ACCESS AND UTILIZATION OF SEASONAL CLIMATE FORECAST AMONG SMALL HOLDER FARMERS IN MASINGA SUB-COUNTY, MACHAKOS COUNTY, KENYA

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A Thesis Submitted to the Graduate School in Partial Fulfilment of the Requirements for the Award of the Degree of Master of Arts in Geography of Chuka University.

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DECLARATION AND RECOMMENDATIONS

Declaration

This thesis is my original work and has not been submitted for any award of a degree or diploma in this University or any other Institution.

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Recommendations

This thesis has been examined, passed and submitted with our approval as University supervisors.

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DEDICATION

I dedicate this thesis is to my parents Eunice Mueni and Morris Masesi who educated me and taught me that even the largest task can be accomplished if it is done one step at a time.

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May the Almighty Lord bless you all.

ABSTRACT

Climate change in Kenya and other East African countries is expected to manifest itself in shifts in seasons and increased frequencies of extreme weather events, such as droughts, heavy rainfall and associated flooding. As climate continues to change, seasonal forecasts will become even more crucial as one way of informing farmers of short-term weather dynamics, impending seasons of below- or above-normal rainfall and extreme rainfall events. Kenyan government has invested considerable resources into the development of understanding and technologies to meet the expected demands of its citizens for improved climate forecasts. Regrettably, many of the benefits of these investments have not yet been realized as farmers do not use this forecasts information to make agricultural sound decisions, hence benefits to the nation are considerably less than they might be otherwise. This therefore called for a study to evaluate the access and utilization of seasonal climate forecast among households in Masinga Sub County, Machakos County in Kenya. A cross-sectional survey research design was used. A systematic random sampling procedure was employed to select 274 respondents in the four sub locations of Masinga Sub County. Structured questionnaires were used to elicit required information from the respondents. Data was analyzed using both descriptive and inferential statistics. Pearson's correlation coefficient was utilized to establish relationship between some socioeconomic characteristics and utilization of climate forecasts. Results indicated that 82% of the respondents were able to access climate forecasts through radio, and television. Majority of the respondents indicated that their major interest was to know the start and the end of rain (63%). Radio was the major source of climate forecast (38%) with 90% of the respondents getting information from radio and 60% from television. Above 60% of the respondents indicated that the climate forecast information received from dissemination channels was inaccurate. Over 60% indicated that bulletins used very difficult and complicated language while chief "Barraza's" was considered to use simple language (56%). Inadequate extension officers (84%) was a limitation to access to climate forecast information. Majority of the respondents (54%) use both indigenous knowledge on climate forecast and seasonal climate forecasts, however 61% stated that they were very unsatisfied with scientific forecasts. Inaccuracy of forecasts (98%) was a key factor affecting adoption of climate forecast. Over 80% of the respondents felt that climate forecasts cover a wide area making it difficult for them to relate the climate reports to their specific local areas. It was noted that seasonal climate forecast information given by the relevant institutions are coarse thus providing little or no detail on the local characteristics of a season, and do not reflect the localized pattern of rainfall. Moreover, difficult terminologies used in climate forecasting limit their usability and usefulness to farmers and other users. Majority of farmers lack confidence in forecasts issued by KMD and perceive them to be incorrect. Most of the climate forecasts broadcasts are done at the wrong time of day, when the households were out in the fields or in their daily activities. This hinders usability of climate forecasts by the targeted groups. The study further established a significant relationship between land, income, age, education level and gender with utilization of climate forecast. Therefore, based on the major findings of this research it is recommended that, (i) climate forecasts should be downscaled into regional level and should be location specific to increase utility (ii) disseminate climate forecast through local media in local languages so that information can reach local farmers (iii) probabilistic nature of seasonal forecasts should be given with technical guidance to help farmers interpret

easily and respond to the forecast and (iv) climate forecasts should be issued in the evening between 6.00 p.m-9.00 p.m. to reach a large audience.

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ABBREVIATIONS

AGRHYMET		Agro meteorology, Hydrology, Meteorology Regional
ASALs.		Arid and Semi-Arid Lands.
AWS		Automatic Weather Stations.
CBOs		Community Based Organization
COF		Climate Outlook Forum.
DMC		Drought Monitoring Centre
ECOWAS		Economic Commission of West African States
GCM		General Circulation Models.
GDP		Gross Domestic Product
GHA	-	Greater Horn of Africa
GHACOFs.		Greater Horn of Africa Climate Outlook Forums.
ICPAC		Intergovernmental Authority on Development Climate
ICT		Information and Communication Technology.
KALRO		Kenya Agriculture and Livestock Research Organization
KEFRI-		Kenya Forest Research Institute
KMD		Kenya Meteorological Department.
NGO		Non-Governmental Organization.
NMHSs.		National Meteorological and Hydrological Services. Prediction and Applications Centre
ROFs.		Regional Outlook Fora.
SADC-CSC		Southern African Development Community Climate Services
SSA	-	Sub-Saharan Africa.
SSTs.	-	Sea Surface Temperatures.
UNDP	-	United Nations Development Program.
WMO	-	World Meteorological Organization.

CHAPTER ONE
INTRODUCTION

1.1 Background of the Study.

Much of the weather and climate information available for Africa comes from global data sets (e.g. CMIP5) and projects with broad geographical coverage. In addition, national meteorological and hydrological agencies play an important role in generating and disseminating climate information within African countries (Singh, Urquhart, Osbahr, & Dorward 2016). While the capacities of different national agencies vary across Africa, typically, they collect and maintain observational data, and provide weather and climate forecasts to communities, private sector, companies, and government departments. Regional hubs, including the Intergovernmental Authority on Development Climate Prediction and Applications Centre (ICPAC), the Agro meteorology, Hydrology, Meteorology (AGRHYMET) Regional Centre, and the Southern African Development Community Climate Services Centre (SADC-CSC), provide additional support and coordination across countries. ICPAC disseminates early warning climate hazard information to Eastern African countries while AGRHYMET provides information on food security and environmental issues for countries in the Economic Commission of West African States (ECOWAS). Traore, Kouressy, Vaskmann Tabo, Maikano, Traoré, & Cooper (2014) noted that because of an increased occurrence of climate extremes throughout West Africa, AGRHYMET has developed additional services, including climate change impact assessments for agriculture and water resources.

The SADC-CSC provides climatic information to Southern and Central African countries, covering operational services for climate monitoring, predicting extremes and hydro meteorological products. The regional centers have a particularly significant role in providing seasonal forecasts at the regional scale, through the Southern Africa Regional Climate Outlook Forum, PRÉvisions Saisonnières en Afrique de l'Ouest for West Africa and the Greater Horn of Africa Regional Climate Outlook Forum (Patt, Ogallo, & Hellmuth, 2007). They create networking opportunities for users of climate information to engage with climate scientists. For example, ICPAC have enhanced collaborations with sector-specific users through pilot projects to develop new tools for supporting the use of weather and climate information in agriculture and food security, livestock, health, water resources, hydropower risk management and environment management. The regional centers also support improving human resource capacity in regional climate modelling, prediction and application. Long-term climate projections are increasingly being produced through international projects such as CORDEX, and through more engagement of national meteorological agencies in Africa with climate modelling institutions in developed countries. For example, the Global Framework for Climate Services recently developed an initiative called 'Climate Services Adaptation and Disaster Risk Reduction in Africa' to work with national meteorological agencies in Africa and build capacity for improved weather and climate services for agriculture.

Recent advances in climate modelling have resulted in increased ability to predict rainfall in many parts of the world with a lead time ranging from a few days to a few months, by using dynamical forecasts or statistical methods (Njau, 2010). Seasonal rainfall forecasts are particularly suited for rain fed farming systems, which constitute the main source of livelihood for African rural households (Klopper, Vogel, & Landman., 2006;). Empirical studies among African farmers have shown that climate forecasts can help farmers reduce their vulnerability to drought and climate extremes, while also allowing them to maximize opportunities when favourable rainfall conditions are predicted (Roncoli, Jost, Kirshen, Sanon, Ingram, Woodin, Somé,& Ouattara, ,2009)

This assessment of potential and opportunities has ignited scientific and institutional processes to develop and disseminate climate forecasts in Africa. In the late 1990s, a series of regional Climate Outlook Forums (COFs) was launched to produce seasonal rainfall forecasts for different parts of Africa (Patt, Ogallo and Helmith, 2007; WMO and ACMAD, 1990). In West Africa, the COF known as the *Prévisions Saisonnières pour l'Afrique de l'Ouest* (PRESAO) is held each year in May, prior to the onset of the rainy season. Recent climate-related disasters, including severe droughts and destructive flooding, as well as growing evidence of climate change (Salack, and Muller, 2011) have given new impetus to the application of climate predictive information for risk management which led the World Meteorological Organization (WMO) to establish a Global Framework for Climate Services (WMO, 2013).

Less progress has been made in assessments of the extent and impact of forecast use, particularly among vulnerable populations, such as smallholder farmers in Africa (Meza, Hansen and Osgood, 2008). Where evaluations have been conducted, they have been carried out using theoretical models (Hansen, and Osgood, 2008) or by monitoring actual dissemination of forecasts to farmers and then evaluating how farmers use the forecasts and the impacts of any changes in management practices based on the forecast (Patt *et al*., 2005).

