agricultural activities in order to reduce the impacts of climate variability?	1= lack of know how/ limited education, 2=limited sources of information, 3=lack of resources, 4=other (specify)	Can have more than one choice

22. a) b) c) d)	Which indigenous strategies are popularly used as early warnings/ local determinants to predict the following in relation to climate variability and agricultural activities in this area over the past 30 years or so? On prediction of rainfall onset Quality of rainfall seasons Natural disaster events e.g drought Quality of harvest to be expected		List the strategies associated with each, accompanied by what they symbolize
23.	Are the above strategies	0=no, 1=yes	If yes, skip to

	still in use today?		question **25**, if no, ask the next question
24.	Why are the strategies not in use today?		
25.	Do the events predicted by the indigenous early warnings come to pass?	0=no, 1=yes	
26.	Do the events predicted through conventional/ scientific knowledge come to pass?	0=no, 1=yes	
27.	How can you rate the reliability of indigenous weather and climate forecasting? ………………………	0=not reliable, 1= least reliable, 2= moderately reliable, 3= reliable, 4= very reliable	
28.	How can you rate the reliability of conventional weather and climate forecasting? ………………………	0=not reliable, 1= least reliable, 2= moderately reliable, 3= reliable, 4= very reliable	

THANK YOU

APPENDIX 3: FOCUS GROUP DISCUSSIONS CHECKLIST

I am a Master of Science student at Kenyatta University pursuing a degree in Environmental Studies (Agro-forestry and Rural Development). My study focuses on aspects to do with climate variability. The information you provide will be treated with utmost **CONFIDENTIALITY. Your assistance in answering the questions will be highly appreciated.**

Thank you

Date of the interview __________________ Time the discussion started ____:____

Sub-county _________________ Division ___________________

Location _________________ Sub-location ___________________

Village _________________

Respondents

i. Total number of **Male** respondents _______________

ii. Total number of **Female** respondents _______________

Climate variability

1. How has the rainfall patterns changed over the past 30 years or so?
2. How has the temperature patterns changed over the past 30 years or so?
3. Kindly describe incidences when rainfall has been too much than normal since 1980
4. Kindly describe incidences when temperatures has been higher than normal since 1980
5. Kindly describe incidences when droughts have been experienced since 1980
6. Which date and month of the year was considered the onset of **short rains** long time ago
7. Which date and month of the year is considered the onset of **short rains** nowadays

8. Which date and month of the year was considered the onset of **long rains** long time ago
9. Which date and month of the year is considered the onset of **long rains** nowadays
10. Which are the popular indigenous strategies used in climate forecasting in this area (in regard to maize farming)
11. On which activities of maize farming are the above mentioned strategies used and why are they used?
12. Which are the popular preparedness techniques employed by farmers in this area?
13. Why are the above mentioned preparedness techniques preferred to others?
14. Comparing indigenous and conventional knowledge of climate forecasting, which one is more preferred and why?
15. On which months of the year are the following activities performed during maize farming (consider both SR and LR)

- Land preparation
- Planting
- Weeding
- Harvesting
- Storage

16. What is the average farm size?