# EFFECTIVENESS OF SEASONAL CLIMATE FORECASTS IN AGRICULTURAL DECISION-MAKING AMONG SMALLHOLDER FARMERS IN SEMI-ARID VOI SUB-COUNTY, KENYA

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**A Thesis Submitted to the Graduate School in Partial Fulfillment for the Requirements of the Award of the Degree of Master of Science in Geography of Egerton University**

**EGERTON UNIVERSITY**

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# DECLARATION AND APPROVAL

## DECLARATION

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

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## APPROVAL

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## DEDICATION

This thesis is dedicated to

All who cherish fellow human life

And endeavour to make the earth

A better home for humankind

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## ABSTRACT

Climate change and variability greatly affect many human activities particularly agriculture. Various adaptation strategies to climate variability have been used over the years with little attention to the vital role played by seasonal climate forecast (SCF) in providing information on the expected climatic conditions to adapt to. Despite dissemination of SCF information to varied users by Kenya Meteorological services (KMS) before rain seasons, it still remains unclear whether the information is used in agricultural decision-making among smallholder farmers in semi-arid areas.This study sought to contribute towards improved use of SCF in response to climate variability by assessing perception, use and constraints to use of seasonal climate forecast in agricultural decision-making by smallholder farmers in semi-arid Voi sub-County, Kenya. SCF for October-November-December (OND) 2015 was obtained from KMSand compared to observed climatic conditions for the season. Climatic data of the study area for the period 1985-2014 was obtained from Voi Meteorological station and used to calculate the OND mean rainfall. Questionnaires were administered to 246 household heads randomly selected from two Locations and interview schedule administered to five purposively selected Key Informants. Primary data collected were analyzed using descriptive statistics, one sample Chi-square and Pearson Correlation tests. The results showed that majority of smallholder farmers' perception of SCF information was somewhat good with a significance of $p=0.000$ in their perception.The study also established that 41.7% of smallholder farmers used OND 2015 SCF in agricultural decision-making. Key constraints to use of seasonal climate forecast were lack of trust in the forecasts and inadequate extension support. The household socio-economic characteristics that were found to have a significant influence on use of SCF were education level and reason for farming. The study concludes that the perception of OND 2015 SCF by smallholder farmers was a limitation to use of the information in agricultural decision-making. The study recommends enhancement of awareness of SCF information, provision of short-term forecasts and training on use of forecasted seasonal climate information in agricultural decision-making.

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| **AO:** | Antarctica Oscillation |
| **COFs:** | Climate Outlook Forums |
| **CPT:** | Climate Predictability Tool |
| **ENACTS:** | Enhancing National Climate Services |
| **ENSO:** | El Niño Southern Oscillation |
| **GCM:** | Global Circulation Model |
| **ICPAC:** | IGAD Climate Prediction and Application Centre |
| **IGAD:** | Intergovernmental Authority on Development |
| **IOD:** | Indian Ocean Dipole |
| **IPCC:** | Intergovernmental Panel on Climate Change |
| **KCCAP:** | Kenya Climate Change Action Plan |
| **KMS:** | Kenya Meteorological services |
| **MAM:** | March, April and May |
| **MDG:** | Millennium Development Goals |
| **NACOSTI:** | National Commission of Science, Technology and Innovation |
| **NAO:** | Northern Atlantic Oscillation |
| **NCCRS:** | National Climate Change Response Strategy |
| **NGO:** | Non-Governmental Organization |
| **NMHS:** | National Meteorological and Hydrological Services |
| **NOAA/CPC:** | National Oceanic and Administration's Climate Prediction Centre |
| **OND:** | October, November and December |
| **RCM:** | Regional Circulation Model |
| **RoK:** | Republic of Kenya |
| **SADC:** | Southern Africa Development Community |
| **SARCOF:** | Southern Africa Regional Climate Outlook Forum |
| **SCF:** | Seasonal Climate Forecast |
| **SPSS:** | Statistical Package for Social Science |
| **SST:** | Sea Surface Temperature |
| **UNCED:** | United Nations Conference on Environment and Development |
| **WMO:** | World Meteorological Organization |

# CHAPTER ONE
# INTRODUCTION

## 1.1 Background to the Study

Climate plays an essential role in many human activities and in particular agriculture (Ogen, 2007). Despite improvements in agricultural technologies such as plant breeding, soil fertility and weed science, climate still remains a primary determinant of agricultural productivity due to the biophysical relationship between crops and the dynamic atmospheric environment (Meza &Wilks, 2008). The agricultural sector remains a key contributor to the socio-economic development of many countries, especially in the developing regions largely due to its multi-functional nature as the main source of food and employment to most of the people especially among rural population (Calzadilla, Zhu, Rehdanz, Tol&Ringler, 2009; Ogen, 2007).

Climate change and variability has been witnessed world over with its impact largely felt in the agricultural sector due to its sensitivity to as well as its strong dependence on climate (Coelho & Costa, 2010; Mendelsohn, 2009). Climate change and variability affects farming as a result of changes in rainfall amounts and distribution, extreme low or high temperatures and occurrence of flooding, drought and severe wind storms (Oyekale, 2015). Seasonal climate variation is caused by the interaction between the atmosphere and the ocean with some modifications by other physical phenomena such as relief and altitude. Globally, the teleconnections of ocean-atmosphere leads to occurrence of major synoptic systems such as El-Nino South Oscillation (ENSO), Northern Atlantic Oscillation (NAO) and Antarctica Oscillation (AO) which bring about climate variability (Hayman, Whitbread &Gobbett, 2010). Climate change and variability became an issue of international concern after it was given a closer attention at the United Nations Conference on Environment and Development (UNCED) summit in 1992 where causes and mitigation measures were addressed (Kpanodou, Adegbola&Tovignan, 2012). Climate variability, which is the manifestation of changing climatic conditions from one place to another, from year to year or within the same year, is mainly attributed to natural causes (IPCC, 2014).

Climate variability brings about changes in the seasonal climate characteristics especially onset, amount and cessation of rainfall which have a great impact on agriculture. In Europe, for example, climate variability is responsible for the shift in the occurrence times of hail, frost, snow and drought which adversely affect agriculture (Gimenez&Lanfranco, 2012). In sub-Saharan Africa, climate change and variability has greatly affected food production due to prolonged droughts which have become severe in recent years (Funk *et al*., 2008). Climate change and variability in Eastern and the Horn of Africa has also been manifested in the frequent occurrence of droughts and shift in growing seasons. For instance in Kenya, rain seasons have become unpredictable and unreliable with many regions such as the semi-arid South-eastern parts of the country experiencing long dry spells (Macharia, Thuranira, Ng'ang'a&Wakori, 2012). Today, more rain occur during OND seasons in semi-arid regions as compared to MAM seasons and therefore essence of "short" and "long" rains has lost its meaning in these regions. This is because the traditional short rains (OND) have for long been the most reliable for agricultural activities as compared to MAM seasons in Eastern Kenya (Hansen &Indeje, 2004).

Mitigation and adaptation are the two main approaches used in dealing with climate change and variability. Mitigation is a global long-term approach to address the problem of greenhouse gases emission while adaptation is a short-term local measure of coping with the climate situation which involves avoiding its adverse effects or taking advantage of positive changes (Bawakyillenuo, Yoro &Teye, 2014). Adaptation to climate change has entailed measures put in place to cope with the changing climatic conditions as well as taking advantages of opportunities created by such changes. In sub-Saharan Africa, adaptation takes the centre stage in dealing with climate change and variability since the region is more vulnerable due to its limited skills and financial resources as well as weak institutions concerned with climate change mitigation efforts (Bagamba, Bashaasha, Claesens&Antle, 2012). Nevertheless, some countries for example Ghana and Zimbabwe have experimented with adaptation efforts such as irrigation and growing of drought tolerant crops (Bawakyillenuo*et al*., 2014; Moyo*et al*., 2012). In Kenya, climate change and variability adaptation policies have been put in place by the National Climate Change Response Strategy (NCCRS),a national policy document that proposes a range of adaptation measures ranging from water and soil resource management to adaptation policy formulation and review (RoK, 2010a). In addition, the Kenya Climate Change Action Plan (KCCAP) gives specific and elaborate time-bound steps towards adaptation to climate change and variability (RoK, 2013a).

Causes of climate change and variability and its effects have been well understood with timing and degree of the change and variability now being a major concern (Crist, 2007). Large-scale predictions of climate world over through modelling and scenario building have been used with little certainty achieved (McGrail, 2013). In response to this, regional climate forecasting centres have been established in many parts of the world. In sub-Saharan Africa, the Southern African Regional Climate Outlook Forum (SARCOF) brings together producers and consumers of climate information from the entire Southern Africa Development Community (SADC) region to discuss, generate and disseminate seasonal climate forecast to many end-users in the region. The Intergovernmental Authority on Development (IGAD) Climate Prediction and Application Centre (ICPAC) also provide climate forecast information to the Horn of Africa countries.

In Kenya, the Kenya Meteorological services (KMS) issues seasonal climate forecasts about one month before onset of the rainfall seasons. Perception of these forecasts by farmers in most cases has been perceived as negative (Macharia*et al*., 2012). Despite this perception, seasonal climate forecasts have been used by farmers, especially the large-scale ones in making on-farm decisions (Klopper, Vogel &Landman, 2006). However, there are many constraints which may arise in the use of these forecasts in agricultural decision-making right from their generation to their application. Seasonal climate forecasts provide information on expected seasonal rainfall conditions in terms of its onset, amount and cessation which is vital in making on-farm decisions on adaptation strategies in semi-arid areas (Recha, Shisanya, Makokha&Kinuthia, 2008; Klopper*et al*., 2006). Voi sub-County is a semi-arid area where smallholder farmers mainly rely on OND rainfall season for crop farming (RoK, 2013b). In light of this, it is important to establish how smallholder farmers perceive these forecasts and whether they use them in agricultural decision-making at farm level.

**1.2 Statement of the Problem**

Use of seasonal climate forecast is an adaptation strategy to climate variability, especially in semi-arid lands. In Kenya, the Kenya Meteorological services (KMS) disseminates seasonal climate forecast before onset of March-April-May (MAM) and October-November-December (OND) rainfall seasons. Despite this, it remains unclear whether this has translated into agricultural risk reduction especially among smallholder farmers in low agricultural potential semi-arid areas such as Voi sub-County. The study, therefore, sought to assess the extent of perception of SCF and its effectiveness in agricultural decision-making process as adaption strategy to climate variability among smallholder farmers in semi-arid Voi sub-County.

### 1.3 Objectives

The study was guided by the following objectives:

#### 1.3.1 Broad Objective

The broad objective of this study was to contribute towards improved use of seasonal climate forecast among smallholder farmers in Voi sub-County with a view of enhancing agricultural productivity in light of climate variability especially in semi-arid areas.

#### 1.3.2 Specific Objectives

i. To evaluate the perception of the quality of seasonal climate forecasts from Kenya Meteorological services among smallholder farmers in Voi sub-County.
ii. To establish smallholder farmers' use of seasonal climate forecasts in agricultural decision-making in Voi sub-County.
iii. To determine constraints to use of seasonal climate forecasts in agricultural decision-making among smallholder farmers in Voi sub-County.

### 1.4 Research Questions

i. How do smallholder farmers in Voi sub-County perceive the quality of seasonal climate forecasts from Kenya Meteorological services?
ii. How do smallholder farmers in Voi sub-County use seasonal climate forecasts from Kenya Meteorological services in agricultural decision-making?
iii. What constraints affect use of seasonal climate forecasts among smallholder farmers in agricultural decision-making in Voi sub-County?

### 1.5 Justification/Significance of the Study

One of the strategic objectives of National Climate Change Response Strategy (NCCRS) policy framework is to recommend measures aimed at minimizing climate change risks with downscaling of weather information suggested as an appropriate adaptation strategy in agriculture (RoK, 2010a). The study findings are, therefore, aimed at making a contribution to the suggested pathways in the NCCRS on improving adaptation to climate variability. The findings are to further suggest ways of improving dissemination of seasonal climate forecasts among smallholder farmers so as to enhance adaptation to climate variability. Finally, the findings also aim at providing knowledge to smallholder farmers on the importance of response strategies to seasonal climate forecasts.

## 1.6 Scope of the Study

The study focused on evaluation of perception of quality and use of seasonal climate forecasts in agricultural decision-making in Voi sub-County. The study was carried in Voi sub-County because it is found in semi arid Southeastern Kenya andwas limited to Mbololo and Sagalla Locations due to their proximity to Voi meteorological station - important for collecting reliable rainfall data. In addition, the two study sites are predominantly occupied by smallholder farmers.

The study also focused on rainfall as one of the elements of climate because of its significance in agricultural production in semi-arid areas. Seasonal climate forecasts may vary based on the tools and institutions involved in generation. Parameters of seasonal climate forecast for this study was limited to the forecast given by Kenya Meteorological services since it is the designated national authority in Kenya.Farmers' perception, use and constraints to use of seasonal climate forecast were limited to the experience and KMS forecast of OND 2015 rainfall season. Although traditionally in Kenya MAM represents the long rains and OND the short rains, OND was used since it is the most reliable season for rain-fed agriculture in South East Kenya (Cooper *et al*., 2008; Hansen &Indeje, 2004).

## 1.7 Limitations

The researcher encountered several challenges during data collection. One of the challenges was language barrier as the study was conducted in a rural setup where some respondents could only communicate in the local language -Taita. As a remedy, the researcher used field assistants on the basis of their knowledge of the local language. Another limitation was the expansiveness of the study area which made the researcher travel long distances by foot or on motorbike. This was due to sparsely distributed households and lack of access roads in some areas. Despite this challenge all sampled households were contacted and provided the necessary information.

The study relied on one meteorological station; Voi. This may not have taken care of the expansiveness and varied topographical characteristics of the study area. However, Voi meteorological station was used since it is the only synoptic station in the study area with reliable rainfall data. Likewise models of seasonal climate prediction are also based on regional scale (Dessai, Hulme, Lempert&Pilke, 2009).

## 1.8 Assumptions

The study assumed that KMS will have released seasonal climate forecast for OND 2015 rainfall season before the start of the season. It also assumed that the seasonal climate forecast information from KMS will be disseminated through various channels such as extension services, radio, television and internet and all respondents will have an opportunity of getting the information.The study further anticipated that the entire sampled households' heads and Key Informants will be able to provide objective and reliable information.

## 1.9 Operational Definition of Key Terms and Concepts

**Adaptation:** this term is used in this study to refer to the planned actions by smallholder farmers in averting negative impacts of rainfall variability.

**Agricultural decision-making:** this refers to decisions made by smallholder farmers regarding farming activities before and during a given rainfall season. These include decision on when to prepare land, which farm inputs to acquire, when to plant and what to plant. This term is used in this study to mean farming decisions made by smallholder farmers in Voi sub-County during the OND 2015 rainfall season.

**Effectiveness of seasonal climate forecast:** this is the ability of seasonal climate forecast information to be used by smallholder farmers as a guide in making decisions which are relevant in enhancing adaptation strategies to climate variability.

**Cessation date of a rainfall season:** according to Odekunle (2006), it refers to a day in a particular rainfall season when recorded rainfall fall below 0.1mm followed by a dry spell of seven days or more. However, for this study, 31$^{st}$ December is considered as the cessation date for OND rainfall season of 2015.

**Climate variability:** in this study it refers to variations of rainfall characteristics of the study area in terms of onset, cessation, amount and number of rainy days.

**Constraints:** this term is used in this study to refer to the socio-economic factors which prevent smallholder farmers from using seasonal climate forecast disseminated by Kenya Meteorological services in agricultural decision-making.

**Highly enhanced rainfall:** this is amount of rainfall which is far much above the usual amount received in a given area for a particular season. The term in this study means OND rainfall amount which is far much more than the usual amount received in Voi sub-County.

**Onset date of a rainfall season:** this term refers to occurrence of at least 0.1 mm of rainfall in a day for two successive days with a dry spell of less than three days (Recha, 2007; KMD, 1984). However, for this study, $1^{st}$ October is considered as the onset date for OND rainfall season.

**Perception:** this term is used in this study to refer to the way smallholder farmers judge seasonal climate forecasts issued by KMS in terms of quality. For the study, perception was limited to OND 2015.

**Quality seasonal climate forecast:** in this study the term is used to refer to a degree of accuracy of seasonal climate forecast when compared to observed climatic conditions for a specified rainfall season. Quality seasonal climate forecast leads to a high likelihood of farmers' confidence in the forecast and consequently its uptake.

**Seasonal climate forecast:** this term is used in this study to refer to prediction of rainfall attributes such as onset, cessation and amount before the start of a particular rainfall season. It covers a period of three months which is sufficient for growing most annual crops in Kenya.

**Smallholder farmers**: in this study the term refers to farmers involved in the production of crops mainly to meet their household's food requirements mostly in the rural areas. They sell small amount of farm produce to buy basic necessities. They use traditional and manual farming equipment and tools, farm on small family pieces of land and have low human and financial capital.

# CHAPTER TWO
# LITERATURE REVIEW

## 2.1 Introduction

This section presents review of literature based on the objectives of the study and in particular the overview of seasonal climate forecast (SCF), perception of the quality of SCF, use of SCF, constraints to the use of SCF by smallholder farmers in agricultural decision-making and the gaps in the literature. It also presents the theoretical and conceptual frameworks of the study.

## 2.2 Generation and Dissemination of Seasonal Climate Forecast

There is a wide range of climate observation and forecasting around the world. Climate forecasts lie in three main categories: weather forecast for the next one to ten days, seasonal climate forecast for the next three to six months and decadal climate forecast which projects climate conditions for several years to come (Faures, Bernardi, &Gommes, 2010). Out of these three, information on seasonal climate is the most appropriate for smallholder farmers growing annual crops.

Knowledge on ocean-atmosphere teleconnections and use of Global Circulation Models (GCMs) has led to improved seasonal climate forecasting skills useful in strategic agricultural decision-making (Baigorria, Jones & O'Brien, 2008; Motha, 2007). Prediction of seasonal climate using GCMs heavily depends on computer softwares which are used to simulate or extrapolate the state of climate and its future effects (Baigorria*et al.*, 2008). These computer-based programs are classified into four: forecasting software for predicting seasonal global seasonal climate conditions, downscaling software for converting global forecasts to smaller spatial scales appropriate for agricultural applications, impact prediction software which simulate effects of down-scaled forecasts and decision support system for integrating down-scaled climate forecasts and impacts of their risks and economic management (Garbrecht& Schneider, 2007). Use of computer softwares has, therefore, led to improvement in the resolution of climate forecast models as well as closer monitoring and prediction of climate variability from the surface, atmosphere, ocean and from space (Power, Plummer & Alford, 2007). Forecasts made with specific tools such as Climate Predictability Tool (CPT), which is designed to eliminate observer bias and to quantify uncertainty, are also very reliable.