Seasonal climate forecasting can increase preparedness and lead to better social, economic and environmental outcomes within agricultural production systems. The production of rain fed crops in semi-arid tropics exhibits large variation in response to the variability in seasonal rainfall. There are several farm-level decisions such as the choice of cropping pattern, whether to invest in fertilizers, pesticides, the choice of the period for planting, plant population density for which the appropriate choice (associated with maximum production or minimum risk) depends upon the nature of the rainfall variability or the prediction of climatic variables for a specific year.

Scientific forecasts are formulated on a much larger scale and presented in a way that is unfamiliar to farmers. This makes it difficult to get farmers to use climate outlooks generated by ICPAC and the Kenya Meteorological Department (Strachan, 2008). If climatic and weather events can be predicted to a degree that makes it possible to respond effectively in the agricultural sector, then this would potentially have a major impact on worldwide food security. Farmers would be better prepared for climatic anomalies and thus less vulnerable. However, there is a considerable gap between the information needed by small-scale farmers and that provided by the meteorological services. Seasonal climate forecasts, attractive, as they may seem, have significant theoretical problems relating to the testability of predictions. A weather forecast is useful to a particular recipient only if it is sufficiently skillful, timely and relevant to actions the recipient can take to make it possible to improve outcomes (Stern & Easterling, 1999).

Studies have revealed that household farmers of Masinga Sub County always experience difficulties in accessing, interpreting and applying forecasts for their own benefit. Information such as the onset and ending of the rains, and the possibility and timing of drought, would be useful to the community, and would enhance the decisions farmers make on the basis of the near-normal, below-normal or above-normal rainfall categories. Despite advances in computing and satellite technologies and improvements in various atmospheric model's scientists use to predict weather there are still significant uncertainties in weather forecasts (Michalakes, Dudhia, Gill, Henderson, & Klemp, 2004).

The widening incompatibility of climate forecasts as viewed against the needs of the farmers in agriculture coupled with the erosion of the integrity of these climate forecasts provided the rationality of this study to evaluate the access and utilization of seasonal climate forecast among households in Masinga Sub County, Machakos County in Kenya.

1.2 Statement of the Problem

The national climate institutes have been issuing climate forecasting information and early warning signals. Despite all these efforts, food insecurity persists and cases of crop failure are particularly common in arid and semi-arid areas. In Kenya climate forecast information are rarely used by farmers and if so, only by commercial farmers or directly by government and research institutions. The limited use of climate forecast information to make appropriate decisions raises concern as to whether farmer's production problems are a result of, accuracy, communication channels, efficiency or inappropriate forecasts. This makes unfavorable climate to rank among major challenges facing agricultural development in many parts of Kenya. Mitigation through access to reliable and timely climate forecasts and other adaptive mechanisms is a great challenge. Kenyan government has invested considerable resources into the development of understanding and technologies to meet the expected demands of its citizens for improved climate forecasts. Regrettably, many of the benefits of these investments have not yet been realized as farmers do not use this forecasts information to make agricultural sound decisions, hence benefits to the nation are considerably less than they might be otherwise. This therefore calls for a study to evaluate the access and utilization of seasonal climate forecast among households in Masinga Sub County, Machakos County in Kenya.

1.3 Study Objectives

1.3.1 General Objective

To contribute to improved access and use of seasonal climate forecast among households in Masinga Sub County, Machakos County in Kenya.

1.3.2 Specific Objectives

The specific objectives of the study were to:

i. To determine dissemination channels of climate forecasts information to small holders farmers in Masinga Sub county
ii. To establish satisfaction levels of seasonal climate forecasts among small holder farmers of Masinga Sub County
iii. To examine the influence of socioeconomic characteristics on utilization of seasonal climate forecasts information by household farmers

1.4 Research Questions

i. What are the dissemination channels of climate forecast information in Masinga Sub County?
ii. To what extend are smallholder farmers of Masinga Sub County satisfied with the different types of seasonal climate forecast
iii. What is the influence of socio-economic characteristics on utilization of seasonal climate forecast among smallholder farmers of Masinga Sub County?

1.5 Significance of the Study

The study will significantly benefit the Ministry of Agriculture, Kenya Agricultural Livestock Research Institute, Kenya Meteorological Department, Agricultural Extension Officers, farmers' policy makers and policy implementers in trying to understand the utilization of climate forecasting information to the farmers in Masinga Sub county. Findings from this study will also be applied in other parts of country experiencing similar characteristics and probably improve in order to reap the benefits of seasonal forecasts.

In addition, findings from this study will inform policy formulation and strategic investment options that will alleviate associated welfare losses resulting from unfavorable climate conditions. This is a critical issue because farm households often lack substantial adaptation capacity to individually take initiatives to reduce their vulnerability. The study will play major role in addressing the recommendation of National Climate Change Response Strategy (NCCRS, 2010) by coming up with robust measures and interventions needed to address most of the challenges faced by household farmers in relation to climate forecasts. Through these interventions, household farmers are likely to regain confidence in seasonal climate forecasts and use them in agricultural production. The recommendation given in this document can be translated by the relevant agencies into policies that would benefit communities and trigger the process of access and utility in climate forecasts. This will be useful in delivering the country out of vicious cycle of poverty exacerbated by uncertainty of access and utility of climate forecasts and its associated severe impacts of livelihood and economic development as suggested by Kenya National Climate Change Action Plan (KNCCAP) 2013-2017.

The findings will also address some of the recommendations suggested by Climate Change Act 2016, with downscaling climate forecast information as adaptation strategy to agriculture. The findings will therefore aim at making a contribution to suggested pathways on improving adaptation to climate variability.

1.6 Scope and Limitation of the Study

Drought in Masinga Sub County is not a new phenomenon. The Sub County is located in the semi-arid environment, which is characterized by changes in climate that usually results in a deficiency in available moisture below levels that are normally expected. The study mainly addressed seasonal climate forecasts. Seasonal forecasts in this study referred to the information received from KMD. The study was carried out in four locations of Masinga Sub County namely, Masinga central location, Katulye location, Musumaa location and Musingini Location. Rainfall patterns in this study was considered as the most critical elements that farmers need to be informed about. The study was limited to household farmers who are found in Masinga Sub County, which is a semi-arid land, found in Machakos County. Primary data was collected from randomly selected farmers using structured questionnaires. This location was chosen because despite weather and climate forecasts made available to the farmers in Arid and Semi-Arid areas they are still vulnerable to drought and climate extremes. There is thus uncertainty on whether farmers in these arid and semi-arid lands receive these forecasts.

There are several categories and types of climate information products and services which include daily weather worecasts; dekadal agro-meteorological bulletins; monthly climate outlooks; seasonal climate outlooks; climate alerts; observed climate impacts; and tailored information for users (farmers) including various types of climate mean maps on different parameters. Seasonal climate outlooks are products that are given out to the farmers and public during the three rainfall seasons, the March to May (MAM), June to August (JJA), and October to December (OND). The forecasts have been very crucial in the detection of the evolution of any significant anomalies that could impact negatively on the socio-economic activities of the country. To determine the satisfaction level of the smallholders farmers, this study was limited to the experience of OND 2016 forecast issued by KMD. It is hoped that the smallholder farmers were able to recall the experiences of the season.

Rainfall is the most important climatic element in Sub-Saharan Africa (SSA). Essentially, rainfall controls agriculture, which is the mainstay of SSA economies and the predominant source of rural livelihoods. Agricultural production is dependent on rainfall performance. However, rainfall exhibits varying characteristics resulting in 'near normal,' 'above normal' or 'below normal' rainfall. For instance, Masinga Sub County has an average OND rainfall of 511 mm (KMD, 2017). For KMD, the term 'below normal' rainfall refers to rainfall below the mean, 'near normal,' rainfall refers to almost normal rainfall to the mean or average rainfall and 'above normal' rainfall refers to rainfall above the mean. This is because KMD gives rainfall forecasts in probabilities.

Probability refers to the chance or likelihood that a particular climate event or condition will occur in the future – for example, a 40% chance of a drier than average (or normal) season in the following year. Seasonal forecasts produced by KMD are usually presented in the form of probability of future climate values (e.g. rainfall) falling within three terciles. Each tercile contains an equal number of values that have been recorded over a 30-year period. The hypothesis used is that if the past climate in a specific location was to repeat itself exactly, then the probability that future climate values would fall in any of the three terciles is one-third, or 33.3%. This means that if the situation could be rerun many times, each outcome would occur one out of three times (KMD, 2017).

For purposes of this study, therefore, the following terms; ‘below normal’ rainfall, ‘above normal’ rainfall and ‘near normal’ rainfall were used to investigate the respondent’s knowledge of climate forecast terms used by KMD when issuing climate forecasts. In respect to KMD probabilities, ‘below normal’ rainfall was taken to fall in the first tercile ranging between 0-170.2 mm, ‘near normal’ rainfall in the second or middle tercile ranging between 170.3-340.3 mm and ‘above normal’ rainfall in the last tercile ranging between 340.4-511mm.

Probabilities of the different terciles provide the direction of the forecast relative to the average from long-term observations as well as the uncertainty of the forecast. For example, suppose a forecast shows rainfall probabilities of 20% ‘below normal’, 35% ‘near normal’ and 45% ‘above normal’. Since the ‘above normal’ tercile is more than 33.3% and the ‘below normal’ tercile is less than 33.3%, this forecast suggests that ‘above normal’ rainfall is more likely and ‘below normal’ rainfall is less likely than has been historically observed.

A potential pitfall in interpreting such a probabilistic forecast is that most attention will be given to the tercile with highest probability, yet there is much uncertainty implied in the forecast. Even though the forecast is in the direction of ‘above normal’ rainfall, the probability of ‘below normal’ rainfall is still 20%, implying that in one of the cases of this climate situation ‘below normal’ rainfall would be expected. In this study, types of seasonal climate forecasts will refer to scientific forecasts and indigenous forecasts.

1.7 Definition of Terms

Accuracy of Forecast: is the degree of closeness of the statement of quantity to that quantity's actual (true) value

Climate Change: Is any long term change in the statistics of weather over periods of time that range from decades to millions of years. In this study climate change is defined to denote a significant change (having significant economic, environmental or social effects) in the mean value of the meteorological elements in the course of a certain period of time where the means are taken in the order of a period over a decade (National Snow and Ice Data Centre, 2009).

Climate Variability: Is the deviation of climate statistics over a given climate statistic in a given period of time (such as specific month, season or year) from the long term climate statistics relating to the corresponding calendar period. (In this sense climate variability is measured by those deviations which are usually termed anomalies) (National Snow and Ice Data Centre, 2009).

Households: Is a composition of a person or group of persons residing together within the same compound and have the same cooking and investment arrangements

Meteorology: Is a study of the atmospheric conditions and especially the weather (Sci-Tech Encyclopedia, 2005.)

Smallholder Farmers: Farmers whose agricultural orientation is mainly subsistence and cultivate land not exceeding 10 acres.

Seasonal Climate Forecast: Is probabilistic information usually issued in equi-probable categories of below normal, near normal and above normal for a specified season and geographic location

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This section reviews literature in the following categories: the current state of climate forecasts in Kenya, dissemination of climate forecast information, types of seasonal climate forecasts, influence of socio-economic characteristics on utilization of seasonal climate forecasts and research gaps. The section further presents a conceptual framework that guided the study.

2.2 Current State of Climate Forecasts in Kenya

Climate is certainly the most important factor determining the success or the failure of agricultural enterprises. It manifests itself through its effects on soil, plant growth as well as on every phase of animal growth and development. A greater proportion of the total annual crop loss results from aberrant weather. In addition, crop and animal disease are greatly influenced by weather. In all, weather and climate accounts for approximately three fourth of the annual loss in farm production both directly and indirectly.

In 1974, climate forecasts were started in Kenya with the objectives of assisting researchers in selecting appropriate plants and animal breeds so as to attain a sustainable food production system in the country (KMD, 2009b). Up to the end of 1980s the Kenya Meteorological Department maintained a dense network of observing stations numbering over 2,500 most of which were rainfall stations. However, since 1990 this network has gradually declined considerably and currently the observing stations stands at below 1000 (KMD, 2009b). This has resulted in dwindling amounts and gaps in data sets and decline in the aerial coverage.

The department maintains a network of 32 Synoptic stations and out of these 12 stations report agro -forecasts information, crop phenology and soil moisture in addition to other meteorological information (KMD, 2009b). The rest of the stations supply climatological information. Advancement in technology and the use of

Information and Communication Technology (ICT) has resulted in modernization of climate observing instruments and equipment's such as Automatic Weather Stations (AWS). The Kenya Meteorological Department has been in the process of installing AWS to replace the manual instruments and more than 24 AWS have been installed (Kinuthia, 2006).

Crop data is obtained from the 12-agro meteorological stations (Figure 2.1) on, variety of crops being grown, stage of development, crop performance, plant density and soil moisture. Expected yields are normally observed at the end of each 10 days and along with the meteorological forecasts, data are communicated to the agro meteorological section to facilitate crop-weather impact assessment (Kinuthia, 2006). In order to obtain a general overview of crop performance in the country, especially on the main staple food such as maize, beans and wheat all the 32 stations (Figure 2.2) report on the stage of crop growth, crop performance and expected yield through visual inspection and oral interviews from farmers (Kenya Meteorological Department (KMD), 2009b).

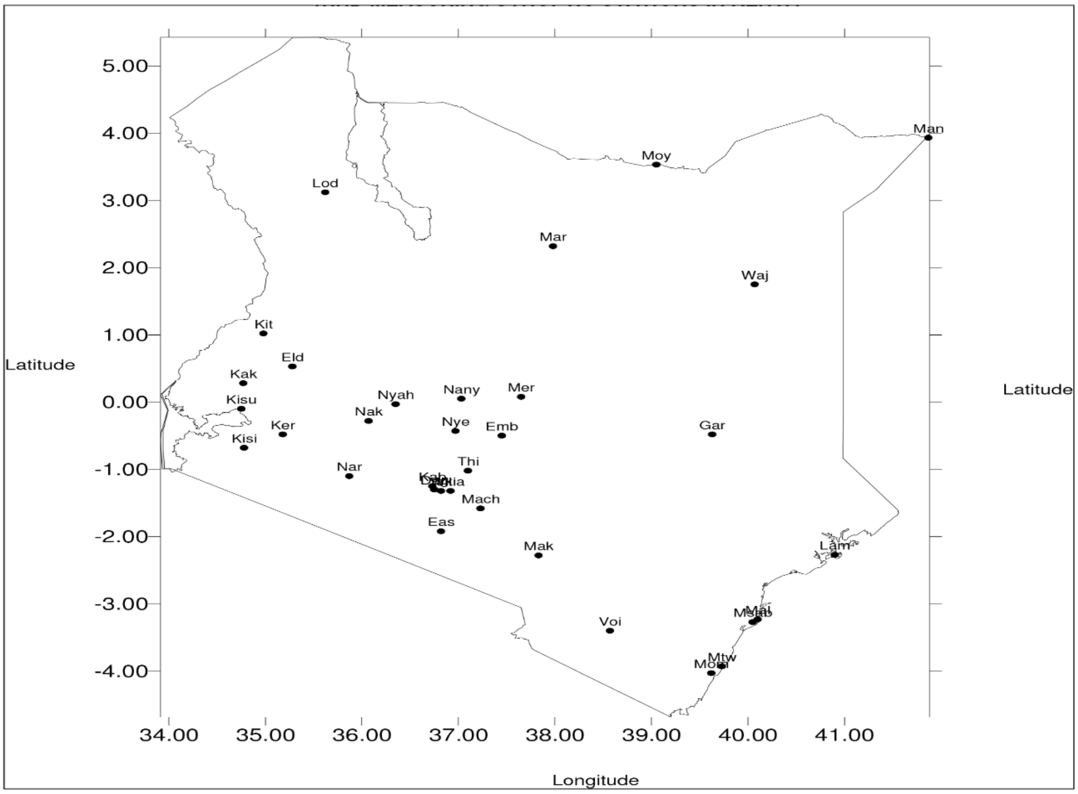


Figure 2.2. Geographic distribution of surface observing stations in Kenya

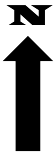


Figure 2.1. Current geographic distribution of agro-meteorological stations in Kenya. Source: Kenya Meteological Department, 2016**.**

Growing understanding of ocean-atmosphere interactions and advances in modelling the global climate systems now provide a usable degree of predictability of climate several months in advance for many parts of the world (Goddard, Barnston, & Mason 2001). Combined with the ability to systematically quantify agricultural management responses via simulation analysis, the enhanced understanding and modelling of climate issues offers an opportunity to improve climate risk management (Meinke & Stone, 2004). Integrating seasonal climate forecasting with agricultural system analysis can increase its effectiveness and utilization (Hammer, Nicholls, & Mitchell 2000; Meinke *et al.*, 2001). The recent improvement of seasonal climate forecasts has meant that forecasts on how much rain to expect over the season, and predictions of seasonal variability of rainfall are now widely available. The seasonal forecast is based on the fact that lower-boundary forcing, measured by sea surface temperatures, drives future atmospheric perturbations (Murphy *et al.,* 2001). These boundary conditions evolve slowly and so enable predictions of rainfall to be made (Goddard, Barnston, & Mason 2001).

Seasonal forecasts are probabilistic and rainfall is often forecast as 'above normal', 'below normal' or 'near normal'. The 'normal' amount of rainfall is the middle third (tercile) of the average rainfall for the past number of years of rainfall data used to develop the forecast. The forecast is usually issued for a period of one to three months and suggests the probability of a given amount of rainfall expected over that period. The forecast gives an indication of date of onset and cessation of rain. The forecast however does not give much weight to the temporal distribution, such that if the amount of rainfall forecast were to fall over a few days, the seasonal forecast would still be correct but the impact could be catastrophic (Agrawala, Broad & Guston, 2001). It is this probabilistic nature that needs to be given attention in dissemination of forecast information so that farmers do not assume it deterministic.