Although GCMs can predict inter-annual climate variability better than the forecasted meteorological values by taking into account all the physical processes which affect climate, they are not capable of capturing the details of regional or national climate changes which requires finer spatial and temporal details provided by the high resolution Regional Climate Models (RCMs) (Nandozi*et al*., 2012). Only seasonal average atmospheric state can be forecasted rather than the weather chronology in any season (WMO, 2002). Rainfall is also hard to forecast accurately because its occurrence in fine spatial scale of convection is not well captured by GCMs making its seasonal forecast to be issued in conditional probability terms such as below normal, normal and above normal (Stedinger& Kim, 2010; McIntosh, Pook, Risbey, Lisson&Rebbeck, 2007). Reliable ground observation is, therefore, the foremost and the most important activity in coming up with dependable forecast (Faures*et al.*, 2010). In some countries such as Ethiopia, Tanzania and Rwanda in Eastern Africa, Enhancing National Climate Services (ENACTS) initiative has been used to improve the quality of available climate information by working directly with National Meteorological and Hydrological Services (NMHS) and other partners (Stedinger& Kim, 2010). This has led to improvement of climate information by combining rigorously evaluated ground station data with satellite and climate model analysis products.

El Niño Southern Oscillation (ENSO) is the most common known driver of inter-annual weather and climate variability around the world (Hayman, Crean, Mullen & Parton, 2007). It is a periodic appearance of unusually high Sea Surface Temperatures (SSTs) in the central and eastern Pacific Ocean. This results into regional warming across the tropics leading to increased probability of drought and other extreme weather events in some areas and excess rainfall in others (Motha, 2007). ENSO is caused by ocean-atmosphere interactions due to eastward expansion and westward contraction of the SST in the western Pacific Ocean which bring about positive SSTs anomalies in the central Pacific. The SSTs and an index of surface pressure gradient is monitored and used to predict seasonal climate conditions over the tropical regions. Measurement of SST in the Pacific allows the simulation of likelihood of ENSO up to six months in advance (Faures*et al.*, 2010). Progress and strength of the El Niño can be monitored through near-real-time ENSO observing systems. El Niño conditions usually persist for 9 – 12 months or longer from June with its peak between November and February where its impacts are felt in a region’s main rainy season (Lyon, 2014). A positive phase of the Indian Ocean Dipole (IOD) is sometimes triggered by El Niño events. This is a pattern of warmer-than-average conditions in the Western equatorial Indian Ocean coupled by cooler-than-average conditions in the East. This positive IOD phase usually results in wetter conditions in East Africa and drier conditions in Southeast Asia and Australia. There exists a positive correlation between IOD phase and precipitation received during OND with less significant changes in precipitation received during MAM as it demonstrates weak correlation with SSTs in the ocean basins (Nandozi*et al*., 2012). Due to interactions between the ENSO and IOD the latter can alter the impacts of the former. Therefore, regional forecasts provided by various national meteorological servicess are the most reliable as they forecast on multiple timescales; seasonal, monthly, weekly and daily (Matondo, 2010).

Seasonal climate forecasts are disseminated world over to farmers and other users. According to Garbrecht and Scheider (2007), dissemination of seasonal climate forecast can adopt three approaches: top-down approach where information flows from forecasters to end-users, end to end approach which is feedback oriented, and the hybrid approach which combines the former two approaches. Many regions of the world have established seasonal climate generation and dissemination centres. In Africa, international institutions in partnership with national ones regularly generate and disseminate climate forecast on seasonal basis through Climate Outlook Forums (COFs). A meeting of climate experts organized by World Meteorological Organization in Gambia in 2010 to look at seasonal climate forecast dissemination in Africa, outlined procedure of forecasting in regional COFs in Africa: pre-forum (collection of information), forum, dissemination, forecasts update and evaluation of the forecasts (Matondo, 2010). Southern African Regional Climate Outlook Forum (SARCOF) disseminates forecasts to the entire Southern African Development Community (SADC) region while the Intergovernmental Authority on Development (IGAD) Climate Prediction and Application Centre (ICPAC) serves the Eastern and the Great Horn of Africa (Moyo*et al*., 2012). In Kenya, seasonal climate forecast information is issued by Kenya Meteorological services (KMS) about one month before onset of both March-April-May (MAM) and October-November-December (OND) rain seasons after rigorous modelling and discussions by various experts such as meteorologists, climatologists and agronomists. The Kenya Meteorological servicess briefs the press on the expected seasonal climate which is carried in the local media as well as posted in the KMS website. Smallholder farmers in low potential agricultural areas are expected to adopt the forecast in their agricultural decision-making.

## 2.3 Perception on the Quality of Seasonal Climate Forecast by Smallholder Farmers

Seasonal climate forecast information is issued to end-users accompanied by relevant sectoral advisory with the view that end user will use it in decision-making. Farmers as the major consumers of this information are expected to make decisions concerning farming activities in line with the received forecast information (Recha, 2007). Adoption of seasonal climate forecast by farmers has, however, been greatly affected by the farmers' perception of its quality in terms of onset, amount and cessation (Garbrecht& Schneider, 2007). A seasonal climate forecast which yields different results from predicted one can discourage farmers and lower their future adoption rates. Climate forecast information is beneficial when there is a defined and clear perceived adaptive response and benefit once the information is considered in decision-making process (Fraisse*et al*., 2006). Seasonal climate forecast information therefore need to be perceived as scientifically credible, salient and legitimate if they are to be adopted by end-users.

In a study conducted on use of seasonal climate forecast in decision-making on corn farming in Philippines, farmers termed forecast as untruthful and unable to materialize making many people to ignore them (Borines, Gravoso&Predo, 2009). Likewise, a survey conducted by Agriculture, Fisheries and Forestry Department in Australia in 2002 showed that 73% of the respondents interviewed stated that seasonal climate forecasts issued were not in line with the observed climate conditions (Hayman *et al*., 2007). Use of seasonal climate forecasts depends on the perception of the user on the quality of the forecasts and this, therefore, merits the need for location-specific studies to establish users' perception of quality of seasonal climate forecast information (Hansen &Indeje, 2004).

Culture and attitude of people in a society affects how they perceive events and integrate information in their decision-making. This was suggested by Crane *et al*. (2008) who established that Georgian farmers manage risks associated with climate variability within a broad array of cultural contexts of social factors, goals and values. This affects the way farmers perceive seasonal climate forecast and therefore there is a need for gradual infiltration of forecast into farmers' social networks rather than acting as a technical information input (Moyo*et al*., 2012). Despite improved seasonal climate prediction and dissemination pathways, farmers' attitude towards the forecast is still poor due to difficulties faced in the attempt to change people's attitudes when transferring scientific information into practical use (PytlikZillig, Hu, Hubbard, Lynne &Bruning, 2010).

In many regions of the world such as the sub-Saharan Africa, seasonal climate forecast information is perceived as uncertain. While looking at the use of indigenous knowledge to predict climate in semi-arid central Tanzania, Elia, Mutula& Stilwell (2014) established that uncertainty about seasonal climate forecast is one of the most critical factors which make farmers to continue using indigenous knowledge-based forecasts to predict seasonal climate and make necessary adjustments to their farming decisions. Likewise, in a survey on uncertainty in weather forecasting in USA, Morss, Demuh&Lazo (2008) found out that communicating uncertainty to users of climate forecast information remain a major challenge to many forecast generators. Many users of seasonal climate forecast, especially smallholder farmers, lack the understanding that the forecast are issued in probabilistic terms and believe that forecasters have lied whenever the forecasts fail (Coelho & Costa, 2010). Seasonal climate forecasts issued in Kenya by KMS are also often faulted by many users as inaccurate due to their greater deviation from the observed seasonal climatic conditions (Hansen &Indeje, 2004). Improving the quality of seasonal climate forecast can greatly increase farmers' capacity to make better use of information and respond quickly to climate variability especially in semi-arid areas such as Voi sub-County.

## 2.4 Use of Seasonal Climate Forecast by Smallholder Farmers in Agricultural Decision-making

Climate has a great impact on agricultural production and therefore the main challenge is for farmers to make appropriate management decisions in the face of existing climate variability. Adoption of seasonal climate forecast depends on the variables being forecasted, the quality and the likely benefits of the forecasts and the manner in which the forecast is communicated (Ash, McIntosh, Cullen, Carberry& Smith, 2007). Seasonal climate forecast can greatly improve agriculture if the timing and reliability of the forecast are improved (Faures*et al.*, 2010). An early provision of seasonal climate forecast with sufficient lead-time can enable farmers adjust most of the agricultural decisions thus contributing to efficient agricultural management practices (Apipattanavis, Bert, Podesta&Rajagopalan, 2010).

It is generally difficult to assess the adoption and effects of information-based seasonal climate forecast since it is not observable material and therefore a researcher has to rely on self-reporting by the respondents (Hayman *et al.*, 2007). Confusion may also arise among the respondents on the distinction between weather forecast, seasonal climate forecast and general climatology of a given region. This makes many farmers not to alter their farm management decisions in line with the forecast despite their inherent advantages (McIntosh *et al.*, 2007).

Seasonal climate forecasts have been used in many parts of the world in making on-farm agricultural decisions. Many studies show that seasonal climate forecast has been used with great success in Australia since late 1980s (Ash *et al.*, 2007; George *et al*., 2007; Hayman *et al.*, 2007; Motha, 2007). Similarly, seasonal climate forecasts have been used in North America with USA National Oceanic and Administration's Climate Prediction Centre (NOAA/CPC) issuing forecast to farmers on regular basis (Schneider &Garbrecht, 2006). In the sub-Saharan Africa many farmers, especially large-scale commercial ones, have used seasonal climate forecast in their major agricultural decision-making with remarkable success (Oyakale, 2015; Klopper*et al*., 2006; WMO, 2002).

In Kenya Seasonal climate forecast information issued by KMS has been used by farmers especially those who practice commercial farming in planning their activities (Macharia*et al*., 2012). This information is usually issued directly to these farmers due to their heavy investments in agriculture. Seasonal climate forecast information has been used as one of the strategies proposed by National Climate Change Response Strategy (NCCRS) in dealing with climate variability in Kenya and the advisory given by KMS supposed to guide end-users, especially farmers, in making appropriate on-farm decisions (RoK, 2010a). In order to improve communication of SCF to farmers, KMS has come up with other ways of passing the information other than the traditional methods of using the mass media. Use of short messages via mobile phones is one of the methods being piloted.

## 2.5 Constraints to Use of Seasonal Climate Forecast by Smallholder Farmers in Agricultural Decision-making

Although it is generally true that seasonal climate forecasts have enormous value, many constraints prevent their optimal use, mainly due to the manner in which the forecast are produced, disseminated, interpreted and applied in varied decision-making processes (Klopper*et al*., 2006). Despite the availability of modern seasonal climate prediction software, the final product has not been widely adopted especially among the marginal groups and lacks immediate effects to end-users due to uncertainties involved as well as difficulties in downscaling and interpreting the forecasts (Garbrecht& Schneider, 2007; Ziervogel, Bithell, Washington & Downing, 2005). In assessing the usefulness of seasonal climate forecast model, Power *et* *al.*(2007) noted that usefulness of forecast derived from climatic models is hindered by factors such as low skills and awareness, mismatch between model forecast and users' needs as well as the complexity and probabilistic nature of the information. In a study conducted on the role of climate education in agriculture among Australian farmers, George *et al*. (2007) established that many farmers lack formal education on use of SCF with those trained having attended only a one-day course. A wide institutional gap, therefore, exist between the producers and the users of seasonal climate forecast (Faures*et al.*, 2010).

Use of imperfect models and averaging of climatic conditions using GCM cells may depict a different climatic zone from the real one (Baigorria*et al.*, 2008). Downscaling of seasonal climate forecast to a specific area is important since even a village cannot be treated as homogenous (Ziervogel*et al.*, 2005). Despite abundance of seasonal climate forecast information in some countries such as USA and Australia, its adoption has been a challenge due to inappropriate site-specific applications (Garbrecht& Schneider, 2007). Furthermore, the impacts of seasonal climate forecast dissemination on better-off and poor households are not the same due to their different response capabilities.

Unreliability of seasonal climate forecasts due to perceived inaccuracy has also been a major hindrance to the uptake of seasonal climate forecast information (Meza &Wilks, 2008). While looking at the need for the generation, dissemination and evaluation of seasonal climate information for targeted groups in Australia, George *et al.* (2007) noted that seasonal climate forecasts' accuracy is a confounding obstacle to the application of the forecasted information in agricultural management.

Another major challenge in the adoption of seasonal climate forecast in agricultural decision-making is the inability by the forecasts generators to demonstrate advantage of using the information. This is due to the fact that seasonal climate forecast is just information and not tangible good where trials can be done to test compatibility with the existing practices in the farm before application (Cabrera, Letson&Podesta, 2007). The forecasts also tend to dictate the type of crops farmers can grow, which is unpopular among many farmers. Hayman *et al*., (2007) noted that integrating seasonal climate forecasts into farming decisions is a challenge by establishing that only 30 - 50% of Australian farmers use climate forecast despite the wide-spread dissemination.

Trust of seasonal climate forecast information by smallholder farmers especially in the sub-Saharan Africa is still low due to perceived forecast errors. A study carried out in Lesotho to assess the impact of anticipated information model on the trust of seasonal climate forecast by end-users found out that forecast errors have negative impact on trust and therefore forecasters ought to inform users of the uncertainties of the forecast (Ziervogel*et al.*, 2005). Despite much efforts in generation and dissemination of climate forecasts on seasonal basis through Climate Outlook Forums (COFs) in the Great Horn of Africa, the forecasts are usually not objectively integrated in application model for decision-making process by end-users such as smallholder farmers in many areas (Coelho & Costa, 2010).

In Kenya, especially in semi-arid regions like Voi sub-County, studies show that seasonal climate forecasts uptake is faced by many challenges. The forecasts are usually less trusted and especially when major forecast errors occur in terms of deviation of the forecasts from the observed seasonal climatic conditions. Also the forecast information is issued by KMS in general terms, in unclear language and on large geographical region making smallholder farmers unable to comprehend and interpret it (Dessai*et al*., 2009; Recha*et al*., 2008).

## 2.6 Gaps in the Literature

Seasonal climate forecasting is done using global and regional forecasting models which give forecasts over a large geographical area and in probabilistic manner. It is therefore important to assess the quality of these forecasts by comparing the forecasts and the observed climatic conditions as a way of providing a feedback to the forecasting communities.

Studies have shown that many farmers perceive seasonal climate forecast information as untruthful due to their perceived inaccuracy. The uncertainty of forecasts has led to poor attitude by farmers towards them thus making manyignore them in agricultural decision-making. Noting that the science of seasonal climate forecasts generation has improved over time, it is important to establish whether the perception of inaccuracy and untruthfulness still persist among smallholder farmers, especially in semi-arid areas, hence this study.

Seasonal climate forecasts are disseminated and used world over as an adaptation strategy to climate variability. As a location-specific study, this study sought to assess uptake of seasonal climate forecast on a specific area and time which will contribute to the understanding of its usefulness in agricultural decision-making. Adaptation to climate variability varies with space and time and no study has been done to show use of seasonal climate forecasts in Voi sub-County.

There are views that hindrance to success in the application of SCF information in agricultural decision-making is caused by failure of GCMs and the variability of seasonal climate forecast over a large geographical region. No study has been done to show specific constraints in use of SCF information in Voi sub-County. As a location-specific study, this study therefore sought to single out a wide range of specific farm-level hindrances to use of seasonal climate forecasts in reducing vulnerability to climate variability in semi-arid areas.

## 2.7 Theoretical Framework

Dissemination of any effective information depend on the method used, the credibility of the information and its timing (Oyakale, 2015). According to Ziervogel (2004), integration of information in decision-making is based on both external and internal factors (filters), decision options and impactsof the information as shown in Figure 2.1.

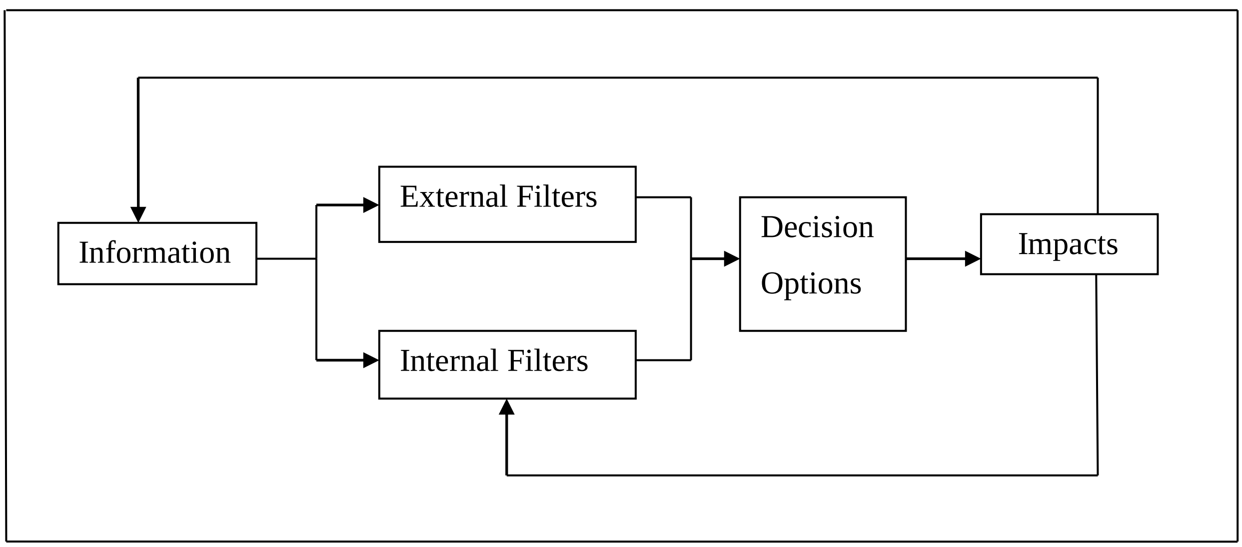


**Figure 2.1: Flow of Information for Decision-making**

*Source: Ziervogel, 2004.*

Eternal filters are the resources available which influence response to the information while internal filters are factors such as indigenous knowledge and past experience.The integration of external and internal filters determines the usefulness of information where decisions are made based on the information received and usefulness reflected on its impacts.