In the agricultural sector, forecasts have provided information for agricultural decisions relating to dry land farming, irrigated farming and livestock management (Marshall, Parton & Hammer, 1996). The types of decisions making that seasonal forecasts can support include both operational short-term decisions, and tactical and strategic longer-term decisions. A strategic decision for smallholder farmers might be to maximize total crop yield. The accompanying operational decision might involve deciding what variety of crop to plant in order to achieve maximum yields. A forecast for below-normal rainfall could encourage drought-resistant seeds to be planted instead of long-maturing varieties that require more moisture and might fail completely without adequate moisture. If the forecast provides better than 'best-guess' information about the rainfall in the succeeding season, it allows better decision making and maximization of conditions (Walker, Mukhala, van den Berg & Manley, 2001).

The opportunity to manage variation is a strength of seasonal forecasts that is just as important as decreasing negative impacts of climatic variability. The most useful forecast information, according to the farmers, are the early warning on anticipated poor season, the commencement of the season and adequacy of anticipated rains (Phillips, Makaudze & Unganai, 2001). It is probable for people living in low rainfall zones that seasonal forecasts for wetter years are of greater value than warnings of a poor season (Phillips, 1998). Above all "the forecast should be stated and presented in a language and in terms that the target end users understand" (Unganai, 2000).

2.3 Dissemination of Climate Forecast Information

Recent advances in technology for communicating data and information electronically have opened up new avenues of opportunity to communicate climate forecast information in a timely and effective manner, but there are varied capabilities between the developed and developing world (Sivakumar, 2006). In Kenya, it is easy to pass climate forecast information to the government departments, research institutions, universities and other stakeholders including large scale farmers especially those in horticulture/floriculture, ranching and agriculture. These stakeholders have knowledge in ICT and also have access to modern communication equipment's (Ngugi, 2002). Providing agro meteorological information and services to the small-scale farmers in the rural areas in a timely framework has been very difficult due to communication barriers. This is because of the assumption that climate forecast information and services successfully reach farmers through agricultural extension services while this has not been the case (Kinuthia, 2006).

The Kenya Meteorological Department provides the following information and services; the start and end of the rainy seasons, and the rainfall performance during the seasons, probable planting dates, monthly and decadal (10 day) agro meteorological bulletin. KMD provides information on weather and crop performance, advisory services on adverse effects of weather on crops, breeding conditions for pests, water status for livestock and pasture conditions and advisory on farm operation (Kenya Meteorological Department (KMD), 2009a). It thus emerges that, understanding climatic parameters, rainfall in particular, can aid in developing optimal strategies of improving the socioeconomic well-being of smallholder farmers. This is particularly important in Sub-Saharan Africa (SSA) where agricultural productivity is principally rain fed yet highly variable. However, field studies of the impact of recent forecasts in Southern Africa suggests that there is a considerable gap between the information needed by small-scale farmers and that provided by the meteorological services. (Kinuthia, 2006).

Improved techniques are making it possible to present the farming community in semi-arid Africa with seasonal climate forecasts some three to six months ahead. Since the 1980s there has been a notable increase in the capacity to model planetary climate systems and every year brings new refinements to the General Circulation Models (GCMs) (e.g. Delecluse *et al.*, 1998). Output from models is not deterministic but is typically presented as a range of probabilities. The use of this format for seasonal forecasts is being promoted by the Regional Outlook Fora (ROFs) which were initiated in 1996 the Southern Africa. These have now been expanded to cover tropical America, the Caribbean, South and SE Asia and West Africa, and the ROFs have been consistently expanded to include a wider range of users.

The output of the ROFs is plotted on national or regional maps and then disseminated to national climate services. If climatic events can be predicted to a degree that makes it possible to respond effectively in the agricultural sector, then this would potentially have a major impact on worldwide food security. Farmers should be better prepared for climatic anomalies and thus less vulnerable. There are both technical problems in transforming the output of GCMs into seasonal forecasts as well as a failure to identify users' requirements. African farmers have always had their own strategies for dealing with climatic uncertainty (Roger Blench, 1999).

In regions that depend substantially on rain fed farming, foreknowledge of the likely pattern of precipitation could imply substantial improvements to food security as well as profits to larger-scale producers. The accuracy of forecasts depends on effective measurement of known predictors, model quality and local interpretation. Other methods KMD uses to disseminate climate forecast to households include use of climate alert bulletins and use of tailored information for users.

Climate Alert Bulletins

These are alerts normally given out when the need arises. These climate alert bulletins provide climate updates as well as timely information on major regional climate stress and impacts associated with extreme climate events such as drought and floods. Some of these climate extremes have been associated with El Niño / La Niña events. It also spells out cumulative associated impacts of previous extreme climate events that are similar to what is evolving phenomenon.

*Tailored information for users (farmers***)**

This is type of information is normally given out on request. The major clients for this information are Agricultural Commercial Farmers, Insurance Companies and Community Based Organizations (CBOs). Some of the climate information required includes onsets and cessation dates for localized places, distribution of rains including amount and time, climatological maps, climate change, vulnerability assessment maps; observed climate change indices for specified places, and advice on types of crops to be grown for particular regions among many others.

Some seasonal climate forecasts available today are issued with probabilities (or error bars) which have been properly calibrated against past cases. Quality check of forecasts is an instrument for services and for end-users. In particular end-users can choose better forecast products and services. Thornton, (2006) presented six attributes of a weather forecast that make up the total quality: reliability, accuracy, skill, resolution, sharpness and uncertainty.

The reliability of a forecast can be measured by calculating the bias. This will show if the forecasters are consistently over-forecasting the number of particular events. The percentage of correct forecasts is a very simple measure of forecast accuracy. There are many different skill scores (e.g.: Pierce Skill Score, Odds Ratio Skill Score) that attempt to assess how much better the forecasts are than those which could be generated by climatology, persistence or chance. Resolution is important in the forecasting of precipitation – being able to distinguish between, for example, snow, sleet, freezing rain, hail, drizzle and rain.

Sharpness is a measure of the spread of the forecasts away from climatology, e.g. a forecast method that can predict frosts in spring as well as winter shows high sharpness whereas a forecast method that can only predict frosts in winter has low sharpness.

Uncertainty relates to the climate, for instance, some areas have comparatively fewer frosts than others. A number of measures of forecast quality are therefore required, but in order to avoid confusion they must be easy to calculate and their statistical significance should be testable (Thornton, 2006). The production and release of quality control weather forecast data is important in order to guide the choice of the right weather prediction by farmers. If quality data aren't available, agro meteorologists or farmers can use directly observed data (meteorological measurements of temperature, precipitation and so on, sky coverage and weather phenomena) in order to evaluate the skill of forecasts. Statistical analysis can be carried out by means of on parametric methods. Thornes and Stephenson, (2001) found that farmers will not use climate forecast if the quality of the forecasts is low. The quality of forecast can be clearly known if the consumers (farmers) show how they access and utilize the climate forecasts in worthwhile decision-making (Chavas, 2015).

Occurrences of erratic climate are beyond human control. However, it is possible to adapt to or mitigate the effects of adverse climate forecast, if the expected climate forecasts can be given in time Chavas, (2015). The keenness of farmers to know in advance the likely climate situations for crop operations is time immemorial. Agronomic strategies to cope with changing climate are available. For example, delay in start of crop season can be countered by using short duration varieties or crops and thicker sowings. However, once the crop season starts the resources and technology get committed and the only option then left is to adopt crop-cultural practices to minimize the effects of mid-seasonal hazardous climate phenomena on the basis of advanced intimation of their occurrences. For example, effects of frosts can be prevented by resorting to irrigation or lighting up of trash fires. Thus, the usefulness of medium range climate forecasts with a validity period that enables farmers to organize and carry out appropriate cultural operations to cope with or take advantage of the forecasted climate is warranted. With the rapid advances in Information Technology and its spread to rural areas, the demand for provision of timely and accurate climate forecasts for farmers is on the increase. According to Meinke *et al*. (2006) this climate forecasts are ill suited for use by farmers for their decision-making. Feleke (2015) noted that climate forecasts in their current form are often ill suited for direct use in decision-making and decision-making is often ill suited for the use of climate forecast information.

Hansen (2002) pointed out the prerequisites for potential benefits of climate forecasts if they are to be realized by farmers. Firstly, these types of forecasts have to address a need for farmers. That is ‘the real and perceived’. Climate forecasts have to be relevant component of the climate system at an appropriate farming system at an appropriate spatial and temporal scale. Importantly, Hansen (2002), points out that the benefits also depends on the existence of decisions for the farmer which are sensitive for the particular incremedal information that the forecasts provide and which are compatible with farmer’s goals. There is need for appropriate interpretation highlighting where farmers require capacity to interpret correct relevant forecasts, which also have to be made with sufficient lead-time to make an impact on their decisions. It is therefore important to know how farmers access and utilize climate forecasts information for decision making if these forecasts ate to remain relevant (Hansen 2002).

2.4 Types of Climate Forecasts

The institutions that provide climate information products and services include the countries NMHSs and the IGAD Climate Prediction and Applications Centre (ICPAC) located in Nairobi, Kenya among other institutions in the Eastern Africa region. ACMAD also issue dekadal and monthly climate watch bulletins covering the region. There are several categories and types of climate information that are issued by KMD. This sub section therefore discuses two types of forecasts, indigenous and scientific forecasts.