Use of SCF information by farmers will therefore depend on their judgment on its quality, availability of resources to implement it and the perceived associated risks. The impact of the information (positive or negative) will influence future perception and consequent use.

Since the scope of this study did not include assessing impacts of SCF information, it was, therefore, anchored on “The Basics of Information Theory” (Hirshleiter& Riley, 1992). This theory shows the value of information in helping people cope with uncertainty. When making choice of resource allocation in the face of uncertain future events or state of nature that affect productivity of different alternatives available, information is important. The value of exogenous information depends on the correlation between the information and the state of uncertainty of future events or the state of nature.

Information received is perceived as capable of changing one’s subjective perception of uncertain state of nature thus underscoring the need of confidence in seasonal climate forecast information received. Constraints make one’s optimal decisions to vary depending on one’s subjective perception of uncertain future events or state of nature. The value of information is equal to the expected change resulting from optimal decisions made in line with the new information in hand. According to this theory what matters is whether decisions are subject to uncertain future change but not whether there is change in outcomes since the latter depend on *ex post* realization of the state of nature.

According to Hirshleiter& Riley (1992), the key variables of the Basics of Information Theory are exogenous information, subjective perception, optimal decisions and uncertain future events or state of nature. In the proposed study the exogenous information is the seasonal climate information disseminated by Kenya Meteorological services before rainfall seasons. Subjective perception is the way smallholder farmers perceive rainfall seasons in terms of onset, amount and cessation based on indigenous knowledge and past experience. Optimal decisions are the agricultural decisions which smallholder farmers make in line with expected seasonal climatic conditions such as change in planting time, cultivars to be grown and farm inputs to be acquired. Uncertain future events or state of nature is climate variability in which smallholder farmers use seasonal climate forecast to adapt to. Therefore, the study is based on the concept that smallholder farmers make decisions on agricultural activities based on the SCF information available, the way they perceive the information and past experience of outcomes of similar decisions.

## 2.8 Conceptual Framework

The framework is based on the understanding of the role played by seasonal climate forecast information in agricultural decision-making. The independent, intervening and dependant variables are used as guidelines for conducting the study where seasonal climate forecast information and non-climate factors determine agricultural decision-making by smallholder farmers as shown in Figure 2.1.

In this study, independent variables are the seasonal climate forecast information components which include onset dates, cessation dates and amount of seasonal rainfall. These variables influence the dependent variables which include choice of cultivars, land preparation time, planting time and farm inputs acquisition. To use seasonal climate forecast information in agricultural decision-making, smallholder farmers need knowledge and information on the expected seasonal climate conditions. Effectiveness of seasonal climate forecast information depends on the intervening variables which include the existing institutions, farmers' indigenous knowledge, socio-economic characteristics, past experience and attitude.

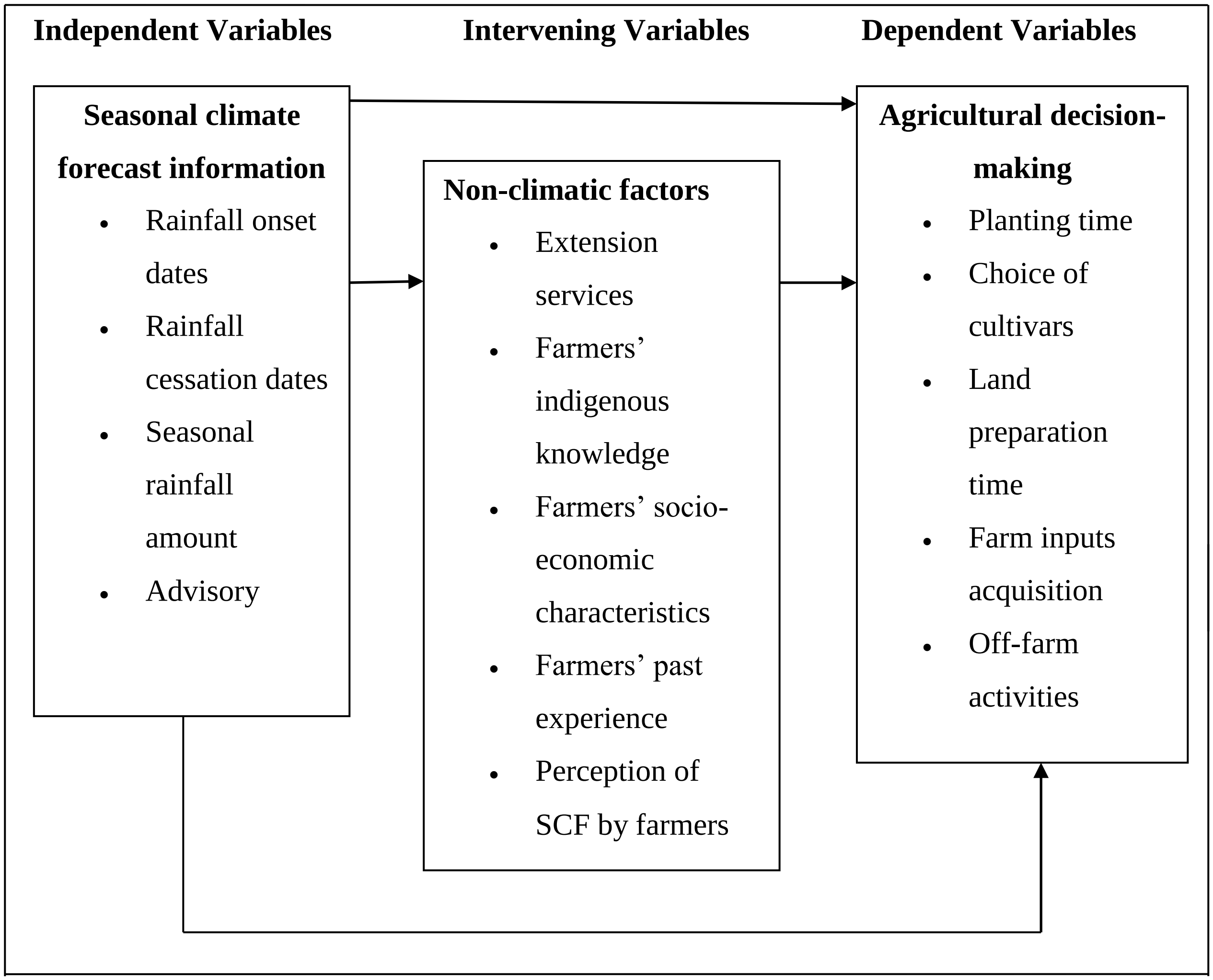


**Figure 2.2: Conceptual Framework**

*Source: Adapted from Hirshleiter& Riley, 1992.*

# CHAPTER THREE
# RESEARCH METHODOLOGY

## 3.1 Introduction

This sectionpresents the following sub-sections: description of the study area, research design adopted by the study, the sampling procedure and sample size used. It also indicates the methods of data collection and analysis, evaluation of validity and reliability of research instruments used during the study, ethical consideration of the study and methods of data analysis used.

## 3.2 Study Area

Voi sub-County (Figure 3.1) is found in TaitaTaveta County in the coastal region of Kenya. It is divided into six administrative locations namely Mbololo, Ngolia, Sagalla, Voi, Marungu and Kasigau. It lies within latitude $2^0$42´S and $4^0$08´S and longitude $37^0$41´E and $39^0$14´E covering an area of 3,269.1 $Km^2$(RoK, 2010b). It borders Makueni and Kitui Counties to the North, Kilifi County to the East, Kwale County to the South and Mwatate sub-County to the West. Tsavo National Park occupies about 55% of the sub-County. The sub-county has a population of 87,803 with an inter-censal growth of 1.6% (RoK, 2010b). Most of the population is rural-based with Voi being the major town in the sub-County.

The sub-County is found in altitude ranging from 250 metresabove sea level in the lowlands to about 850 metres above sea level at the peak of Sagalla hill. Mbololo Location is generally lowland as compared Sagalla location whose topography is generally rugged. Sagalla hill, which is found in Sagalla Location, has a considerable influence on the climatic conditions in the area making the Location wetter than Mbololo Location.

The study area is generally dry with an average temperature of $25^0$ C and a mean annual rainfall of about 500mm. Rainfall is received in two seasons; long rains between March and May and short rains between October and December. The short rains have an average of about 290mm as compared to the long rains whose average is about 180mm and therefore the short rains are more reliable for smallholder farming (RoK, 2013b). The rains received are generally erratic in terms of onset, amount and cessation. This has led to low agricultural productivity and even crop failure for the last five years in the sub-county (RoK, 2013b)

The main soil types are luvisols, kastanozems and ferrasols which are deep dark-red well drained low to moderate fertile soils (RoK, 2013b). Most of these soils are sedimentary types whose origin is volcanic activities which took place in the region. The sub-County stretches up to Yatta plateau to the North which has volcanic lava flow rocks.

The area covered by the sub-County is well drained. The major rivers in the area are Voi and Galana found in Tsavo National Park. Mzima spring, which is the main source of water for Mombasa town, is also found in the sub-County. There are numerous small seasonal streams across the sub-County which provide water to the population during the rainfall seasons.

The main economic activity carried out in the sub-County is small-scale farming where major crops grown are maize, beans, sorghum, cowpeas, millet, cassava and green grams (RoK, 2013b). Small-scale farming is mainly carried out in Sagalla and Mbololo Locations as compared to the other locations where commercial sisal farming and ranching practices are predominant land use activities.

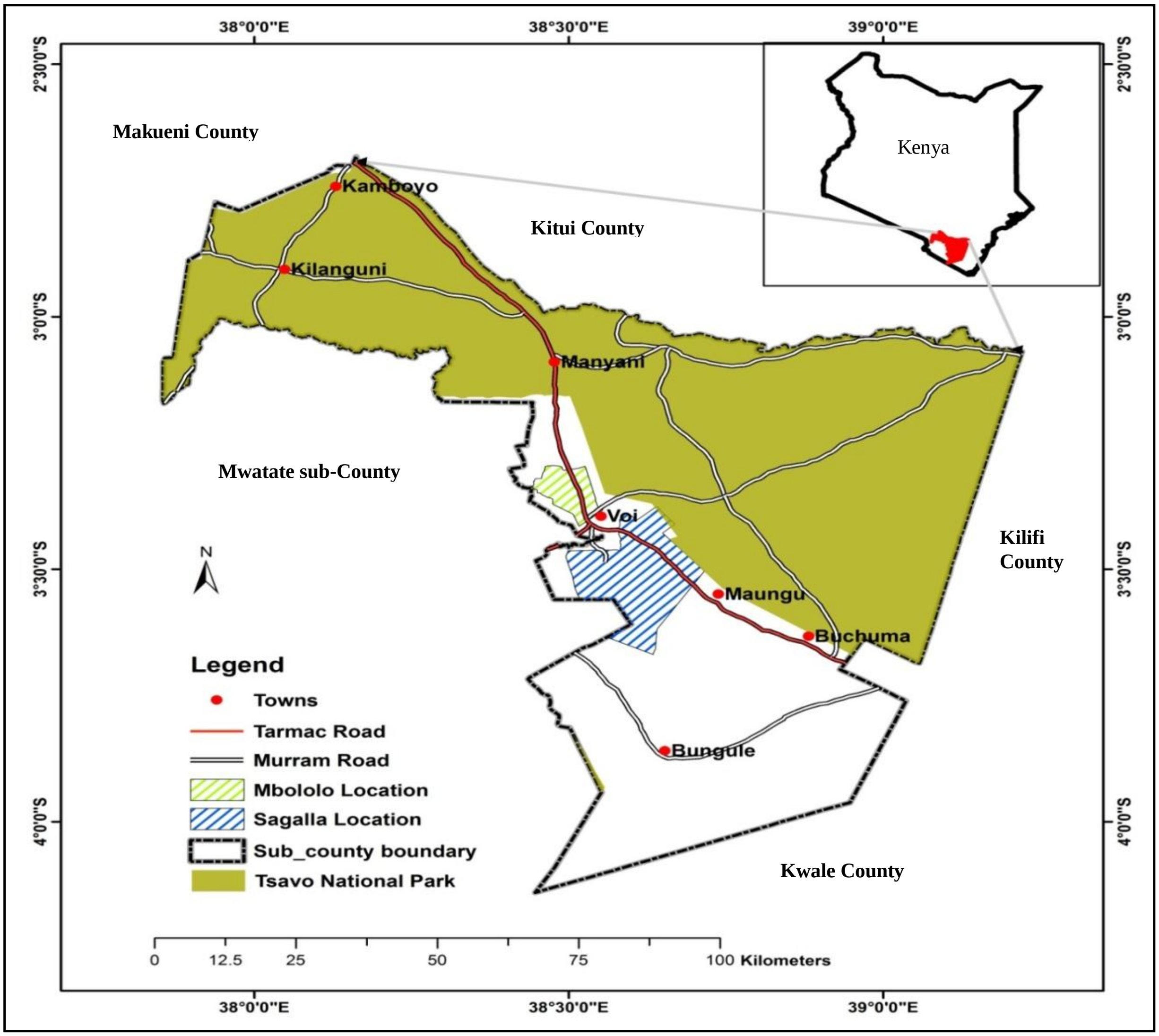


**Figure 3.1: Map of the Study Area: Voi sub-County**

*Source: The Independent Electoral and Boundaries Commission, 2012.*

## 3.3 Research Design

The study used a survey research design where a researcher selects a sample of respondents from a given population for detailed study. Surveys are ideally suitable for describing characteristics of large population as its relatively inexpensive and therefore large samples are feasible (Mugenda&Mugenda, 2003). The survey research design entailed sampling of households and Key Informants to provide information on use of seasonal climate forecast information in agricultural decision-making and challenges faced in the dissemination and use of the information.

## 3.4 Sampling Procedure and Sample Size

Two study Locations -Sagalla and Mbololo, were purposively selected from the six Locations in Voi sub-County due to availability of many smallholder farmers when compared to the other four Locations. Another reason for selecting the two Locations was to ensure that mitigation of the effects of scale on quality of seasonal climate forecasts was achieved as they are found near Voi Meteorological Station.

The target population included all smallholder farming households found in Mbololo and Sagalla administrative Locations. A complete list of all smallholder farming households was drawn through the assistance of the Chiefs of the two Locations and used to develop the sample frame where a sample of 246 households was selected for the study. This represented five per cent of the total 4,917 households in Sagalla (2756) and Mbololo (2161) Locations according to 2009 Kenya population and housing census (RoK, 2010b). A relative small sample size of five per cent can be used when the population under study exhibit fairly homogenous socio-economic characteristics as of the case in Mbololo and Sagalla Locations (Neuman, 2007; Mugenda&Mugenda, 2003). Random sampling was used to pick required samples from the two Locations proportionately as shown by the formula below:

$n = P/N \times 246$

where:

$n$ – sample population for the Location

P – population of the households in the Location

N –total households in the two Locations

Sagalla Location: $n = (2{,}756/4{,}917 \times 246) = 138$ households

Mbololo Location: $n = (2{,}161/4{,}917 \times 246) = 108$ households.

Five key informants were also purposively sampled. These comprised of two agricultural extension officers and two Chiefs, one picked from each of the study Locations and one meteorologist picked from Voi meteorological station. Voi meteorological station was purposively sampled since it is found close to the two study sites and is one of the major synoptic stations in Kenya. Other rainfall stations in the study area are found in Sagalla ranch and Taita sisal estate in Sagalla Location and in Mwakikiseed farm and Rukanga-Kasigau estate in Mbololo Location. However these stations do not provide reliable rainfall data since they are on privately owned premises and measurement and recording of rainfall data is made on voluntary basis. KMS forecast for OND 2015 rainfall season was purposively sampled since the study was to be based on one rainfall season due to time constraints and also due to the fact that OND rains are the most reliable for rain-fed agriculture and has a high skill of prediction compared to MAM (Cooper *et al*, 2008; Hansen &Indeje, 2004).

### 3.5 Data Collection

Questionnaire was used to collect data at household level. The questionnaire was used to collect information on smallholder farmers' perception of quality of seasonal climate forecast information, their use and constraints to its use. It was pre-tested in the neighbouringMwatate and Ronge Locations which has similar climatic characteristics to the study sites so as to adjust and clarify unclear questions. While there were specific questions (closed questions) in the questionnaire, there were also questions which were open-ended requiring the respondent to give his or her opinion about the study topic. Questionnaires are reliable in data collection as they enable the researcher get first-hand information and also provide an opportunity for anonymity so as to promote high response rate (Kothari, 2004).

Beside the questionnaire, Interview Schedule was also used to collect data from Key Informants. Key Informant Interview provides in-depth data and an opportunity to clarify issues arising from the interview process (Kothari, 2004). Three secondary datasets were collected and used to determine the quality of seasonal climate forecast for OND 2015 issued by KMS. Observed daily rainfall data for OND 2015 season and monthly OND rainfall data for the period 1985 – 2014 were obtained from Voi meteorological station. Seasonal climate forecast information for OND 2015 was downloaded from KMS website after its release. Other secondary data were obtained from published books, relevant journals, theses and policy research working papers.

Research assistants were taken through a one day training session by the researcher on the interpretation of the items in the questionnaire before the pre-testing exercise. They were also trained on the procedure of administering the questionnaire and how to gauge accuracy/biasness of responses.

### 3.6 Validity and Reliability

Validity refers to the extent to which the instrument used in research measures what it is supposed to measure therefore leading to accurate and meaningful inferences (Kothari, 2004;

Mugenda&Mugenda, 2003). The questionnaire, which was the main instrument of data collection for this study, was validated through content validity method. This involved the supervisors reviewing it to determine whether the items it contains would yield results appropriate for the study. Validity was also justified by other literature related to this study.

Reliability on the other hand is the extent to which any measuring procedure yields the same results on repeated trials (Neuman, 2007). To test the reliability of the instrument, a pilot study was conducted in the neighbouringMwatate and Ronge Locations with similar climatic characteristics to the study area. Questionnaires were administered to 20 randomly picked smallholder farmers (10 from each Location) and the Cronbach alpha test of reliability was run on the collect data.

### 3.7 Ethical Consideration

Before the study was conductedresearch authorization (appendix III) and a research clearance permit (appendix IV) were obtained from National Commission for Science, Technology and Innovation (NACOSTI) to authorize the study. Permission was also sought from the local administration and other institutions such as Voi meteorological station and agricultural offices within the study area. All the respondents were also assured of confidentiality of the information they provided for the study as indicated in the preamble of the questionnaire (appendix I and appendix II).

### 3.8 Data Analysis

The data collected (primary) was first edited to check for errors and omissions. It was then coded and keyed into a computer for subsequent analysis. Analysis was done using both descriptive and inferential statistics using Statistical Package for Social Studies (SPSS) version 20.0 computer software. Mean (normal) rainfall for OND in Voi sub-County was obtained by analyzing monthly rainfall data for OND for the period 1985 – 2014 acquired from Voi meteorological station. Analysis of rainfall data for the last 30 years (1985 – 2014) was done to meet the WMO standard of climatological data analysis.

Descriptive statistics were used to give the general view of the smallholder farmers' use to SCF in agricultural decision making. One sample Chi-square (Chi-square goodness of fit) was used to analyze smallholder farmers' perception of quality of SCF. This is because it is a statistical tool that can be used to determine if the observed frequencies are significantly different from the expected frequencies (Neuman, 2007). The test was, therefore, used to find out whether there is a significant difference in the perception of the quality of OND 2015 SCF from KMS among smallholder farmers in Voi sub-County.  Correlation was used to find out the relationship between the smallholder farmers' socio-economic characteristics and use of seasonal climate forecasts. Table 3.1 provides a summary of the study variables and analytical procedures.

**Table 3.1: A Summary of Data Needs, Measurable Variables and Methods of Analysis**

| Objective | Data required | Source | Measurable variables | Data analysis & tool |
|---|---|---|---|---|
| Evaluate smallholder farmers' perception of the quality of seasonal climate forecasts from KMS for Voi sub-County | • Household responses on perception of quality of SCF<br>• OND 2015 forecast | • Household questionnaire | • Rating of quality of seasonal climate forecasts | • Descriptive statistical analysis – SPSS<br>• Chi-square – SPSS |
| Establish smallholder farmers' use of seasonal climate forecasts in agricultural decision-making in Voi sub-County | • Household responses on their response to OND 2015 SCF<br>• OND 2015 forecasts | • Household questionnaire<br>• KMS headquarters | • Response to OND 2015 SCF (land preparation, acquisition of farm inputs, choice of cultivars) | • Descriptive statistical analysis – SPSS |
| Determine constraints to use of seasonal climate forecasts in agricultural decision- making among smallholder farmers in Voi sub-County | • Household responses on constraints to use of SCF<br>• OND 2015 forecast | • Household questionnaire<br>• Key informant interview<br>• KMS headquarters | • Quality of the forecast<br>• Access to SCF<br>• Availability of support programmes (e.g extension)<br>• Farmers' characteristics (e.g age, income etc.) | • Descriptive statistical analysis – SPSS<br>• Correlation analysis - SPSS |

***Source: Author, 2015***

# CHAPTER FOUR

# RESULTS AND DISCUSSIONS

## 4.1 Introduction

This chapter presents findings on validity and reliability tests on the questionnaire, response rate, socio-economic characteristics of the respondents and rainfall characteristics of the study area. It also gives detailed analysis of each specific objective of the study.

## 4.2 Validity and Reliability Results

The questionnaire was found to be valid upon its validation through content validity method. The Cronbach alpha test of reliability yielded a 0.85 coefficient – a reliable results (Mugenda&Mugenda, 2003).

## 4.3 Response Rate

The study had set out to collect data from 246 farmers representing five percent of the total smallholder farming households in proportions of 138 from Sagalla and 108 Mbololo Locations of Voi sub-County. However, only 204 respondents - 114 from Sagalla and 90 from Mbololo - provided reliable information which was used in analysis. The main reason for decrease in the response rate was due to incompleteness of questionnaires. This response rate represents 82.9% of the total sampled respondents which is high and acceptable in social research (Neuman, 2007).

## 4.4 Socio-economic Characteristics of Respondents

This section presents findings on socio-economic characteristics of the respondents. This provides the basis of understanding how seasonal climate forecast is perceived and used in Voi sub-County.

### 4.4.1 Gender of Respondents

Gender of respondents was analyzed. The results are shown in Figure 4.1

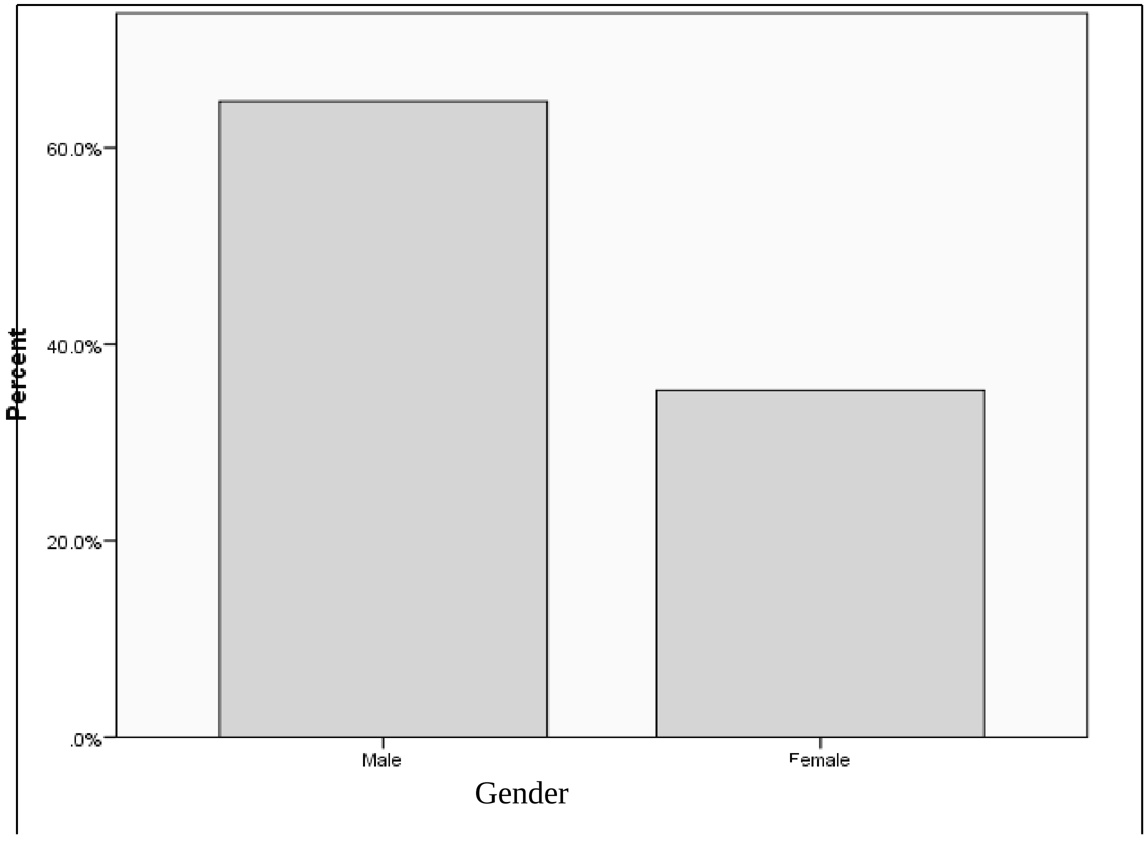


**Figure 4.1: Gender of Respondents in Voi sub-County**

*Source: Survey Data, 2015*

There were more (63.7%) male respondents (household heads) as compared to their female counterpart (36.3%) as shown in Figure 4.1. This is close to the national statistics which stands at 70% for males and 30% for females headed households (RoK, 2006). The variation between study findings and the national statistics is likely to be caused by the rural-urban migration of the males in search for employment.This suggests that agricultural decisions in Voi sub-County are mainly done by males.

### 4.4.2 Age of Respondents

The age of the respondents was cross tabulated with the residential location. The results are shown in Table 4.2

**Table 4.1: Distribution of Age among Households in the Study Area (N=204)**

| Age category | Frequency | Percentage | Cumulative |
|---|---|---|---|
| below 20 | 5 | 2.5 | 2.5 |
| 20 - 29 | 18 | 8.8 | 11.3 |
| 30 - 39 | 47 | 23.0 | 34.3 |
| 40 - 49 | 57 | 28.0 | 62.3 |
| 50 - 59 | 28 | 13.7 | 76.0 |
| over 60 | 49 | 24.0 | 100.0 |
| Total | 204 | 100.0 | |

*Source: Survey Data, 2015*

Results in Table 4.1 shows that 62.3% of the respondents were aged below 50 years and only 24.0% were above 60 years. This generally implies that Voi sub-County has a population in its most productive stage, important in agricultural production. In addition, adoption of technology in most cases is high among the young as compared to the aged who seem to be rigid to change (Comin and Hobija, 2010). Therefore, smallholder farmers in Voi sub-County were expected to adopt the OND 2015 SCF information in agricultural decision-making.

### 4.4.3 Reason for Farming

The study sought to find out reasons why the respondents engaged in farming. This was to confirm the main reason for smallholder farmers engaging in farming. The results are shown in Figure 4.2.

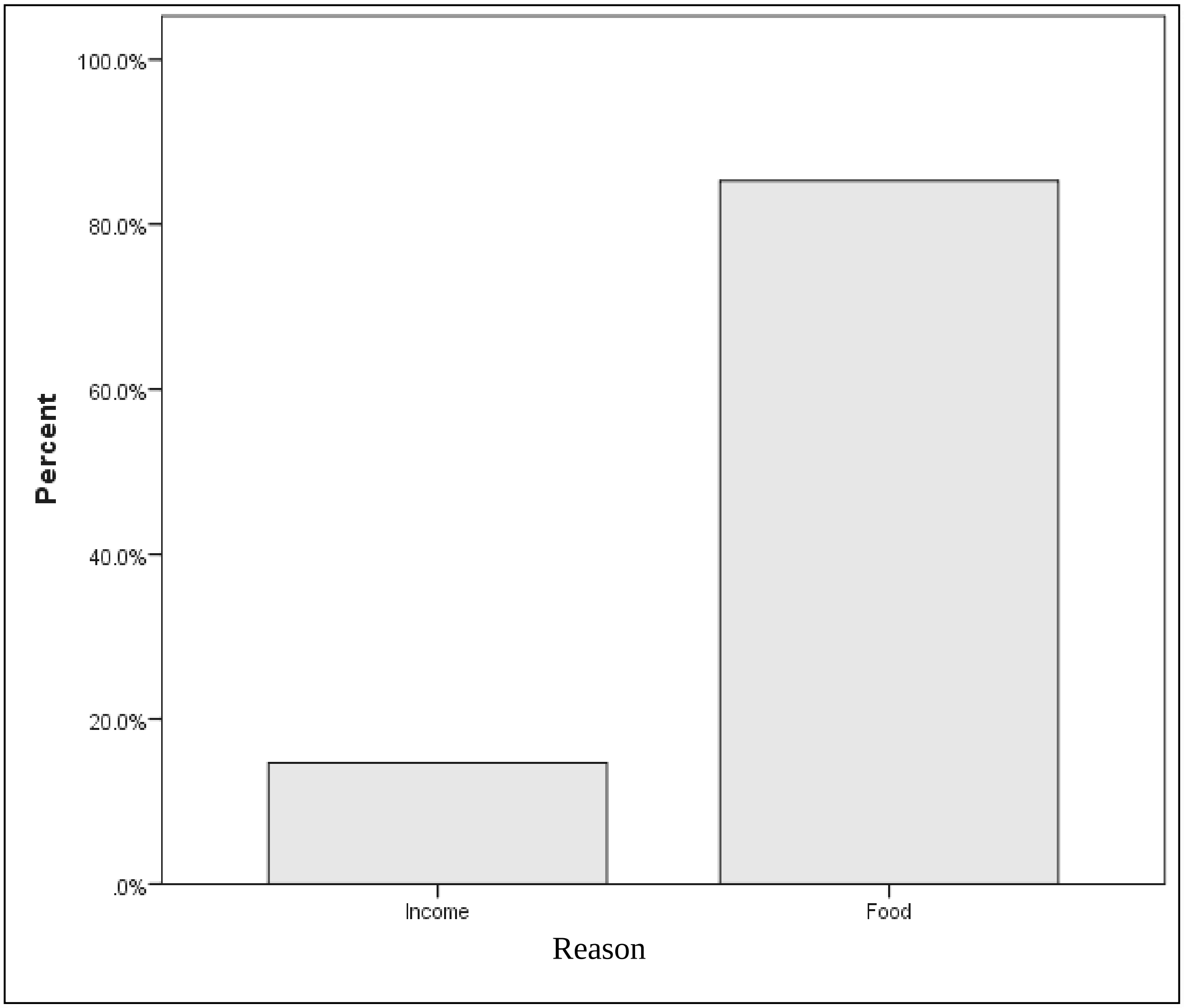


**Figure 4.2: Reasons for farming by smallholder farmers in Voi sub-County**

*Source: Survey Data, 2015*

Agriculture in Voi sub-County is done mainly for subsistence purpose as shown by Figure 4.2 with over 80% of respondents indicating that they do farming for food compared to less than 20% doing it for income purpose. This supports the fact that smallholder farmers are mostly concerned with farming for food self-sufficiency purpose. This approach, however, needs to change. There are increasing efforts by stakeholders in the agricultural sector where farming need to be approached as a source of income – an approach that can potentially increase yields and poverty among ASALs households.

### 4.4.4 Education Level of Respondents

The study sought to establish the education level of respondents. The results are shown in Table 4.3.

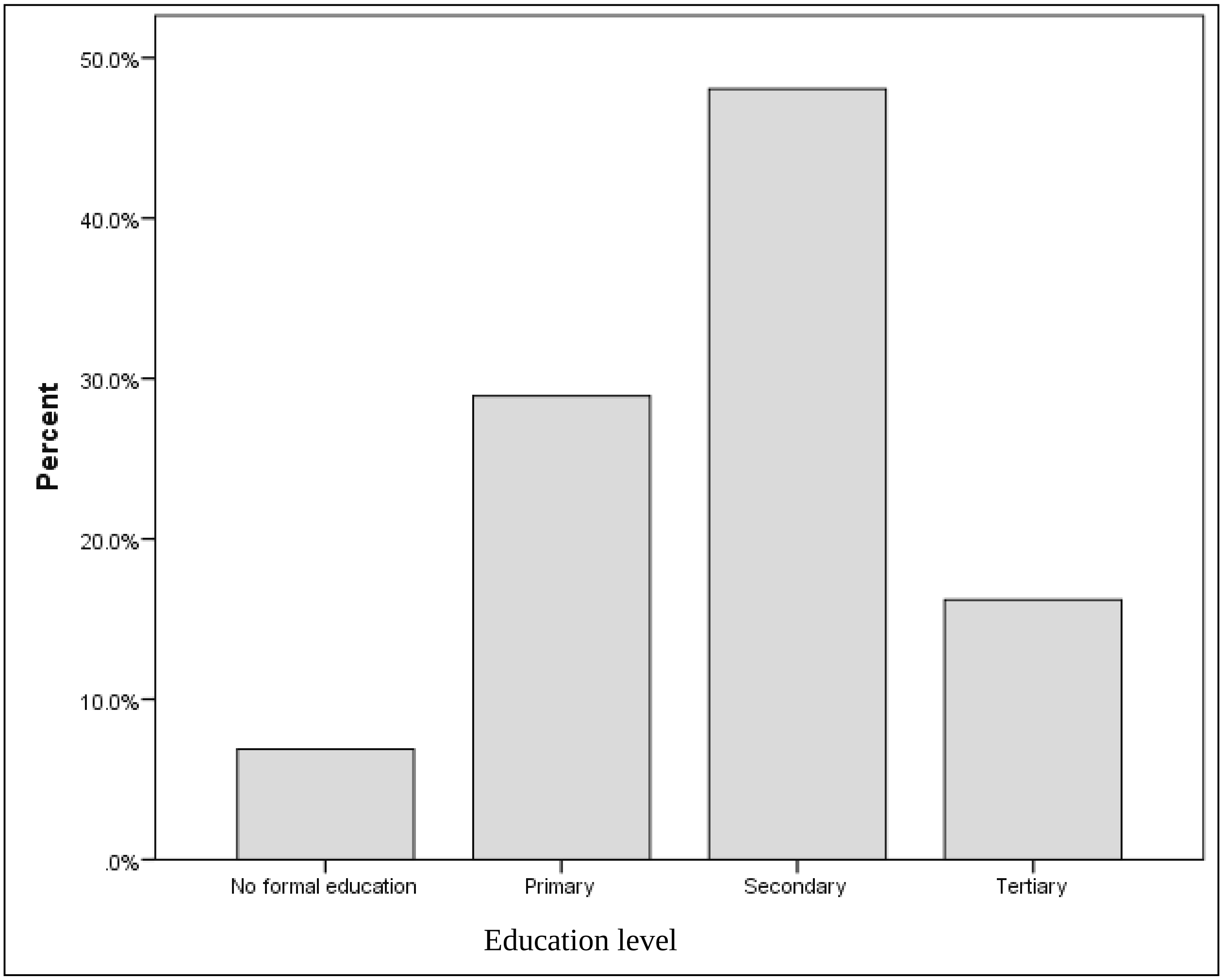


**Figure 4.3: Education level of smallholder farmers in Voi sub-County**

*Source: Survey Data, 2015*

It is shown in Figure 4.3 that most of the respondents had attained secondary and tertiary education. There is a positive relationship between education level and adoption to new information (Comin and Hobija, 2010). Smallholder farmers in Voi sub-County are, therefore, likely to adopt SCF information in agricultural decision-making given their relative high level of education.

### 4.4.5 Farm Sizes

The study also compared the acreage of land under farming in the two Locations. The results are presented in Table 4.4.