2.4.1 Scientific Forecasts

Since the inauguration of regional climate outlook forums, prior to the 1997/98 El Niño event, (WMO, 2013) around the world and Great Horn of Africa climate outlook forums (GHACOF) in Eastern Africa, there has been effort from the climate application community to have farm household (and other sections of the economy) access and utilize climate forecast information (Oduor *et al*., 2002). This has been with an aim of reducing climate related risks for sustainable agricultural development. In spite of the effort, application of seasonal climate forecast at the level of an individual farmer remains the greatest challenge to smallholder farmers particularly those in Africa.

Application of scientific climate forecast (SCF) has evolved in conjunction with advances in the accuracy and utility of the climate prediction since the early 1990's. This had a primary purpose of developing a forecaster-user dialogue and provides an avenue for information exchange. Agro-meteorologists have, in the past few decades, developed different types of science-based knowledge, to better cope with climate variability, but, operationally, this leaves for farmers much to be desired. (Philips *et al*., 2001)

Climate forecasts are made by collecting as much data as possible about the current state of the atmosphere (particularly the temperature, humidity and wind) and using understanding of atmospheric processes (through meteorology) to determine how the atmosphere evolves in the future. However, the chaotic nature of the atmosphere and incomplete understanding of the processes mean that forecasts become less accurate as the range of the forecast increases. Many times climate forecast cover a wide geographical area (DMCN, 2004) and fail to take into consideration local factors influencing rainfall. Studies by Patt and Gwata (2002), Philips (2003) and Mwinamo (2001) give evidence that climate forecast predictions do not trickle down to the user, especially resource poor farmer. If the individual users receive forecast product, are they able to use them? It is important to target farmers in disseminating seasonal climate forecast products since decisions that determine production are made at the scale of the individual. Secondly, for maximum benefits of forecast product a thorough understanding of human social and economic system within which climate forecast is applied is crucial (Ramamasy, 2007). Some of scientific forecasts issued by KMD are:

Daily Weather Forecasts

These weather forecasts are issued out to the agricultural communities and public daily. They normally contain detailed likelihood of forecasts (possibility of showers and temperature) for the following day for every region in Kenya. They also include detailed daily weather statistics (usually for yesterday), including temperature and precipitation.

Dekadal Agro-meteorological Bulletins

This bulletin contains observed climate statistics for the previous 10-days over the country. These statistics includes spatial and temporal performance of rainfall within the country, temperature, relative humidity and winds among others. It also gives report on the stage of crop development, general assessment of crop performance and yield expected (visual) from the farmers' farms on the basis of what they see from nearby farms and oral interviews with farmers by Kenya Meteorological Department (KMD) agro-meteorological observers from 12 agro-meteorological stations across the country. Other crucial information on general assessment of crop performance is obtained from some County Agricultural Officers through emails and cell phone text messages. The bulletin also includes the weather systems that were responsible for the occurrence of the previous 10-day's weather. In addition, the climate forecast for the next ten days is also provided.

Monthly Climate Outlooks

This forecast is given out monthly especially to farmers. It gives the monthly updates of the rainfall and temperature performance for every climatological zone in the country. It contains statistics on the observed climate parameters like rainfall and temperature against long-term mean. It also gives out probabilistic outlook for the next month in three categories (Above normal; Near Normal; Below normal) in order to detect the evolution of any significant anomalies that could impact negatively on the socio -economic activities of the region. (Kadi, *et al* , 2011)

Seasonal Climate Outlooks

These are products that are given out to the farmers and general public during the three rainfall seasons, the March to May (MAM), June to August (JJA), and October to December (OND). The forecasts have been very crucial in the detection of the evolution of any significant anomalies that could impact negatively on the socio - economic activities of the country. These forecasts are derived from statistical models and dynamical model outputs from advanced prediction centres. Other information that is contained in the seasonal forecasts includes the performance of the previous season in terms of rainfall and temperature, performance of crops and observed impacts. Other information includes the onset and cessation dates, distribution of seasonal rains based on the selected analogue years. The regional climate outlook forum (RCOF), the GHACOF organized by ICPAC in collaboration with NMHSs of Greater Horn of Africa countries and partners provide a platform for interaction between providers and users of seasonal climate consensus forecasts downscaled at national level for decision-making in agricultural production and food security, health, water and energy resources management (Figure 2.3 and 2.4).

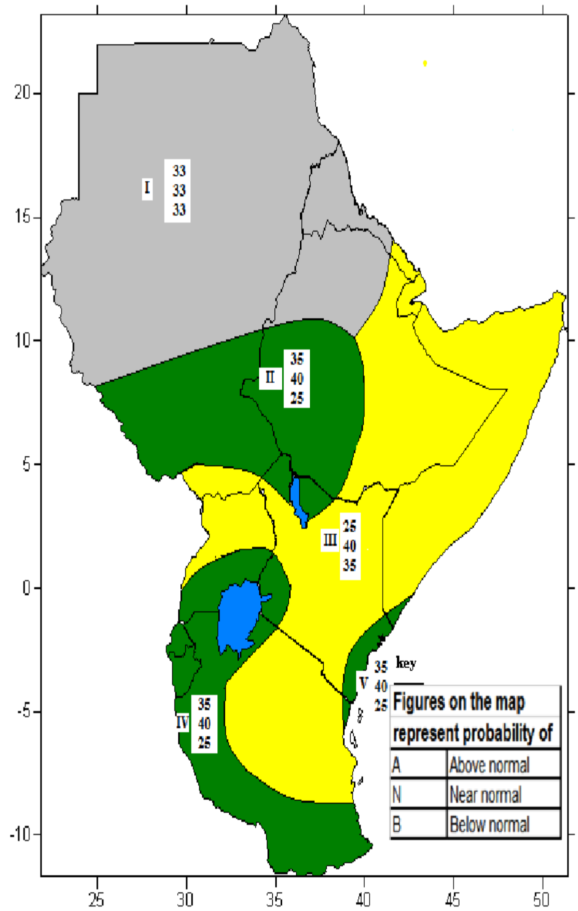


Figure 2.3: GHACOF 27 Seasonal consensus forecast for October-December (OND) 2016 Rainfall season (Source: ICPAC-2017).

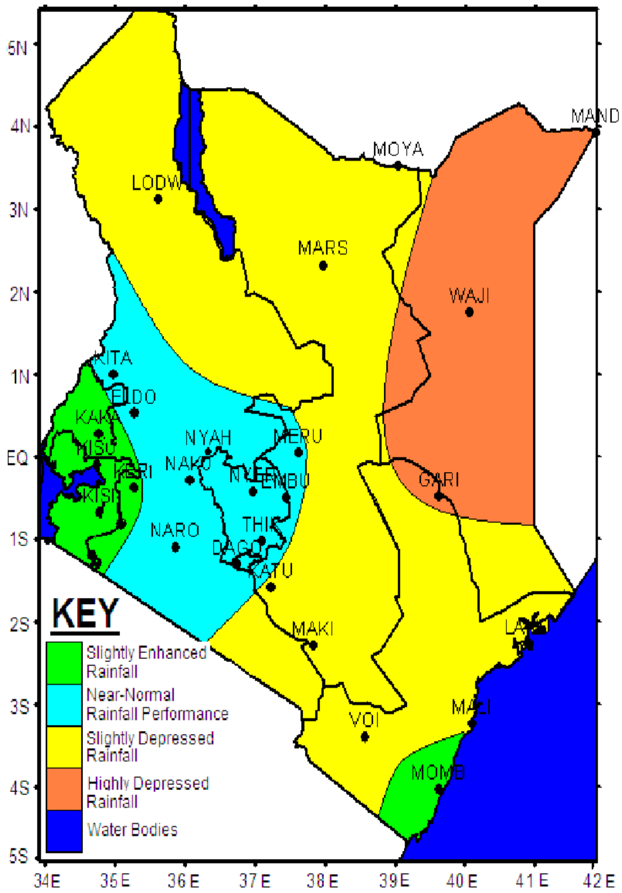


Figure 2.4 GHACOF -27 Seasonal Consensus forecast (OND) downscaled for Kenya.
(Source: ICPAC)-2017

2.4.2 Indigenous Forecasts

Indigenous forecasts can be defined as a body of knowledge built up by a group of people through generation of living in close contact with the nature; it is knowledge used by local people to make a living in a particular environment (Roncoli *et al.*, 2002). Indigenous forecasts has been used in such areas as biodiversity conservation, disaster prediction and management and in agriculture for seasonal rainfall forecast. This knowledge is learned and identified by farmers within a cultural context and the knowledge base reflects the specific language, beliefs and cultural processes (Chang'a, Yanda & Ngana, 2015).

Most African communities still rely on traditional forms of climate forecasting by mainly using environmental, meteorological and astronomical indicators. Some even still rely on traditional “rainmakers” (Conway, 2009). Local communities have developed intricate system of gathering, predicting, interpreting and decision making in relation to climate. A study in Nigeria, for example shows that farmers are able to use knowledge of climate systems such as rainfall, thunderstorm, windstorm and sunshine to prepare for future climate forecast (Ajibade & Shokemi, 2003).