**Table 4.2: Household Farm Sizes in Voi Sub-County (N=204)**

| Farm size | | Location | | Total | Cumulative |
|---|---|---|---|---|---|
| | | **Sagalla** | **Mbololo** | | |
| Below 1 acre | Count | 11 | 39 | 50 | 50 |
| | % of Total | 5.4% | 19.1% | 24.5% | 24.5% |
| 1 -3 acres | Count | 80 | 39 | 119 | 169 |
| | % of Total | 39.2% | 19.1% | 58.3% | 82.8% |
| 3 - 5 acres | Count | 12 | 8 | 20 | 189 |
| | % of Total | 5.9% | 3.9% | 9.8% | 92.6% |
| 5 and above acres | Count | 11 | 4 | 15 | 204 |
| | % of Total | 5.4% | 2.0% | 7.4% | 100% |

*Source: Survey Data, 2015*

Generally smallholder farmers in Voi sub-County own small size farms. From Table 4.2 82.8% of the farmers own three and below acres of farms. Smallholder farmers in Sagalla Location have larger farm sizes (above 3 acres) as compared to their counterparts in Mbololo Location. This is likely to be attributed to the relatively wetter conditions in Sagalla Location as compared to Mbololo Location due to presence of Sagalla hill.

## 4.5Rainfall Characteristics and October-November-December 2015 Seasonal Climate Forecast for Voi Sub-County

This section presents rainfall characteristics of Voi sub-County starting with a 30-year (1985 – 2014) OND rainfall trend important for calculating the mean OND rainfall. The section also discusses both forecasted and observed OND 2015 rainfall characteristics.

### 4.5.1 October-November-December Rainfall Characteristics for 30 Years (1985-2014)

The mean OND rainfall for Voi sub-County was found to be 296.1mm. This was used as the 'normal' rainfall when interpreting the OND 2015 seasonal climate forecast issued by KMS.

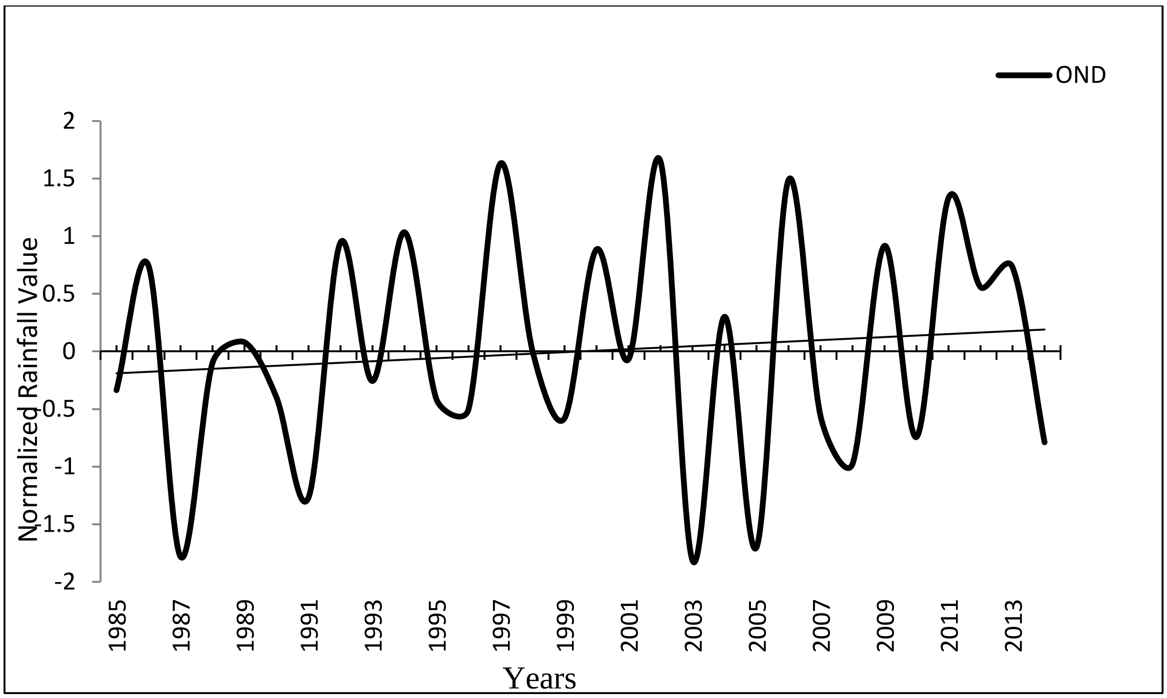


**Figure 4.4: Variation of OND Rainfall from the Mean in Voi**

*Source: Survey Data, 2015*

OND rainfall for the period 1985 – 2014 greatly varies from the mean as shown in Figure 4.4. Three years, 1997, 2002 and 2006, recorded great deviation above the mean while 1987, 2003 and 2005 the deviation was greatly below the mean. This is similar to study findings of Ochieng', 2013, which established that rainfall is very variable in Southeastern Kenya with a decreasing trend in Voi between 1992 and 2011. Likewise, in a study conducted in Southeastern Kenya, Recha*et al.*, 2012 established that rainfall is highly variable for all seasons. However, Figure 4.4 shows that the trend line indicates that the OND rains have not significantly deviated from the mean. With variable climate, there is need for dissemination of SCF information to smallholder farmers and training on its use to enable them to have appropriate adjustments to their farming decisions.

### 4.5.2 October-November-December 2015 Rainfall Forecast by Kenya Meteorological services

KMS released forecast to the press on 1st September, 2015, one month ahead of the OND 2015 season. The forecast showed a likelihood of highly enhanced rainfall during the season. The forecast further indicated that the OND 2015 rainfall season was to be influenced by the evolving El Niño conditions as well as the warming of the SSTs in the western equatorial Indian Ocean adjacent to the East Africa coastline (KMS, 2015). The forecast indicated higher than normal temperatures around the world with increased chance of high OND rainfall in East Africa. KMS issued forecast for OND 2015 indicating onset, cessation and amount of rainfall expected during the season as well as relevant advisory (KMS, 2015). Figure 4.5 shows the rainfall outlook for OND 2015 released by KMS.

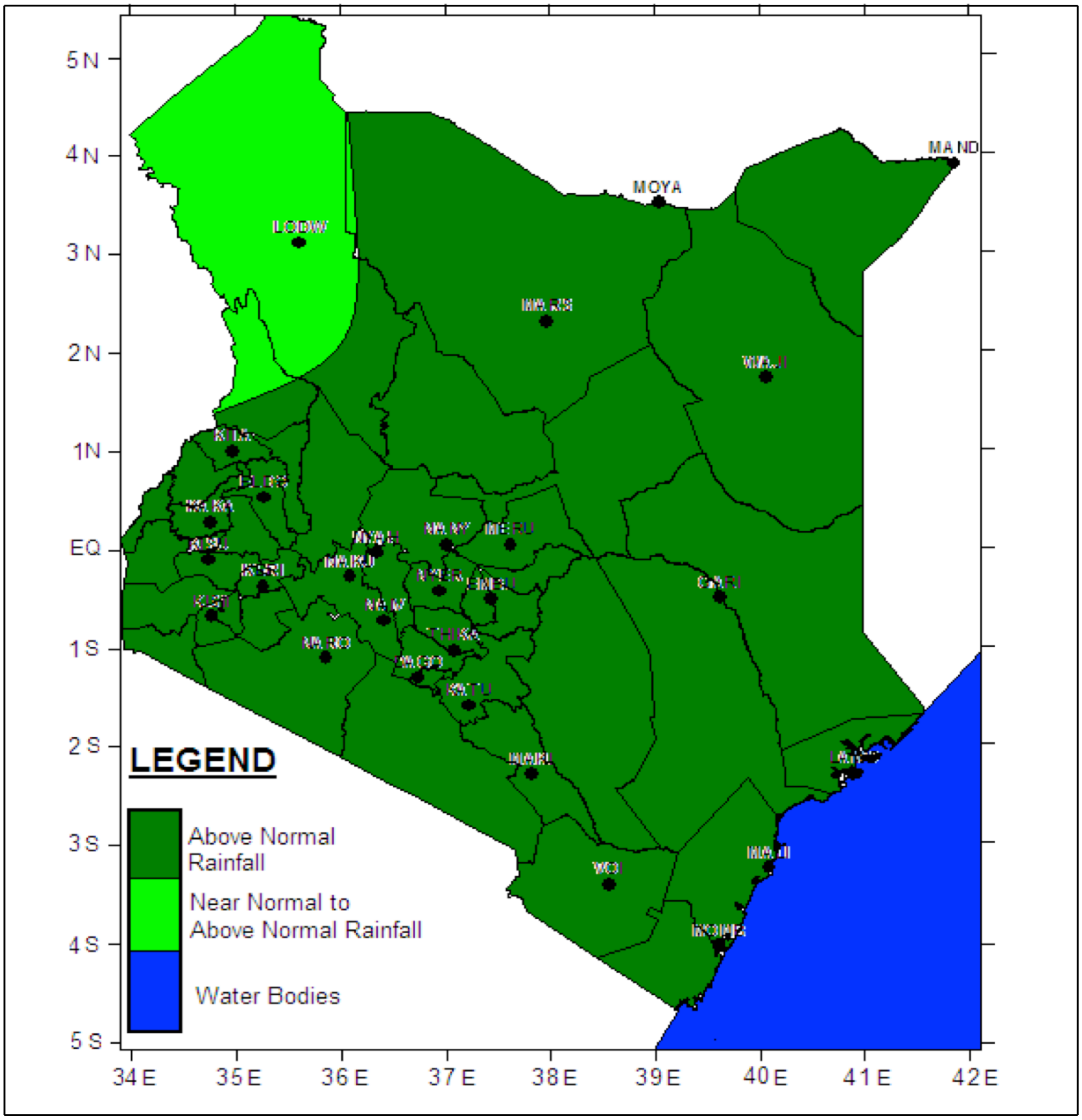


**Figure 4.5: Forecasted Rainfall Outlook for OND 2015 in Kenya**

*Source: KMS, 2015*

Voi sub-County was expected to receive above normal rainfall as shown in Figure 4.5. It therefore means that farmers in the area were to prepare for a growing season with highly enhanced rainfall. KMS advised farming communities to maximize crop yield by applying appropriate land use management. The advisory from KMS read in part;

> "Farmers (should) double their efforts to reap maximum benefit from these good conditions" (KMS, 2015).

Farmers were further advised to work closely with agricultural extension officers for relevant advisories to avoid losses which could arise as a result of the highly enhanced rainfall. KMS had also given rainfall onset dates for the whole country as shown by Figure 4.6.

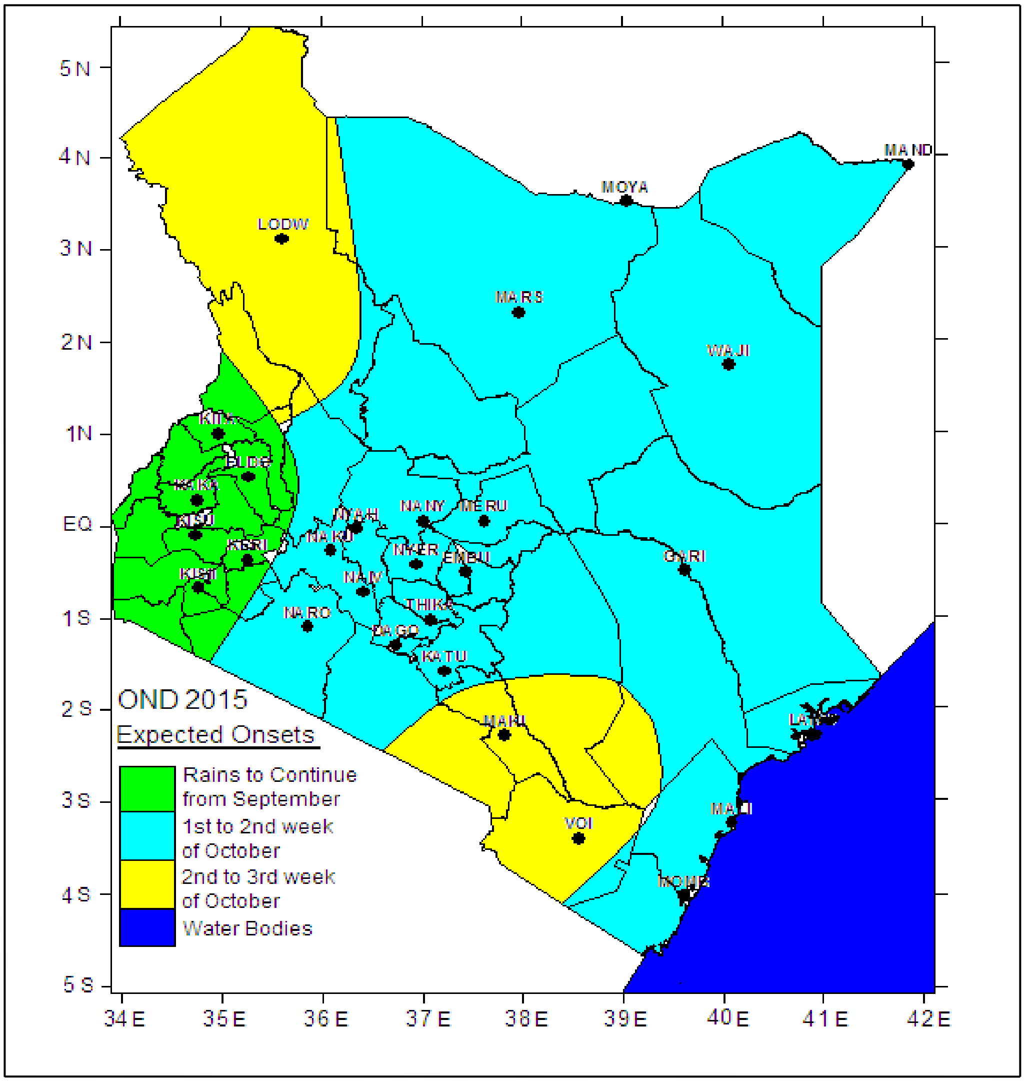


**Figure 4.6: OND 2015 Expected Onset Dates**

*Source: KMS, 2015*

The onset date for OND 2015 rainfall season for Voi sub-County was forecasted to be in the 2nd to 3rd week of October as shown in Figure 4.6. Likewise KMS issued cessation dates for OND 2015 for the whole country as shown by Figure 4.7. The cessation date for OND 2015 rainfall for Voi sub-County was forecasted to be in the 4th week of December.

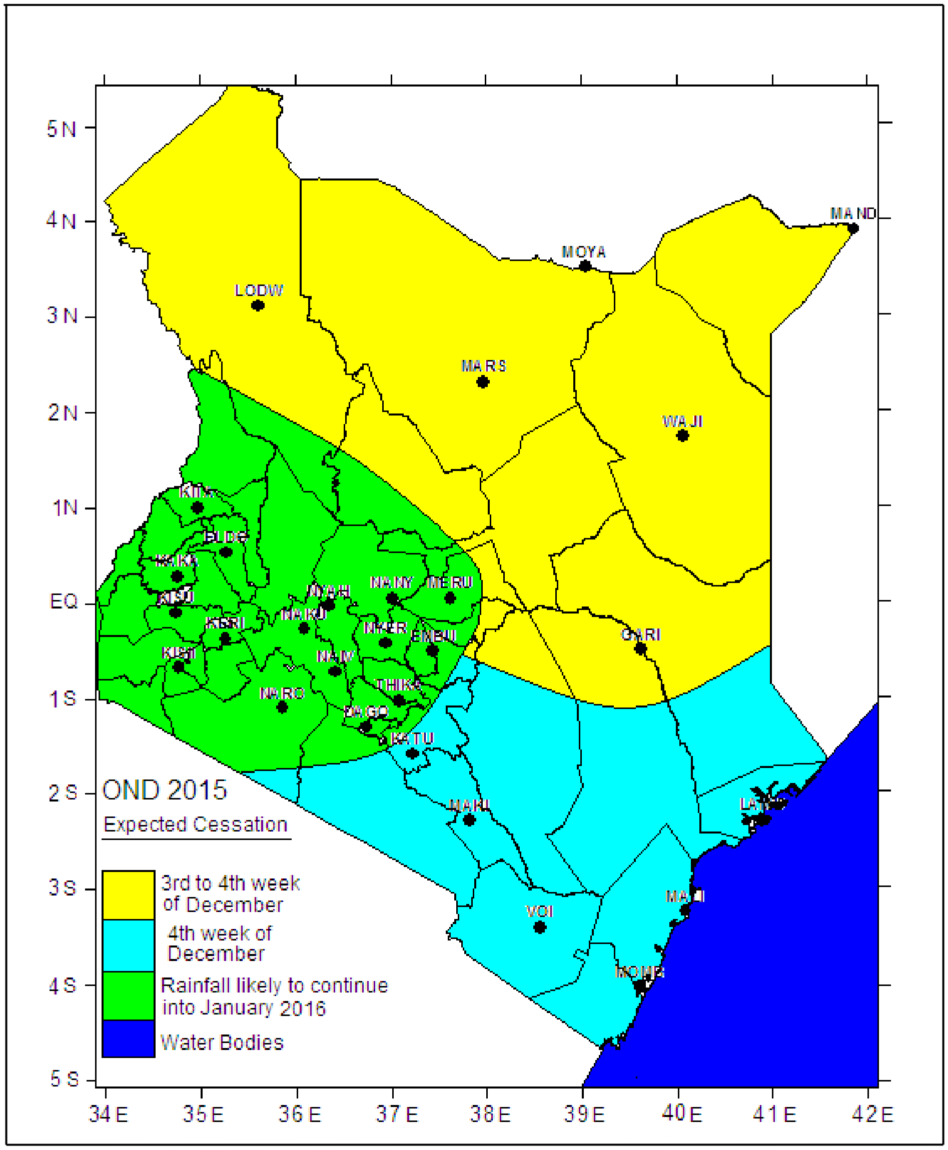


**Figure 4.7: OND 2015 Expected Cessation Dates**

*Source: KMS, 2015*

### 4.5.3 October-November-December 2015 Observed Rainfall in Voi sub-County

Daily rainfall for OND 2015 recorded at Voi meteorological station was obtained and analyzed. Figure 4.8 shows daily rainfall trend for OND 2015 recorded at Voi Meteorological station.

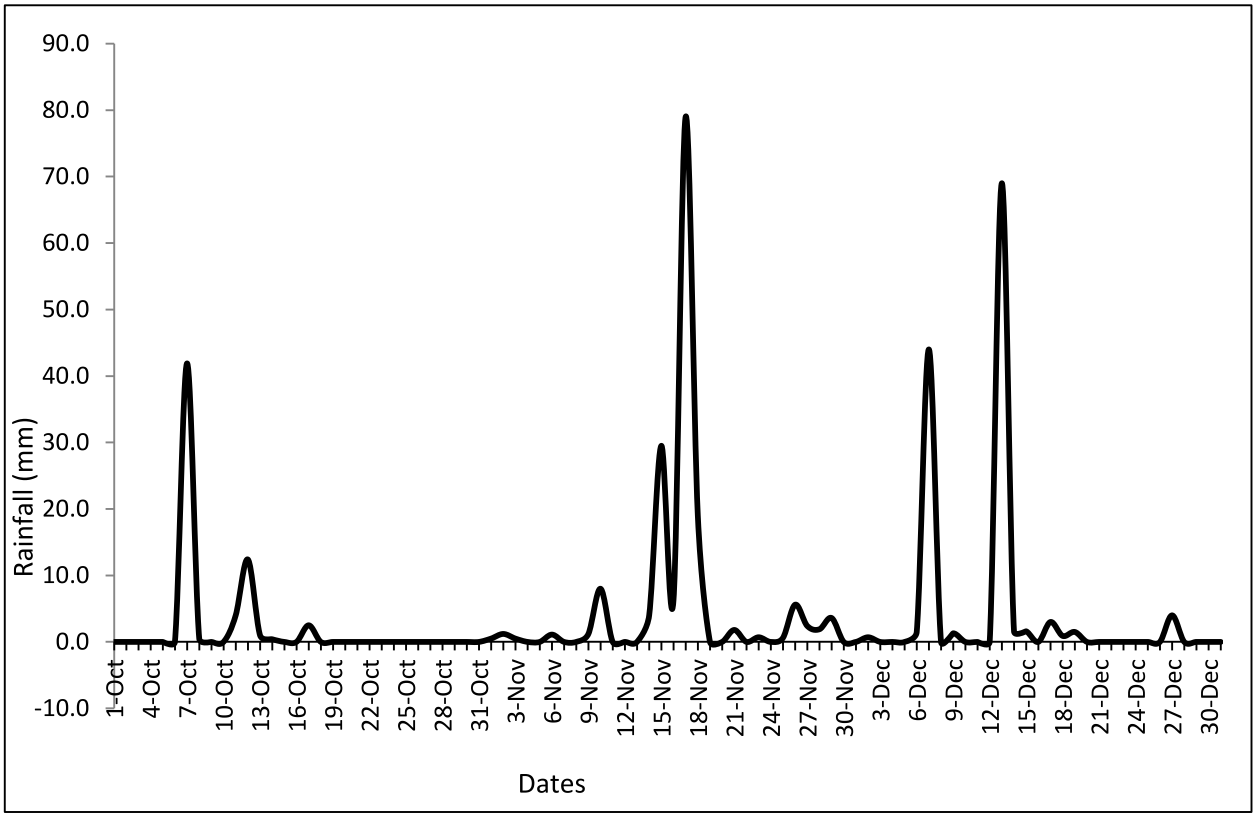


**Figure 4.8: Daily OND 2015 Rainfall for Voi Meteorological Station**

*Source: Survey Data, 2015*

From Figure 4.8 the onset date for OND 2015 rainy season was on 7th October. This was in agreement with the forecasted onset date for Voi sub-County which was indicated as the 2nd to 3rd week of October. The forecast on the onset date was therefore accurate. The cessation date for OND 2015 rainfall was forecasted to be in the last week of December. This was also in line with the cessation date observed at Voi which was on 27th December. According to the records at Voi meteorological station, the total amount of rainfall for OND 2015 rainy season received in Voi sub-County was 358.7mm. This was more than the calculated 30 years mean of 296.1mm. When expressed as a percentage, this was 121.14%. According to KMS guidelines, normal rainfall lies between 75% - 125% of the mean, above normal is rainfall over 125% of the mean while below normal is rainfall less than 75% of the mean (KMD, 1984). From these guidelines it can be observed that Voi sub-County received normal with a tendency to above normal rainfall during the OND 2015 rainfall season. According to Ziervogel*et al*. (2005) forecasts need to be correct more than 70% below which they are they are not likely to benefit farmers. Although Voi sub-

County received rainfall amount close to the forecasted by KMS, the distribution was poor. Although the onset date for the rainfall was in line with the forecast (7th October), the area had six rainy days in October with only two days receiving rainfall of over 10mm. This indicated a great within-season rainfall variability which can greatly influence distribution of water needed for crop growth (Recha et al., 2012).Such irregular distribution can lead to agricultural drought (WMO, 2006) and potentially hamper crop germination – forcing farmers into re-planting.

## 4.6 Smallholder Farmers' Perception of the Quality of October-November-December 2015 Seasonal Climate Forecast

This section presents results on the confidence smallholder farmers had OND 2015 SCF information from KMS. It also indicates the rating of the quality of OND 2015 forecast received by smallholder farmers in Voi sub-County.

### 4.6.1 Rating of the Quality of October-November-December 2015 Seasonal Climate Forecast by Smallholder Farmers

The study established that about 88% of the respondents received OND 2015 SCF. This group was then asked to rate the quality of the forecast as issued by KMS. This was done by asking the respondents who received 2015 SCF from KMS if they had confidence in the SCF information. Out of 179 respondents who had received the SCF information, 75 (41.9%) indicated that they had confidence in the forecast. This implies that majority of smallholder farmers in Voi sub-County do not see SCF information provided by KMS as accurate. This may have been influenced by past experience since forecasts which are consistently low is not likely to positively influence farmers' perception of the information (Chang'a*et al*., 2010). The study further analyzed the level of confidence of the respondents in SCF. The responses are presented in Table 4.3.

**Table 4.3: Rating of Confidence in SCF by Smallholder Farmers in Voi sub-County (N=75)**

| Response | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| Not very confident | 5 | 6.7 | 6.7 |
| Somewhat confident | 28 | 37.3 | 44.0 |
| Very confident | 42 | 56.0 | 100.0 |
| Total | 75 | 100.0 | |

*Source: Survey Data, 2015*

There was high rating of level confidence (56%) among smallholder farmers who trusted the OND 2015 SCF as shown by Table 4.3. However, this was only 23.5% of the total respondents who accessed the forecast and 20.6% of total respondents (42 out of 204). This implies that most of smallholder farmers in Voi sub-County generally have low confidence in SCF issued by KMS. These findings are similar to those of Borines*et al.*, (2009) who found that most farmers in Philippines ignored forecast terming them as untruthful and unable to materialize. This is an indictment to KMS as some of the intended consumers of their services are not confident with what they do.

The perception that farmers have on the quality of seasonal climate forecast issued by the KMS determines the level of uptake and utilization of such information in agricultural decision-making. The study, therefore, sought to establish the perception that smallholder farmers in Voi had on the OND 2015 SCF from KMS. Smallholder farmers who received OND 2015 SCF were asked to rate the quality of the forecast. About 67.6% of the respondents perceived OND 2015 SCF as somehow good. Only 3.9% of the respondents indicated that the forecast was poor. This is contrary to the general assumption that the perception of most farmers of seasonal climate forecast is poor (Coelho & Costa, 2010; Borines*et al.*, 2009; Hansen andIndeje, 2004).

In order to find out whether there is significance difference in the perception of the quality of OND 2015 SCF among the smallholder farmers in Voi sub-County, a one sample Chi-square test was analyzed. The results are shown in Table 4.4.

**Table 4.4: Perception of the quality of the season OND 2015 forecast (N=179)**

| | Observed N | Expected N | Residual |
|---|---|---|---|
| Good | 51 | 59.67 | -8.67 |
| Somewhat good | 121 | 59.67 | 61.33 |
| Poor | 7 | 59.67 | -52.67 |
| Total | 179 | | |

| | Rating of the quality of the season OND 2015 forecast |
|---|---|
| Chi-Square | 147.29[a] |
| Df | 2 |
| Asymp. Sig. | 0.000 |

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 59.67.

The results of calculated $x^2$showed high value (147.29 at p=0.000) as shown in Table 4.4. This implies that the perception of smallholder farmers that SCF from KMS is somewhat good is not as a result of chance but due to the fact that smallholder farmers are gradually having confidence in SCF information from KMS. These findings are in agreement with those of Mogotsi*et al.* (2011) whose study established that use of SCF in agricultural decision-making is gradually improving among the Kalahari smallholder farmers in Botswana. Likewise, Zinyengere*et al.* (2011) established that use of SCF has greatly improved maize production among farmers in Zimbabwe. The perception of smallholder farmers in Voi sub-County may also have been attributed to information on the El Niño episode that was forecasted for OND 2015 rainfall season.

## 4.7Smallholder Farmers' Use of October-November-December Seasonal Climate Forecast in Agricultural Decision-making

This sub-section starts by discussing access and source of OND 2015 SCF information by smallholder farmers in Voi sub-County. It then shows how the smallholder farmers used the information received in agricultural decision-making.

### 4.7.1 Access to October-November-December 2015 Seasonal Climate Forecast Information

Respondents were asked to indicate whether they had received the SCF of OND 2015. This was to establish the proportion of the smallholder farmers who had received OND 2015 SCF information before finding out how they used it in agricultural decision-making. The responses are given in Table 4.5.

**Table 4.5: Access to Seasonal Climate Forecast of OND 2015 from KMS (N=204)**

| Response | Frequency | Percent |
|---|---|---|
| Accessed | 179 | 87.7 |
| Did not access | 25 | 12.3 |
| Total | 204 | 100.0 |

*Source: Survey Data, 2015*

Majority (87.7%) of smallholder farmers received OND 2015 SCF as shown by Table 4.5 and only 12.3% did not. This implies that most smallholder farmers in the study area had information of the climate outlook for the OND 2015 season. Thus, majority of the smallholder farmers in Voi sub-County were expected to be guided by the forecast in agricultural decision-making. These findings are in line with Hayman *et al.*, (2007) who established that majority of Australian farmers had awareness of SCF information before rainfall seasons.Similarly, Oyekale (2015) established that access to climate forecast information is high (65.9%) among East African countries.

The study also sought to establish sources of OND 2015 SCF information. Results on sources of SCF information is shown in Table 4.6

**Table 4.6: Source of OND 2015 SCF in Voi Sub-County (N=179)**

| Source | Frequency | Percent |
|---|---|---|
| TV | 17 | 9.5 |
| Radio | 109 | 60.9 |
| Extension Officers | 6 | 3.4 |
| Friends/Neighbours | 40 | 22.3 |
| Local elders | 7 | 3.9 |
| Total | 179 | 100.0 |

*Source: Survey Data, 2015*

Majority of the respondents (60.9%) indicated that they relied on the radio to get the information as shown in Table 4.6. This was followed by friends/neighbours at 22.3% and the TV was third with 9.5%. Only 3.4% of the respondents indicated that they got the forecast from agricultural extension officers. It is surprisingly that agricultural extension officers were the least source of seasonal climate forecast yet they are expected to continuously pass vital information on farming activities to farmers and train them on its use. The manner in which the forecast are disseminated is one of the major constraints in the adoption of SCF information (Klopper*et al.*, 2006). This suggests that government extension officers are not actively involved in the dissemination of SCF information. This needs to change if the farmers are to take up new technologies and innovations that are being churned out.

### 4.7.2 Use of October-November-December 2015 Seasonal Climate Forecast Information

In order to assess effectiveness of OND 2015 SCF information in agricultural decision-making, the study looked at the proportion of smallholder farmers who used the information in relation to those who did not use. It also looked at how the information was used in decision-making by the respondents who accessed and used it.

The study first set out to find out if respondents used OND 2015 SCF information in agricultural decision-making. This was compared for the two Location and the results are shown in Table 4.7.

**Table 4.7: Location and Use of Seasonal Climate Forecast Information (N=179)**

| Location | Number of respondents | |
|---|---|---|
| | **Used SCF Frequency (Percentage)** | **Did not use SCF Frequency (Percentage)** |
| Sagalla | 50 (67.57%) | 24 (32.43%) |
| Mbololo | 35 (33.33%) | 70 (66.67%) |
| Total | 85 (47.49%) | 94 (52.51%) |

*Source: Survey Data, 2015*

The smallholder farmers who used OND 2015 SCF information in agricultural decision-making were 47.5% of respondents who received the forecast as shown by Table 4.7. This was however 41.7% of the total respondents for the study. Surprisingly, there was low use of seasonal climate forecast information in agricultural decision-making among smallholder farmers in Mbololo Location, which is relatively drier, when compared to Sagalla Location. This difference could be due to the fact that smallholder farmers practicing agriculture for income purpose was higher in Sagalla Location than in Mbololo Location. This, therefore, implies that the farmers were keen on climate parameters to avert agricultural losses.

The study set out to establish how smallholder farmers in Voi sub-County responded to the OND 2015 SCF information. In order to accomplish this, smallholder farmers who received and used the forecasts were asked to indicate farm management decisions they changed in response to information received. The results are shown in Table 4.8.

**Table 4.8: Change in Farm Management Decisions by Smallholder Farmers (N=85)**

| Change | Response | Sagalla | Mbololo | Total |
|---|---|---|---|---|
| Land preparation dates | Yes | 66.7% | 54.1% | 61.2% |
| | No | 33.3% | 45.9% | 38.8% |
| Type of crops planted | Yes52.1% | | 18.9% | 28.2% |
| | No | 47.9% | 81.1% | 71.8% |
| Crop variety planted | Yes | 60.4% | 32.4% | 48.2% |
| | No | 39.6% | 67.6% | 51.8% |

*Source: Survey Data*, *2015*

Majority (61.2%) of smallholder farmers who used OND SCF information altered land preparation dates. Although SCF information is expected to guide farmers on the types of crops to grow in a particular season based on the expected onset, amount and cessation of the rainfall, this was not the case. Respondents who changed the type of crops planted were the least (28.2%). Smallholder farmers in Sagalla Location had greater use of OND 2015 SCF information in agricultural decision-making as compared to their counterparts in Mbololo Location. This is contraryto the general expectation that smallholder farmers in Mbololo Location should be keen on information on climate variability as it's relatively drier than Sagalla Location (RoK, 2013b). This could be attributed to the fact that smallholder farmers in Sagalla Location have larger farm sizes (Table 4.2) and therefore interested in information which will avert losses associated with crop failure. This suggests that there is generally low uptake of SCF in agricultural decision-making among smallholder farmers in Voi sub-County. These findings are in agreement with PytlikZillig*et al*. (2010) whose study on use of SCF among Nabraska farmers showed low use of SCF information in agricultural decision-making. However, the ways smallholder farmers responded to OND 2015 SCF were similar to the study findings of Oyekale (2015) on use of SCF in Sub-Saharan Africa. Farmers adopt seasonal climate forecast information depending on the variables being forecasted, the quality of forecast, the likely benefits of the forecast and the manner in which the forecast are communicated (Ash *et al*., 2007).

Respondents who received SCF for OND 2015 were asked if they found the information useful. The results are given in Table 4.9.

**Table 4.9: Level of Usefulness of OND 2015 SCF (N=179)**

| | Most useful | Useful | Least Useful | Not useful | Total |
|---|---|---|---|---|---|
| Count | 9 | 60 | 16 | 94 | 179 |
| % of Total | 5.1% | 33.5% | 8.9% | 52.5% | 100% |

*Source: Survey Data, 2015*

Out of the 179 respondents who received OND 2015 SCF from KMS, 38.6% (5.1% + 33.5%) of the respondents indicated that the forecast obtained was useful to their farming decisions. This was likely caused by the accuracy of the forecast especially the onset of the rainfall season. However, majority of the respondents (52.5%) termed the forecast not useful thus compromising on the general credibility of SCF among smallholder farmers. These findings are in agreement with those of Vinocur*et al*. (2004) who established that low credibility is the main constraint in the use of SCF among Central Argentina farmers. Likewise, Chang'a, Yanda and Ngana (2010) established that rainfall forecast was useful in agricultural decision-making among majority (58%) of farmers in South-western highlands of Tanzania.

## 4.8 Constraints to Use of October-November-December 2015 Seasonal Climate Forecast in Agricultural Decision-making

This sub-section discusses constraints to access of OND 2015 SCF by some smallholder farmers in Voi sub-County. It also shows hindrances to use the information by smallholder farmers after accessing it.

### 4.8.1 Constraints to Access and Use of October-November-December 2015 Seasonal Climate Forecast

The study sought to establish constraints that hinder smallholder farmers in Voi sub-County from accessing SCF information issued by KMS. The study established that 12.3% of the respondents did not access SCF of OND 2015. Results in Table 4.10 show the different reasons for not accessing SCF.

**Table 4.10: Constraints to Access to OND 2015 SCF (N=25)**

| Reason | Frequency | Percent |
|---|---|---|
| *I was not aware of such information* | 5 | 20.0 |
| *I did not  know where to get the information* | 10 | 40.0 |
| *I did not have the means of accessing theinformation* | 10 | 40.0 |
| Total | 25 | 100.0 |

*Source: Survey Data, 2015*

The two most cited reasons for not accessing the information were *'I did not have the means of accessing the information*' and *'I didn't know where to get the information'* both at 40% as shown in Table 4.10. This finding suggests that KMS, although has been able to reach 87.7% of the smallholder farmers in Voi sub-County, should aim for total coverage as far as dissemination of information is concerned. These findings are supported by Power *et al.* (2007) whose study established that low of awareness is one of the key factors which make farmers not use SCF information in Australia. Awareness is, therefore, key in using seasonal climate forecast information disseminated to end users.

After SCF information has been prepared, KMS briefs the press on the expected seasonal climate about one month before onset of the season. The information is then carried in the mass media such as TV and radio as well as posted on the KMS website. It is also circulated to agricultural extension officers and other users in written form. Farmers and other users are expected to access and use the forecasts in decision-making regarding their activities. However, some of the smallholder farmers in Voi sub-County were not able access OND 2015 SCF.

About 52% of smallholder farmers in Voi sub-County who accessed OND 2015 SCF did not use it in agricultural decision-making. The study sought to establish the reasons as to why some smallholder farmers in Voi sub-County would not use the SCF information even after receiving it. The results are presented in Table 4.11.