According to studies carried out by Egeru (2012), the Hausa of Northern Nigeria, for example, developed a wealth of indigenous knowledge systems to cope with vulnerability to drought and famine in sub-humid to arid regions of the Sahel. People in rural or remote areas rely mostly on indigenous climate forecasting systems to get daily and seasonal climate forecasts. These indicators are derived from the environment and differ from place to place

Indigenous methods of forecasting are known to complement farmers-planning activities in Nigeria. Pratt (2001) argues that practitioners of traditional knowledge, perceptive members of the community observe the sky colour, cloud and wind patterns, flowering cycles and fauna movement to determine the imminence of rain. Star pattern provide information on the arrival of seasons and moon crescents and rings of its nature, while historical knowledge indicates which long-term cyclical climate pattern is prevailing. Animals grazing and watering behavior are also perceived as indicators of forthcoming meteorological events and pastoralists are not adverse to most mystical indicators such as intestnology; studying the intestines of a slaughtered animal could give a clue on the expected season.

Manyatsi (2011) carried out a research in Swaziland on the use of indigenous knowledge to manage hydrological disasters. The study revealed that varieties of methods are used to predict the climatic conditions such as environmental cues and the behavior of animals. The nesting position of *Ploceus ssp* bird is used to predict floods. The cry of *cuculus solitaries* bird signals the start of the wet season between August and November. On hearing this cry, the farmers assemble their inputs. Manyatsi (2011) also established that when there is abundance of creatures such as butterflies, locusts and grasshoppers during the farming season then drought would be imminent. Sign of wet conditions approaching makes farmers embark on land preparation in anticipation of the wet rainfall season.

2.5 Influence of Socio-economic Characteristics on Utilization of Seasonal Climate Forecasts

Social economic factors such as labour credit facilities, draft power and access to certified seeds are determinants in the application of seasonal climate forecast consequently affecting farm management and food security strategies at the household level. According to Hansen and Indeje (2004) socio-economic constraints still form a critical gap between climate forecast information and its application at farm level decision making. In a good rain year, farm households, which are limited by labour, may decide to reduce cultivated area, use more manure and focus on weeding to maximize yields while households that have more labour can expand the cultivated area to maximize use of good rainfall conditions. In a drier year, the behaviour of both sets of households would be different (UNEP, 2006)

According to Philips (2003), a biophysical event such as agro-ecological zone, plays a strong role in delivering crop management decision. The options mainly include change of area planted, crop or cultivars and planting dates. A case in point is during 1998/99 La Nina event in Zimbabwe where farmers who accessed the forecast in the drier natural zones shifted from planting small grains (like sorghum) to maize given the expectation of the wet season. In a separate study results by Philips *et al*. (2001) showed that marginal drier zones where long term means are experienced, yield are extremely low and crop failure common, early planting during favourable season has the potential to increase yields. Given that the decision making relies on a variety of socio-economic and geographical factors.

A study by Isabirya *et al*. (2003) amongst crop farmers, pastoralists and fishermen in two districts in Uganda aiming at establishing methods used in conveying climate forecasts information pointed out that climate forecast information is used for planning and scheduling seasonal activities. According to Isabirya *et al*. (2003), dissemination is the main problem in the forecasts application. Although studies by Philips *et al*., (2001), Philips (2003), and Patt and Gwatta (2002) show that factors such as labour, credit facilities, animal power and farmers' perception are key to utilization of forecast, Isabirya *et al*. (2003) do not explain whether crop farmers, pastoralists and fishermen experience the same problem or not. Whereas dissemination of climate forecast is a challenge to forecast application, it is important to look at other factors such as labour, level of education, income and beliefs in forecast among others factors.

A study carried out in West Africa, Jagtap and Jones (2005) found out that knowledge of approaching drought is potentially advantageous to all farmers. It helps them develop better coping strategies, however, farmers without a socio-economic base were found not to respond to an approaching drought or maximize benefits when a good season is expected. The study by Jagtap and Jones (2005) does not examine whether factors such as ownership of animal power, level of education and income among others can affect use of forecast information. The current study attempted to investigate socio-economic constraints in the application of forecast information.

2.6 Research Gaps

It has been established that probabilistic climate forecast is released by KMD to support decision making for the different sectors in Kenya. There are 32 agro-met/synoptic stations distributed around the country that support the generation of forecasts. The generated forecasts are labelled as normal, below normal, or above normal for each of the season – both MAM and OND. In this study, the OND season of 2016 is used to determine smallholder farmer's access and utilization of seasonal climate forecasts in Masinga Sub County in Machakos County. There are increasing number of studies on the use of seasonal climate forecasts. From the literature, it has been observed that, there is lack of conclusive evidence of the positive effects of current efforts to link forecast information to the rural farmer in sub-Saharan Africa in a large scale, in a sustainable manner. In addition, one potential reason is lack of focus on how the individual rural farmer accesses information for use in decision-making. In addition, previous studies have not examined access, utilization and the perception and the attitude farmers have towards forecasts of any kind, an aspect that is key to forecast application and utilization by farmers. Thus, this is being examined in the current study.

In this review, the central role of institutions in dissemination of seasonal climate forecasts has been established. There are however gaps on effectiveness and smallholder farmer preferences of the existing dissemination channels. Against this background, the present study sought to establish the preferred and effective dissemination channel of seasonal climate forecast among smallholder farmers

Literature review shows that there are different types of forecasts broadly scientific and indigenous. There is considerable attempt to highlight the merits of scientific types of forecasts. There is however little efforts to offer a comparative perspective of both indigenous and scientific climate forecasts. In this study, effort is made to access smallholder forecasts preferences for indigenous and scientific climate forecasts.

Seasonal climate forecasts are disseminated and used worldwide as an adaptation strategy to climate variability. This study is location specific and therefore will assess utilization of seasonal climate forecast on a specific area and time, thus contributing to the understanding of its usefulness in agricultural decision-making. Climate variability adaptation varies with space and time and no study has been done to show use of seasonal climate forecast in Masinga Sub County,

Studies has shown that socio economic factors are key to utilization of climate forecast. Whereas dissemination of climate forecast is a challenge to forecast application, it is important to look at other factors such as labor, level of education, income and beliefs in climate forecast among others. In Marginal drier zones, yield are extremely low and crop failure is common, early planting during favorable season has the potential to increase yields. Given that the decision-making relies on a variety of socio- economic factors, the current study attempted to investigate how the said factors affect use of climate forecast information in Masinga Sub County.

2.7 Conceptual Framework

Information is valuable in aiding the decision-making process. Farmers make most of production decisions before the starting of the agricultural season. They have to select ex-ante the crops to grow, decide the most efficient allocation of different resources (land, assets, time, labour and other inputs) and manage the daily operations (sowing date, plant density, date of application of fertilizer and other chemicals). In other words, farmers must choose the optimal combination of strategies that maximizes the expected utility. In this situation, the problem is to select the optimal level of input using probabilistic information about potential climate outcomes.

Valuable information possesses certain attributes such as accuracy, timeliness, relevance, aggregation, impartiality and convenience. Accuracy or correctness refers to the level of agreement between the forecast and the observed meteorological realizations. Forecasts are considered “reliable” when the forecast probability is an exact estimation of the relative frequency of the predicted outcome. The effect of climate forecasts on yield depends on the quality of forecasts. High accuracy of meteorological forecasts may lead to impartiality. Impartiality refers to the level of trust between the forecasts provider and the users, in this case the farmers. The trust between forecasts providers and users will lower or cancel the cost of checking of the quality of information and increase its use.

Farmers will make effort to acquire climate forecasts only if the information is relevant to them i.e. meet their needs of information. The farmer’s needs can be expressed in terms of details contained in the forecast. Aggregation of information refers to the level of detail contained in the forecasts. The use of climate forecasts depends highly on the degree of ease of access and the ease of use of the forecasts. These two factors define the convenience of information. For climate forecasts to be valuable it has to be delivered in advance and at the right time to enable farmers to make appropriate decisions. The delivery of information in advance and at the appropriate time is defined as timeliness.

There is therefore need for an agro forecast system to disseminate climate information at national level. This national agro forecast service should comprise of scientists/experts who are capable of analyzing data from different sources including satellite, process and package this information into usable formats. One of the requirements for good packaging is adequacy of appropriate knowledge. Knowledge in this case includes knowledge of other people’s language usage (e.g. scientific terms), knowledge of the subject matter (meteorology) and general knowledge. If the farmers or users have no knowledge of the subject matter, then packaging of information has to be in such a way that it is not difficult for them to understand.

The communication channel for climate forecasts information should ensure that the correct medium or communication channel is being used for the packaged message. The meteorological services should ensure that the farmers are able to interpret the climatic forecasts. Shared meaning between the scientists and farmers should be understood by those who disseminate information for effective communication.

To enhance agricultural productivity among smallholder farmers, access to and effective utilization climate forecasts by farmers play crucial roles. The abilities to use climate forecasts could be constrained by factors such as age, gender, literacy levels, and availability of extension services and packaging of such information for application by farmers. The accuracy and importance of climate forecasts is not valuable if the affected farmers do not have options for their decisions. The available options will include adequate draft power, sources of income, crop cultivars, irrigation, fertilizers etc. Identifying these options is essential in understanding how farmers may use and or benefit from climate forecasts. To enhance productivity, one of the options would be to increase farmers' access to and effective utilization of climate forecasts information through identifying and working on the problem that affects the extent of efficiency, effectiveness and utilization of climate forecasts. This can be done through analyzing the socio-economic, demographic and psychological factors that might significantly influence information access and utilization and decision making.

The conceptual framework of this study is based on the assumption that the access and utilization of climate forecasts is influenced by a number of demographic, socio-economical, and psychological factors of the farmers.

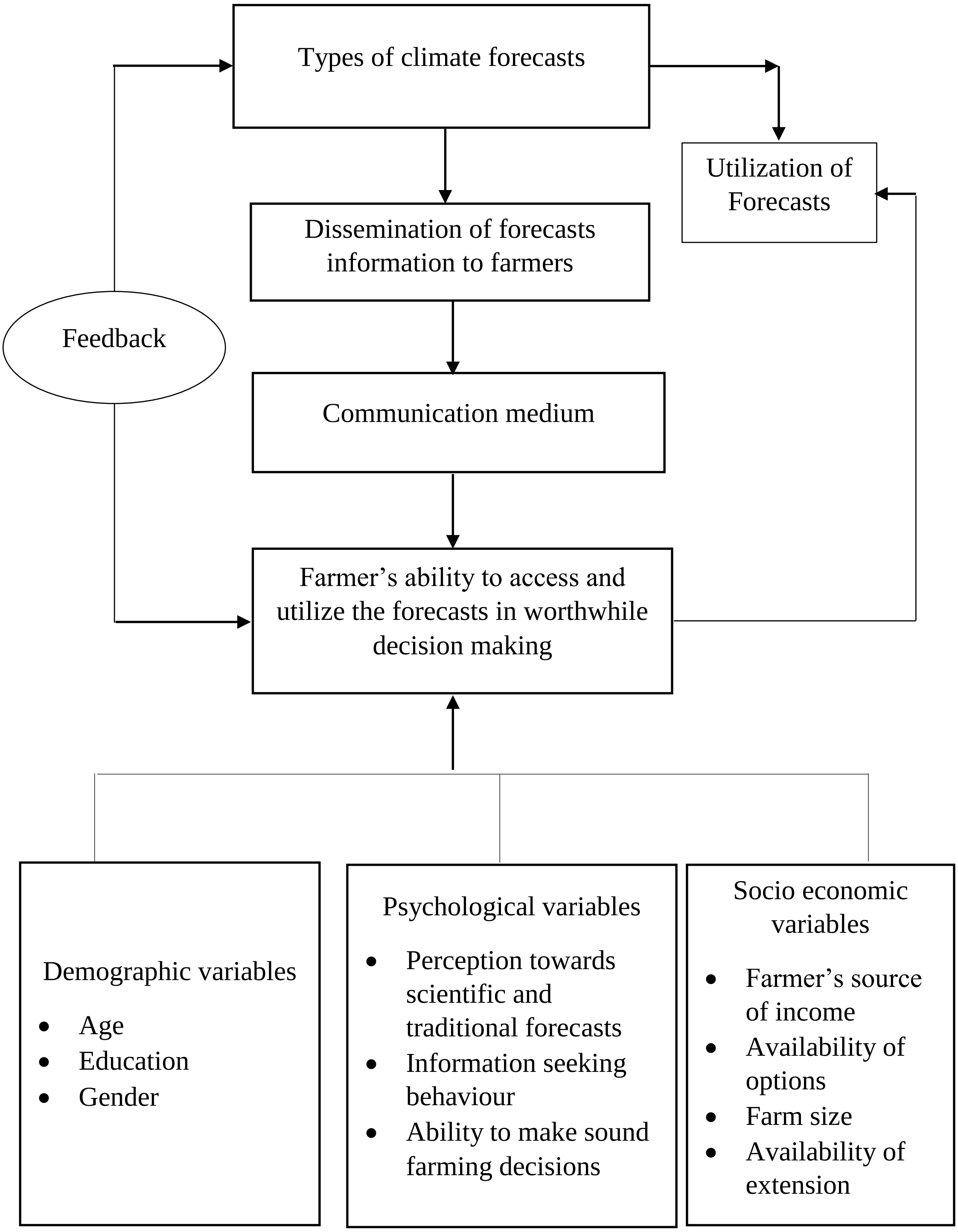


Figure 2.5: A Conceptual Framework Showing Utilization of Climate Forecast

Source: Author conceptualization

CHAPTER THREE

RESERCH METHODOLOGY

3.1 Introduction

This chapter deals with procedures and methods the researcher used in order to obtain and analyze the data. The chapter entails the description of the study area, the target population, the sampling procedures, the data collection procedures and methods of data analysis and interpretation.

3.2 Research Design

This study was guided by a cross-sectional survey research design. This design is ideal for a study where sampling from a specific population is done at one point in time (Kathuri, 1993). The design allows collection of data to be done under natural setting, and is relatively quicker and cheaper to undertake and the results can easily be inferred to the larger population. Its application allows for collection of both qualitative and quantitative data from smallholder farmers whose productivity is dependent on climate information such as seasonal forecast. In order to reduce potential biases, sampling of the target farmers was randomized; a relatively higher sample size was taken. All other confounding variables were built in the study.

3.3 Study Area

Masinga Sub County is an arid and semi-arid region in the Eastern part of the larger Machakos County of Kenya. The sub county experiences a bimodal Rainfall pattern with annual rainfall averaging between 500 - 700mm per year (GOK, 2008). The short rain season occurs in March-May while long rains are received in the October/December period. Generally, rains in Masinga Sub County are erratic. Temperatures range between $29^{o}C$ - $36^{o}C$, though at certain periods they can rise to as high as $40^{o}C$ (ibid). Food crops cultivated in the area are millet, sorghum, maize, pigeon peas, green grams and cowpeas. Cash crops are hardly cultivated but if done, they comprise cotton, sunflower and castor.

The Sub County is divided into four administrative locations, namely, Masinga central location, Musumaa Location, Musingini Location, and Katulye Location. Masinga Sub County covers an area of 213 square kilometers and comprises of a total population of 7241 persons (3240 males and 4001 females). It is comprised of 1978 households of which 954 are farm families (Ministry of Agriculture & Livestock [MoA&L] Office, Masinga District, 2011). The study area was chosen for the study because it has salient characteristics of ASAL areas. Climate forecasts is one of challenges of concern in such areas.