**Table 4.11: Reasons for not Using SCF upon Access (N=94)**

| Response | Frequency | Percent |
|---|---|---|
| Inability to interpret forecast | 8 | 8.5 |
| Financial challenges | 14 | 14.9 |
| Lack of extension support | 24 | 25.5 |
| Lack of trust on forecast | 48 | 51.1 |
| Total | 94 | 100.00 |

*Source: Survey Data, 2015*

A total of 94 respondents did not use OND 2015 SCF after accessing it. This represents 52.5% of those who accessed the forecast and 46.07% of the total respondents. Lack of trust on the SCF information was cited by the majority (51.1%) of the respondents, followed by lack of extension support at 25.5%, financial challenges at 14.9% and finally the inability to interpret forecast at 8.5%. This implies that there is lack of trust in SCF by most of smallholder farmers in Voi sub-County which could have led to its low use. This findings confirm what Meza and Wilks, (2008) found out in Chile that many would-be-users do not trust SCF information due to perceived inaccuracy thus a major hindrance to its uptake. Seasonal climate forecast information has not been adopted by most marginal groups and lacks immediate effects to end-users due to uncertainties involved, difficulties in downscaling and poor interpretation of the forecast (Garbrecht& Schneider, 2007). Likewise, Tall *et al*. (2012) established that climate forecasts have been underutilized due to information gap between forecasters and would-be users, cultural barriers, luck of funds and technicality of attached to the information.

### 4.8.2 Training on Seasonal Climate Forecast Information Interpretation

This study set to find out if the KMS trained farmers on how to interpret the SCF information. The responses are presented in Table 4.12.

**Table 4.12: Smallholder Farmers' Training on Use of OND 2015 SCF (N=179)**

| Response | Frequency | Percent |
|---|---|---|
| Yes | 16 | 8.9 |
| No | 163 | 91.1 |
| Total | 179 | 100.0 |

*Source: Survey Data, 2015*

Respondents who received OND 2015 SCF training on interpretation and use of the information were 8.9% as shown in Table 4.12. This implies that the existing effort to improve on interpretation of SCF information remain insufficient. This was collaborated by findings from interview with the agricultural officers in the study area who said that only a few farmers are invited to the Agriculture Development Support Programme(ADSP) meetings. The meetings are usually organized at sub-County level and the few invited farmers are expected to train other farmers on use of SCF information. However, no follow-up is done to ascertain the same. Therefore, there is normally a disconnection between producers of SCF information and the end-users (Faures*et al.*, 2010).These findings agree with those by George *et al*. (2007) who established that many farmers in Australia lacked formal education on use of SCF. There is need for more concerted efforts by the extension officers and KMS in disseminating the entire climate forecast that includes onset dates, cessation dates, rainfall amount, and the relevant advisory. Importantly too is the need to educate farmers on the probabilistic nature of forecast since forecasts which are in formats that cannot be accurately decoded by farmers are not only frustrating but also not useful (Kiem and Austin, 2013). In so doing, if will help address the widespread perception of inaccuracy in seasonal climate forecasts.

### 4.8.3 Socio-economic Characteristics Constraining Access and Use of October-November-December 2015 Seasonal Climate Forecast

Socio-economic characteristics of smallholder farmers may, to some extent, influence the access and use of seasonal climate forecast information. These include location, gender, and education level of the respondents. Pearson Correlation was, therefore, used to test the relationship between use of OND 2015 SCF and socio-economic characteristics of the smallholder farmers. The results are shown in Table 4.13.

**Table 4.13: Correlation between Use of SCF and Socio-economic Characteristics**

| Variable | Pearson Correlation Coefficient | Significance |
|---|---|---|
| Farmers location | .068 | .337 |
| Gender | .115 | .103 |
| Education level | -.15* | .032 |
| Age | .108 | .124 |
| Reasons for farming | .321** | .000 |
| Acreage | .037 | .597 |

** significant at 0.01 level

* significant at 0.05 level

*Source: Survey Data, 2015*

The study established that use of SCF is not significantly correlated to the location of the farmer, gender, age and acreage under farming. However, it has a weak but significant correlation with education level ($r=-0.15$, $p=0.032$, $\alpha=0.05$) and reasons for farming ($r=0.321$, $p=0.000$, $\alpha=0.01$). In this study, there is a weak negative and significant relationship between the level of education and use of SCF. This implies that respondents with higher education level are unlikely to use SCF information in agricultural decision-making. This could be attributed to the fact that smallholder farmers with higher education levels may have alternative sources of livelihood beyond crop farming.These findings are contrary to those of Comin and Hobija (2010) who established that there is a positive relationship between education level and adoption of technology. Deressa*et al*. (2009)also established that education level increased significantly with the probability of farmers to use SCF information in agricultural decision-making. This necessitates dissemination of seasonal climate forecast information in a manner that can be easily interpreted by even illiterate farmers.

On the other hand, there is a weak positive and significant relationship between use of SCF information and reason for farming. This implies that farmers who practice agriculture mainly as a source of income are more likely to use SCF than subsistence farmers. A farmer who has invested in farming for income will be keen on seasonal climate characteristics so as to avert losses and maximize yield. These findings are in agreement with those of Oyekale (2015) and Klopper*et al.* (2006) whose study findings established that SCF information has been a vital decision-making tool among commercial farmers in sub-Saharan Africa as compared to subsistence farmers.

# CHAPTER FIVE

# SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Introduction

This chapter presents summary and conclusions from the study. It also identifies the recommendations which need to be addressed as well as suggestions for further research on emerging issues from the study.

## 5.2 Summary of Findings

Use of seasonal climate forecast (SCF) is one of the adaptation strategies to climate variability, especially in semi-arid areas. This study sought to assess the extent to which SCF has been used as an effective adaptation strategy to climate variability among smallholder farmers in Voi sub-County. The study set out to achieve the following objectives: (i) to evaluate the perception of the quality of seasonal climate forecasts from Kenya Meteorological services among smallholder farmers in Voi sub-County, (ii) to establish smallholder farmers' use seasonal climate forecasts in agricultural decision-making in Voi sub-County, (iii) to determine constraints to use of seasonal climate forecasts in agricultural decision-making among smallholder farmers in Voi sub-County.

A survey research design was used. A sample of 246 households was picked through random sampling procedure and questionnaire was used to collect data. Data was also collected through Key Informant Interview from five purposively selected key informants and used to clarify issues arising from the study. Data collected was analyzed using SPSS software. Section 5.2.1 to 5.2.3 gives a summary of the findings per objective.

### 5.2.1 Objective 1: Smallholder Farmers' Perception of October-November-December 2015 Seasonal Climate Forecast

The study established that 87.7%of smallholder farmers in Voi sub-County received OND 2015 SCF information. Majority (67.6%) of those who receivedthe forecast rated its quality as somewhat good.This was 59.3% of total respondents, a result that was found to be significant. This implies that the perception of somewhat good was not caused by random factors, a likely indication that smallholder farmers are gradually having confidence in seasonal climate forecast information which may be as a result of improved accuracy (Cooper *et al*., 2008).

### 5.2.2 Objective 2: Smallholder Farmers' Use of October-November-December 2015 Seasonal Climate Forecast in Agricultural Decision-making

The study established that 41.7% of the smallholder farmers in Voi sub-County received and used OND 2015 SCF information. Majority (61.2%) used the information to guide them on choice of land preparation dates before onset of the rainfall. A small percentage (28.2%) of smallholder farmers used SCF information in making decision on the type of crops to be planted during the season. Majority (52.5%) of the smallholder farmers in Voi sub-County who accessed OND 2015 SCF did not consider SCF information useful in making on-farm decisions terming it not useful.

### 5.2.3 Objective 3: Constraints to Use of October-November-December 2015 Seasonal Climate Forecast Information in Agricultural Decision-making

The study established that only 8.9% of the smallholder farmers in Voisub-County who received OND 2015 SCF were trained on interpretation and use of the forecast in agriculture. These results are further given credence when the study established that only 3.4% of respondents had received SCF from Government extension officers. Fifty-two percent of those who accessed OND 2015 SCF did not use it in agricultural decision-making mainly due to lack of trust on the forecast and unavailability of extension support service. About 12.3% of the smallholder farmers did not access OND 2015 SCF at all. Majority cited lack of knowledge on where to access and lack means of accessing information as the main hindrances to access.Correlation results showed that there exist a significant relationship between use of SCF information and education level (r=-0.15) and reasons for farming (r=0.321). However, there was no significant correlation between use of SCF information and location, gender and age of farmer as well as acreage of land under farming.

## 5.3 Conclusion

The study has assessed the perception of quality of SCF, and established level of use of the forecast and constraints faced by smallholder farmers in Voi sub-County in its use. It established that smallholder farmers have partial confidence in the SCF information disseminated by KMS. There is therefore need to improve on the existing dissemination pathways so as to improve on its perception.

Smallholder farmers demonstrated different farming management strategies by altering land preparation dates, the types and variety of crops grown in response to the SCF information received. Given the benefits of SCF information, agricultural extension officers can assist to improve use of this information by providing farm-level training of its role in agricultural decision-making.

Use of SCF information among smallholder farmers in agricultural decision-making is hampered by many socio-economic constraints related to the farmers. This affects access of the information, its interpretation and consequent use. There is, therefore, need to improve this so as to reap the benefits of this information.

## 5.4 Recommendations

This study makes the following recommendations:

i. Given that the perception of the quality of SCF information among smallholder farmers is still low, KMS should strive to ensure that monthly and weekly forecasts are disseminated promptly. This will ensure that forecast on intra-seasonal climate variability are used in agricultural decision-making thus improving trust and reinforcing use of SCF.

ii. In order to improve on use of SCF in agricultural decision-making, there is need for training local administrators and leaders within the communities on dissemination of SCF advisory which is a vital component of SCF. This can be done through seminars organized by the Ministry of Agriculture in conjunction with KMS in order to make such leaders trainers in their localities.

iii. Since training was found to be the major constraint to use of SCF in agricultural decision-making, smallholder farmers should be trained through extension services on its use. Smallholder farmers should also be encouraged to look at farming as a source of livelihood so as to appreciate the role of seasonal climate forecast in agricultural decision-making in order to improve on its use.

## 5. 5 Suggestions for Further Research

This study suggests the following for further research:

i. A research on analysis of seasonal climate forecasts issued by KMS over a longer period of time and the observed climatic characteristics over the same period of time. This will help determine whether the trust (or lack)of seasonal climate forecast among smallholder farmers in Voi sub-County has merit.
ii. The current study looked at the constraints to use of SCF in agricultural decision-making in a population whose access of the forecast is not pre-determined. It is suggested that an experimental approach is used where a group of respondents are issued and trained on use of SCF before the OND season. This will bring out the constraints on use of SCF by smallholder farmers in Voi sub-County which are not related to access and training.

## REFERENCES


Apipattanavis, S., Bert, F., Podesta, G. &Rajagopalan, B. (2010). Linking Weather Generators and Crop Models for Assessment of Climate Forecast Outcomes.*Agriculture and Forest Meteorology*, 150, 166 – 174.

Ash, A., McIntosh, P., Cullen, B., Carberry, P. & Smith, M. S. (2007). Constraints and Opportunities in Applying Seasonal Climate Forecast in Agriculture. *Australian Journal of Agricultural Research*, 58, 952 – 965.

Bagamba, F., Bashaasha, B., Claessens, L. &Antle, J. (2012).Assessing Climate Change Impacts and Adaptation Strategies for Smallholder Agricultural Systems in Uganda. *African Crop Science Journal*, 20(2), 303 – 316.

Baigorria, G. A., Jones, J. W. & O'Brien, J. J. (2008).Potential Predictability of Crop Yield Using an Ensemble Climate Forecast by Regional Circulation Model.*Agriculture and Forest Meteorology*, 148, 1353 – 1361.

Bawakyillenuo, S., Yoro, J. A. &Teye, J. (2014).Exploring the Autonomous Adaptation Strategies to Climate Change and Climate Variability in Selected Villages in the Rural Northern Savannah Zone of Ghana.*Local Environment*, 1, 1 – 24.

Borines, G. C. M., Gravoso, R. S. &Predo, C. D. (2009). Corn Farmers' Decision-making Based on Seasonal Climate Forecast. *Philippine Journal of Development*, 26(1), 85 – 100.

Cabrera, V. E., Letson, D. &Podesta, G. (2007).The Value of Climate Information When Farm Programs Matter. *Agricultural Systems*, 93, 25 – 42.

Calzadilla, A., Zhu, T., Rehdanz, K., Tol, R. S. J. &Ringler, C. (2009).Economy-Wide Impact of Climate on Agriculture in Sub-Saharan Africa. International Food Policy Research Institute (IFRI). *Discussion Paper00873:1*.

Chang'a, L. B., Yanda, P. Z. &Ngana, J. (2010). Indigenous Knowledge in Seasonal Rainfall Prediction in Tanzania: A Case of the South-western Highlands of Tanzania. *Journal of Geography and Regional Planning*, 3(4), 66 – 72.

Coelho, C. A. S. & Costa, S. M. S. (2010).Challenging of Integrating Seasonal Climate Forecast in User Applications.*Current Opinion in Environmental Sustainability*, 2, 1 – 9.

Comin, D. &Hobija, B. (2010).An Exploration of Adoption of Technology Diffusion.*The American Economic Review*, 100(5), 2031 – 2059.

Cooper, P. J. M., Dimes J., Rao K. P. C., Shapiro B., Shiferaw B. &Twomlow, S. (2008). Coping better with current climatic variability in the rain-fed farming systems of the sub-Sahara Africa: An essential first step in adapting to future climate change. *Agriculture, Ecosystem and Environment*, 126, 24 – 35.

Crane, T. A., Roncoli, C., Breuer, N. E., Broad, K., Ingram, K. T. &Hoogenboom, G. (2008). Seasonal Climate Forecasts among Georgia Farmers: Seasonal Climate Forecasts and Risk Management. Southeast Climate Consortium Technical Report Series 2008, 35 – 64.

Crist, E. (2007). Beyond the Climate Crisis: A Critique of Climate Change Discourse. *Telos*, 141, 29 – 55.

Deressa, T. T., Hassan, R. M., Ringler, C., Alemu, T. & Yusuf, M. (2009).Determinants of Farmers Choice of Adaptation Methods to Climate Change in the Nile Basin of Ethiopia. *Global Environmental Change*, 19, 248 – 255.

Dessai, S., Hulme, M., Lempert, &Pilke, R. (2009). Climate Prediction: a limit to adaptation? In Adger, N., Lorenzoni, I.and O'Brien, K. (Ed). *Adapting to Climate Change: thresholds, values, governance* (pp 64-78), Cambridge University Press, UK.

Elia, E. F., Mutula, S. & Stilwell, C. (2014). Indigenous Knowledge Use in Seasonal Weather Forecasting in Tanzania: the Case of Semi-arid Central Tanzania. *SA Jnl Libs & Info Sci*, 80(1), 18 – 27.

Faures, J. M., Bernardi, M. &Gommes, R. (2010). There is No Such a Thing as an Average: How Farmers Manage Uncertainities Related to Climate and Other Factors. *Water Resource Developmen*t, 26(4), 523 – 542.

Fraisse, C. W., Breuer, N. E., Zierden, D., Bellow, J. G., Paz, J., Cabrela, V. E., … O'Brien, J. J. (2006).AgClimate: A Climate Forecast Information System for Agricultural Risk Management in Southeastern USA. *Computers and Electronics in Agriculture*, 53, 13 – 27.

Funk, C. C., Dettinger, M. D., Michaelsen, J. C., Verdin, J. P., Brown, M .E., Barlow, M. & Hoell, A. (2008). Warming of the Indian Ocean Threatens Eastern and Southern African Food Security but Could be Mitigated by Agricultural Development. *Pro Nat AcadSci USA*, 105, 11,081 – 11,086.

Garbrecht, J. D. & Schneider, J. M. (2007). Climate Forecast and Prediction Product Dissemination for Agriculture in the United States. *Australian Journal of Agricultural Research,* 58, 966 – 974.

George, D.A., Birch, C.J., Clewett, J. F., Wright, A., Allen, W. & Keogh, D. U. (2007).Need for Applied Climate Education in Agriculture.*Australian Journal of Experimental Agriculture*, 47, 1 – 12.

Gimenez, A. &Lanfranco, B. (2012). Adaptation to Climate Change and Variability: Some Response Options to Agricultural Production in Uruguay. *Revista Mexicana de Ciencias Agricolas*, 3(1), 611 – 620.

Hansen, J. W. &Indeje, M. (2004). Linking Dynamics Seasonal Climate Forecast with Crop Simulation for Maize Yield Prediction in Semi-arid Kenya.*Agricultural and Forest Meteorology*, 125, 143 – 157.

Hayman, P. T., Crean, J., Mullen, J. & Parton, K. (2007). How do Probabilistic Seasonal Climate Forecast Compare with Other Innovations that Australian Farmers are Encouraged to Adopt? *Australian Journal of Agricultural Research*, 58, 975 – 975.

Hayman, P. T., Whitbread, A. M. &Gobbett, D. L. (2010). The Impact of El Niño Southern Oscillation on Seasonal Drought in Southern Australia Grainbelt. *Crop & Pasture Science*, 61(7), 528 – 539.

Hirshleifer, J. & Riley, J. G. (1992).The Analysis of Uncertainty and Information.*Journal of Economic Literature*, 17, 1375 – 1421.

Independent Electoral and Boundaries Commission (IEBC) (2012). *National Assembly Constituencies and County Assembly Wards Order*. Nairobi: Government Printer.

IPCC (2014).Climate Change 2014: Impacts, Adaptation and Vulnerability, Summary for Policymakers, Working Group II Contributing to the Intergovernmental Panel on Climate Change Fifth Assessment Report. Cambridge: Cambridge University Press.

Kiem, A. S. & Austin, E. K. (2013). Drought and the Future of Rural Communities: Opportunities and Challenges for Climate Change Adaptation in Regional Victoria, Australia. *Global Environmental Change*, 23, 1307 – 1316.

Klopper, E., Vogel, C. H., &Landman, W. A. (2006). Seasonal Climate Forecast - Potential Agricultural-risk Management Tool? *Climate Change*, 76, 73 – 90.

KMD (1984).*Climatological Statistics for Kenya*. Nairobi: Government Printer.

KMS (2015). Short Rains Season October to December 2015. http://www.meteo.go.ke/pdf/seasonal_2.pdf. (Accessed on 5/10/2015).

Kothari, C. R. (2004). *Research Methodology: Methods and Techniques*. (2nd ed.). New Delhi: New Age International Ltd.

Kpadonou, R. A., Adegbola, P. Y. &Tovignan, S. D. (2012).Local Knowledge and Adaptation to Climate Change in Oueme Valley, Benin.*African Crop Science Journal*, 20(20), 181 – 192.

Lyon, B. (2014). Seasonal Drought in the Horn of Africa and its Recent Increase During the March-May Longrains. *Journal of Climate*, 16, 78 – 96.

Macharia, P. N., Thuranira, L. W., Ng'ang'a, J. &Wakori, S. (2012).Perceptions and Adaptation to Climate Change and Variability by Immigrant Farmers in Semi-arid Regions of Kenya.*African Crop Science Journal*, 20(2), 289 – 296.

Matondo, J. I. (2010). Adaptation Options to Climate Change and Variability on the Water Resources in Africa.Proceedings of the Second Science with Africa Conference – 2010. http://www.uneca.org/sciencewithafrica/. (Accessed on 12/5/2015).

McGrail, S. (2013).Tension, Trends and Possibilities in Climate Discourses Epitomised by Three Prominent Climate Experts.*Journal of Future Studies*, 17(3), 21 – 40.

McIntosh, P. C., Pook, M. J., Risbey, J. S., Lisson, S. N. &Rebbeck, M. (2007). Seasonal Climate Forecast for Agriculture: Towards Better Understanding the Value. *Fields Crops Research*, 104, 130 – 138.

Mendelsohn, R. (2009). The Impact of Climate Change on Agriculture in Developing Countries. *Journal of Natural Resources Policy Research*, 1(1), 5 – 19.

Meza, F. J. &Wilks, D. S. (2008). Value of Operational Forecast of Seasonal Average Sea Surface Temperature Anomalies for Selected Rain-fed Agricultural Locations of Chile. *Agriculture and Forest Meteorology*, 116, 137 – 158.

Mogotsi, K., Moroka, A. B., Stang, O. &Chibua, R. (2011). Seasonal Precipitation Forecasts: Agro-ecological Knowledge among Rural Kalahari Communities. *African Journal of Agricultural Research*, 6(4), 916 – 922.

Morss, R. E., Demuh, J. L. &Lazo, J. K. (2008).Communicating Uncertainty in Weather Forecasts: A Survey of US Public.*Weather and Forecasting*, 23, 974 – 991.

Motha, R. P. (2007). Implications of Climate Change on Long-lead Forecasting and Global Agriculture. *Australian Journal of Agricultural Research*, 58, 939 – 944.

Moyo, M., Mvumi, B. M., Kunzekweguta, M., Mazvimavi, K., Craufurd, P. &Dorward, P. (2012). Farmer Perception on Climate Change and Variability in Semi-arid Zimbabwe in Relation to Climatology Evidence.*African Crop Science Journal*, 20(2), 317 – 335.

Mugenda, M. &Mugenda, A. G. (2003).*Research Methods: Quantitative and Qualitative Approaches*. Nairobi: ACTS Press.

Nandozi, C. S., Majaliwa, J. G. M., Omondi, P., Komutunga, E., Aribo, L., Isubikalu, P., … Massa-Makuma, H. (2012). Regional Climate Model Performance and Prediction of Seasonal Rainfall and Surface Temperature in Uganda.*African Crop Science Journal*, 20(2), 213 – 225.

Neuman, (2007).*Basics of social research: Qualitative and Quantitative Approaches.* Nairobi: African Centre for Technology Studies.

Ochieng', R. (2013). *Rainfall Variability and Adaptation Mechanisms by Farmers in Kwale County: A Case Study of Samburu and Tsimba Locations*, Egerton University, Kenya. Unpublished Masters Thesis.

Odekulne, T. O. (2006). Determining Rainfall season Onset and Retreat over Nigeria from Precipitation Amount and Number of Rainy Days. *Theor. Appl. Climatol*., 83, 193 – 201.

Ogen, O. (2007). The Agricultural Sector and Nigeria's Development: Comparative Perspectives from the Brazilian Agro-industry Economy 1960 – 1995. *Nebula*, 4(10), 184 – 194.

Oyekale, A. S. (2015). Factors Explaining Farm Household's Access to and Utilization of Extreme Climate Forecasts in Sub-Saharan Africa (SSA).*Environmental Economics*, 6, 91 – 103.

Power, S. B., Plummer, N. & Alford, P. (2007).Making Climate Model Forecast More Useful. *Australian Journal of Agricultural Research*, 58, 945 – 951.

PytlikZillig, L. M., Hu, Q., Hubbard, K. G., Lynne, G. D. &Bruning, R. H. (2010). Improving Farmers Perception and Use of Climate Predictions in Farming Decisions: A Transitional Model. *Journal of Applied Meteorology and Climatology*, 49(6), 1333 – 1340.

Recha, C. W. (2007). *Seasonal Climate Forecast, Access and Use in Agricultural Production: A Case of Semi-Arid South-East Kenya*, Kenyatta University, Kenya. Unpublished Masters Thesis.

Recha, C. W., Shisanya, C. A., Makokha, G. L. &Kinuthia, R. N. (2008). Perception and use of climate forecast information amongst smallholder farmers in semi-arid Kenya. *Asian Journal of Applied Sciences*, 1(2), 123 – 135.

Recha, C. W., Makokha, G. L., Traore, P. S., Shisanya, C. A., Lodoun, T. &Sako, A. (2012). Determination of Seasonal Rainfall Variability, Onset and Cessation in Semi-arid Tharaka District, Kenya.*Theoretical and Applied Climatology*, 108, 479 – 494.

Republic of Kenya (2006).*Kenya Integrated Household Budget and Expenditure Survey*. Nairobi: Government Printer.

Republic of Kenya (2007).*Kenya Vision 2030*. Nairobi: Government Printer.

Republic of Kenya (2010a).National Climate Change Response Strategy. Nairobi: Government Printer.

Republic of Kenya (2010b).*Kenya National Bureau of Statistics: 2009 Kenya Population and Housing Census, Vol. 1A.* Nairobi: Government Printer.

Republic of Kenya (2013a).*Kenya Climate Change Action Plan*. Nairobi: Government Printer.

Republic of Kenya (2013b).*The First TaitaTaveta County Integrated Development Plan 2013 – 2017.* Nairobi: Government Printer.

Scheneider, J. M. &Garbrecht, J. D. (2006).Dependability and Effectiveness of Seasonal Forecast for Agricultural Applications.*American Society of Agricultural and Biological Engineers*, 49(6), 1737 – 1753.

Stedinger, J. R. & Kim, Y. (2010).Probabilities for Ensemble Forecast Reflecting Climate Information.*Journal of Hydrology*, 391, 9 – 23.

Tall, A., Hansen, J., Jay, A., Campbell, B., Kinyangi, J., Aggarwai, P. K. &Zougmoré, R. (2014). *Scaling up Climate Services for Farmers: Mission Possible. Learning from good practice in Africa and South Asia.* CCAFS Report No. 13. Copenhagen: CGIAR Research Programme. http://www.ccafs.ogiar.org (accessed on 18/12/2016).

Vinocur, M. A., Rivarola, A. V. & Seiler, R. A. (2004).*Use of Climate Information in Agricultural Decision-making: Experience from Farmers in Central Argentina.* Paper Presented for the Second International Conference on Climate Impact Assessment. University of Rio Cuarto, Argentina.

WMO (2002). Application of Climate Forecasts for Agriculture: Proceedings of an Expert Group Meeting for Regional Association I (Africa) 9 – 13 December 2002, Banjul, Gambia.

World Meteorological Organization. (2006). *Drought Monitoring and Early Warning: Concepts, Progress and Future Challenges*. WMO-No.1006. ISBN 92-63-11006-9.

Ziervogel, G. (2004). Targeting Seasonal Climate Forecasts for Integration into Household Level Decisions: The Case of Smallholder Farmers in Lesotho.*The Geographical Journal*, 170(1), 6 – 12.

Ziervogel, G., Bithell, M., Washington, R. & Downing, T. (2005). Agent-based Social Simulation: A Method of Assessing the impact of seasonal climate forecast application among smallholder farmers. *Agriculture Systems,* 83, 1 – 26.

Zinyengere, N., Mhizha, T., Mashonjowa, E., Chipindu, B., Geerts, S. and Raes, D. (2011). Using Seasonal Climate Forecasts to Improve Maize Production Decision Support in Zimbabwe.*Agricultural and Forest Meteorology*, 151, 1792 – 1799.

# APPENDICES

## APPENDIX I: QUESTIONNAIRE FOR SMALLHOLDER FARMERS

***Preamble***

*My name is Morris MaingiMwatu. I am a student at Egerton University pursuing Masters of Science Degree in Geography. This is an academic study whose main purpose is to collect data on perception of seasonal climatic forecasts, their use and related constraints faced by smallholder farmers in Voi sub-County. You are requested to be honest in your responses that will be highly appreciated and treated with utmost confidentiality.*

**FOR OFFICIAL USE ONLY**
**SERIAL NO……………………………….**
**Location……………………… Sub-Location…………………….. Village…………………….**
**Name of researcher/research assistant……………………………………. Date……………**
**Status of the questionnaire: Complete** ☐ **Not complete** ☐

***Please tick* (√ )*the appropriate response(s) or give a brief comment where applicable***

**Part A: Personal details**

1. Name (Optional): ……………………………………………………………..
2. Gender:
   Male ☐ Female ☐
3. Age bracket (in years):
   Below 20 ☐ 20-29 ☐ 30-39 ☐ 40-49 ☐ 50-59 ☐ 60+ ☐
4. Education level:
   No formal education ☐
   Primary ☐
   Secondary ☐
   Tertiary ☐

**Part B: Farming Activities**

5. Why do you practice farming?
   Source of income ☐
   Source of food ☐
   Other interests (Specify)……………………………………………………………………
6. How long have you been practising small-scale farming in your current farm?
   10 years and below ☐
   11-20 years ☐
   21-30 years ☐
   Over 30 years ☐
7. What is your current land acreage under farming?
   Below 1 acre ☐ 1 – 3 acres ☐ 3 – 5 acres ☐ 5 – 7 acres ☐ 7 – 9 acres ☐
   9 – 11 acres ☐ Over 11 acres ☐

8. Rate your soil quality in terms of fertility

- Very Good ☐
- Good ☐
- Fair ☐
- Poor ☐

**Part C: Seasonal Climate Forecast Perception, Response and Constrains.**

9. Did you receive seasonal climate forecast for OND 2015 from KMS? Yes ☐ No ☐

***NB: if No in question 9, please go to question 23***

10. If you received the forecast, what was the source (or sources) of the information?

- TV ☐
- Radio ☐
- Newspaper ☐
- Extension officer ☐
- NGO extension officers ☐
- Friends/neighbours ☐
- Local elders/administrators ☐

11. Did you receive seasonal climate forecast of OND 2015 on the following aspect?

i) Onset date Yes ☐ No ☐
ii) Cessation date Yes ☐ No ☐
iii) Amount Yes ☐ No ☐
iv) Advisory Yes ☐ No ☐

12. When did you receive the forecast for OND 2015 rainfall season?

- August ☐
- September ☐
- October ☐
- November ☐

13. a) Were you confident with the forecast for OND 2015 rainfall season you received?

Yes ☐ No ☐

b) If yes, what was your level of confidence in the forecast?

- Not very confident ☐
- Somewhat confident ☐
- Very confident ☐

14. Rate the quality of seasonal climate forecast for OND 2015 rainfall season:

Very good ☐ Good ☐ Somewhat good ☐ Poor ☐

15.a) Have you received training on use of seasonal climate forecasts?

Yes ☐ No ☐

b) If yes, who trained you on how to use the forecasts?

- Neighbour/Friend ☐
- Government extension officer ☐
- Local leaders ☐
- NGO extension officer ☐
- Religious leaders ☐
- Other(s)………………………………………………………………………………

16. Did you use the seasonal climate forecast for OND 2015 you received in your agricultural decision-making?

Yes ☐ No ☐

***NB: If No in question 16 (above), please go to question 22***

17.a) Indicate your usual dates of implementing the following farm-level activities:

| **Activity** | **September** | | | **October** | | | **November** | | |
|---|---|---|---|---|---|---|---|---|---|
| | Early | Mid | Late | Early | Mid | Late | Early | Mid | Late |
| Time for land preparations | | | | | | | | | |
| Time of planting | | | | | | | | | |
| Farm inputs acquisition | | | | | | | | | |

b) Did the forecast of OND 2015 rainfall season make you change the following activities?

| **Activity** | **YES** | **NO** |
|---|---|---|
| Time for land preparation | | |
| Crop types you planted | | |
| Crop varieties you planted | | |

18. Indicate the level of usefulness of OND 2015 forecast to you in the table below:

| | **A**:Most useful | **B**:Useful | **C**:Least useful | **D**:Not useful |
|---|---|---|---|---|
| Forecast on rainfall onset | | | | |
| Forecast on rainfall amount | | | | |
| Forecast on rain cessation | | | | |
| Advisory | | | | |

19. How many weeks in advance of the season for which a forecast is made would you prefer to receive seasonal climate forecast information?

0 – 1 ☐ 2 – 3 ☐ 4 – 5 ☐ 6 – 7 ☐ 8 and above ☐

20. What information would you like to receive when seasonal climate forecast is issued?

Information on rainfall onset ☐
Information on rainfall amount ☐
Information on rainfall cessation ☐
Information on advisory ☐

21. Which channel(s) of communication would you prefer to receive seasonal climate forecast information?

TV ☐
Radio ☐
Newspaper ☐
Extension officer ☐
NGO extension officers ☐
Friends/neighbours ☐
Internet ☐
Traditional forecasters ☐
Local elders ☐
Religious leaders ☐

Other(s)………………………………………………………………………………………..

22. If you accessed seasonal climate forecast information for OND 2015 from KMS and did not use, what prevented you from using it?

I was unable to interpret the forecast ☐
I lacked money to buy the required inputs ☐
There was no extension support service ☐
I could not trust the information ☐
Any other reason(s) (Specify)……………………………………………….....................
………………………………………………………………………………………………..

23. a) If you did not access SCF for OND 2015, what prevented you from accessing this information?

I was not aware of existence of the information ☐
I did not know where I can access the information ☐
I did not have means of accessing the information ☐
Any other reason(s)………………………………………………………………………...
………………………………………………………………………………………………...

b) What made you choose the types of crop you planted during OND rainfall season?

Tradition ☐
Past experience ☐
Own decision ☐
Other(s)…………………………………………………………………………………
………………………………………………………………………………………………

24. In your opinion, what should be done to improve access and use of seasonal climate forecasts in agricultural decision-making?.........................................................................................
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**THANK YOU VERY MUCH FOR YOUR COOPERATION**

## APPENDIX II: INTERVIEW SCHEDULE FOR KEY INFORMANTS

***Preamble***

*My name is Morris MaingiMwatu. I am a student at Egerton University pursuing Masters of Science Degree in Geography. This is an academic study whose main purpose is to collect data on perception of seasonal climatic forecasts, their use and related constraints faced by smallholder farmers in Voi sub-County. You are requested to be honest in your responses that will be highly appreciated and treated with utmost confidentiality.*

**FOR OFFICIAL USE ONLY**

**SERIAL NO……………………………….  Station………………………………………….**

**Key informant: Meteorologist☐ Agricultural officer☐ Administrator ☐**

**Location ……………………… Name of the Interviewer……………………………………..**

**Name of the interviewee………………………………Designation…………………………**

**Date……………………….. Time started…………………… Time ended…………………**

**Interview Questions**

1. What is the main source(s) of seasonal climate forecasts for Voi sub-County?
2. Comment on the effectiveness of the existing channels used in communicating seasonal climate forecasts.
3. Comment on the quality of seasonal climate forecasts issued by KMS for Voi sub-County
4. What information usually accompanies seasonal climate forecasts issued by KMS for Voi sub-County?
5. Do smallholder farmers in Voi sub-County factor in seasonal climate forecasts in agricultural decision making?
6. a) Are smallholder farmers in Voi sub-County trained on use of seasonal climate forecast information before onset of the rainfall seasons?

   b) If yes;

   i) who trains them?

   ii) when are they trained?

   iii) for how long are they trained?
7. What challenges are faced by smallholder farmers in Voi sub-County in access and use of seasonal climate forecasts in agricultural decision-making?
8. Suggest some ways that need to be put in place to improve seasonal climate forecasts generation, dissemination and use by smallholder in agricultural decision-making.

**THANK YOU.**

# APPENDIX III: RESEARCH AUTHORIZATION

NACOSTI

**NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION**

Telephone: +254-20-2213471,
2241349, 310571, 2219420
Fax: +254-20-318245, 318249
Email: secretary@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No.

**NACOSTI/P/15/69630/8859**

Date:

**8th December, 2015**

Morris Maingi Mwatu
Egerton University
P.O. Box 536-20115
**EGERTON.**

**RE: RESEARCH AUTHORIZATION**

Following your application for authority to carry out research on ***"An assessment of effectiveness of seasonal climate forecast in agricultural decision-making among small-holder farmers in Voi Sub-County, Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Taita Taveta County** for a period ending **8th December, 2016.**

You are advised to report to **the County Commissioner and the County Director of Education, Taita Taveta County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

**DR. S. K. LANGAT, OGW**
**FOR: DIRECTOR GENERAL/CEO**

Copy to:

The County Commissioner
Taita Taveta County.

The County Director of Education
Taita Taveta County.

*National Commission for Science, Technology and Innovation is ISO 9001: 2008 Certified*

## APPENDIX IV: RESEARCH CLEARANCE PERMIT

**CONDITIONS**

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officers will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

**REPUBLIC OF KENYA**

NACOSTI

**National Commission for Science, Technology and Innovation**

**RESEARCH CLEARANCE PERMIT**

**Serial No. A** 7452

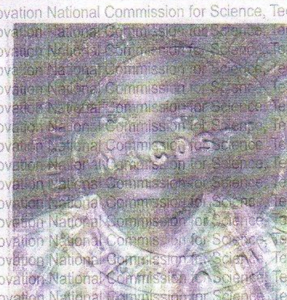
**CONDITIONS: see back page**

**THIS IS TO CERTIFY THAT:**
***MR. MORRIS MAINGI MWATU***
**of EGERTON UVINERSITY, 0-80400 Ukunda,has been permitted to conduct research in *Taita-Taveta County***

**on the topic: *AN ASSESSMENT OF EFFECTIVENESS OF SEASONAL CLIMATE FORECAST IN AGRICULTURAL DECISION-MAKING AMONG SMALL-HOLDER FARMERS IN VOI SUB-COUNTY, KENYA.***

**for the period ending:**
***8th December,2016***

**Permit No : NACOSTI/P/15/69630/8859**
**Date Of Issue : 8th December,2015**
**Fee Recieved :Ksh 1,000**



...............................
***Applicant's Signature***

...............................
***Director General***
***National Commission for Science, Technology & Innovation***