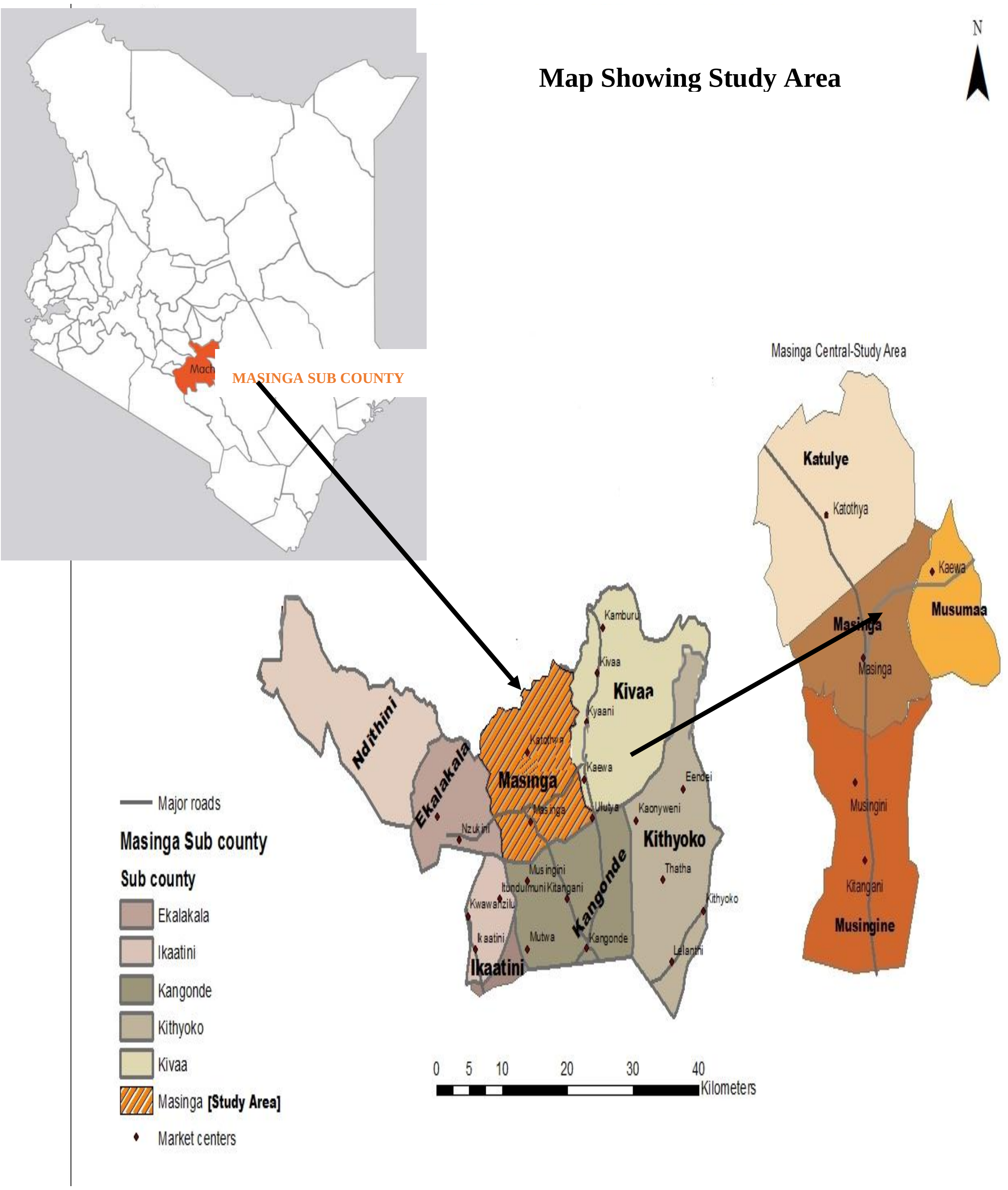


Figure 3.1: Map showing the study area-Masinga Sub-County within Machakos County

Source: Geomaps, 2018

3.4 Sample Size and Procedure

The study utilized two data sets; household survey and seasonal climate forecasts from KMD. Below is an explanation on how each of the data sets was sampled.

3.4.1 Households Survey

Households were drawn from across the four main sub locations namely Katulye, Musingini, Musuma and Masinga sub locations. Sample size for the farmers was determined using the formula below (Mugenda & Mugenda 2003)

$$n = \frac{Z^2pq}{d^2} \text{-} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

where,

n = the desired sample size if the target population is greater than 10,000

Z= the standard normal deviate at the required confidence interval

P= the proportion in the target population estimated to have the desired characteristics being measured

q= 1-p

d = the level of statistical significance

In this case, pilot study has not been done to establish the proportion of the population with the desired characteristics that is, households that access and use climate forecast information. In such a case, Mugenda and Mugenda (1999) recommended that 50% should be used. Thus, the target population who has access and use of climate forecast information will be taken to be 0.5 and the statistical level of significance of 0.05 giving a z-value of 1.96. Sample size for population greater than 10 000 is as follows:

In this case, the total sample size of the study is less than 10 000 therefore, the formula below was used

$$n = \frac{(1.96)^2(0.5)(0.5)}{0.5^2}$$

= 384

In this case, the total sample size is less than 10 000 therefore; the formula below was used

$$n_f = \frac{n}{(1+n)/N} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where:

nf = the desired sample size (when the population is less than 10,000)

n= the desired sample size (when the population is more than 10,000)

N= the estimate of the population size

$$n_f = \frac{384}{(1+384)/954}$$

$$= 274$$

Final sample size for Masinga Central Location = 320/954* 274= 92

Final sample size for Katulye Location = 251/954 * 274=72

Final sample size for Musumaa Location =170/954 * 274=49

Final sample size for Musingini Location =213/954 * 274=61

Total sample size is 274

A systematic random sampling procedure was employed. This approach was chosen because it ensured an equal probability of inclusion of each unit in the population than simple random sampling (Nassiuma and Mwangi, 2004). The procedure involves drawing a sample of size n from a population consisting of N units in such a way that starting with a unit corresponding to a number r chosen at random from the numbers 1,2…., k every k^{th} unit is selected.

The number k is taken as the nearest integer N/n and is called the random interval. The number r picked at random is called the random start.

For Masinga central location k= 320/92 =3

For Katulye location k= 251/72=3

For Musumaa location k=170/49=3

For Musingini location k= 213/61=3

To get a random start number between 1 and 3 was randomly picked from a container. In this study, the number 2 was picked and from the list obtained every 3^{rd} number was selected from the list until a total of 274 households obtained from the list for

Masinga Central location 72 for Katulye location 92, Musumaa location 49 and 61 respondents for Musingini location.

3.4.2 Seasonal Climate Forecasts from KMD

Seasonal climate forecast for OND 2016 was downloaded from the KMD website. The forecasts were used to aid in evaluation of household's accuracy and satisfaction level on utilization of forecasts.

3.4.3 Key Informants

A key informant interview guide (Appendix b) was used to establish the responses from agricultural extension officers in the Sub County. Key informant interviews involve interviewing a select group of individuals who are likely to provide needed information, ideas, and insights on a particular subject. All six agricultural extension officers in the sub county were interviewed. Key informant interviews were essentially qualitative. They were conducted using interview guides that listed the issues to be covered during a session. The interviewer framed the actual questions in the course of interviews. The atmosphere in these interviews were informal, resembling a conversation among acquaintances. The interviews for four officers were done in their respective homesteads while interviews for the two officers were done in their offices. The whole of Masinga Sub County has only six extension officers. The interviewer subtly probed informants to elicit more information and took elaborate notes, which were developed later. Key informant interviews were appropriate in generating information and ideas that aided in understanding the underlying motivations and attitudes of using climate forecasts. Some of the information that was sought was on the impact of seasonal climate forecasts in achieving food security, the form of education they offer to farmers, efficiency and effectiveness of climate forecasts, accuracy of the forecasts, some of the constraints experienced in the use of forecasts and indigenous strategies used in climate forecasts in the area.

3.5 Data Collection Procedures

Data collection was carried out during a one-month fieldwork period. Both qualitative and quantitative data was collected.

3.5.1 Primary Data

Primary data was collected from randomly selected farmers in the area through questionnaires. A questionnaire containing both structured and unstructured questions (Appendix A and B) was administered on the selected farmers in the four locations, namely, Masinga central Location, Katulye location, Musumaa location and Musingini location. The variables collected from the household farmers include:

i. **Age –** the age of the respondents/farmers has an impact on the experience that they have in agriculture. The ability to make use of new innovations and integrate climatic data and personal judgment regarding weather is a function of age.
ii. **Gender of respondent-** gender has an effect on access to information from different sources. It influences the information seeking behaviour and ability to make decisions.
iii. **Education level-** educational level has an influence on the interpretation and understanding of climatic data and applications of this information in decision making.
iv. **Major occupation (on farm/off-farm) -** occupation of the farmer influences concentration of the farmer on farming activities his/her ability to learn new ideas in agriculture and off farming income that influences other farming options.
v. **Land size-** the size of the farm gives the farmer options as to whether he/she can expand the area under cultivation and it also influences farmer diversification of crops.
vi. **Types of crops grown–** High value crops and sensitivity of these crops to weather influences the farmer's information seeking behaviour.
vii. **Access to electronic media -** usefulness in disseminating climate information. The time of the day and language used in disseminating information has an effect on farmer's access to this information.
viii. **Use of print media –** usefulness in disseminating climate information. Frequency of the print media and detail on actions to take in the event of abnormal weather conditions is critical.

ix. **Access to internet-** is very important in getting detailed information about weather/climatic conditions and it is also important as a follow up for radio/TV forecasts.

x. **Accuracy of information on: -**

i. Onset and cessation date of the main rains
ii. Quality forecast of the rainy season (rainfall amount)
iii. Temporal and spatial distribution of the main rains
iv. Timing and frequency of active and dry periods (wet and dry spells)
v. Agronomic recommendations in terms of which crop varieties to grow
vi. Packaging of this information (easy to understand)
vii. Utilization of climate forecast information in decision making

A field data collection plan was prepared during the fieldwork preparation period. The plan outlined pre-fieldwork activities, the data collection schedule followed, the data collection methods used and the resources spent during the fieldwork. The questionnaires targeted the small-scale farmers. The distribution of the questionnaires was done randomly by hand to the respective respondents and given about one week to complete them. This mode of distribution gave the respondents ample time to complete the questionnaires. The questionnaires were completed on a voluntary basis and the respondents were free to determine the extent to which they would participate in the questionnaire survey (e.g. respondents could complete one or both parts of the questionnaire).

3.5.2 Secondary Data Sources

Secondary data on sources of climate forecasting and population were collected from reports, bulletins and documents from regional, county and local extension, CBOs and National meteorological service. Seasonal climate forecasts were collected from KMD website (www.kemeo.go.ke). Information such as climate forecasting data, spatial distribution of forecasts and population were collected as secondary data. Dissemination channels such as radio stations, internet and bulletins were established from the above secondary sources of information.

3.6 Reliability and Validity of the Instrument of the Study

To ascertain reliability, the study instruments were pretested in one identified location which had household farmers experiencing similar socio-economic and physiographic characteristics. In this study, pretesting was done in Kalama Sub County in Machakos. Kalama Sub County is predominantly occupied by small-scale farmers. Pretesting was done with 20 small scale farmers and responses and analysis were used to review the data capture tool. Pretesting enabled focusing of questions which led to clarity and reduced ambiguity.

The study established the validity of structured questionnaires by pretesting based on a small sample in Kalama Sub County in Machakos before proceeding to the field to collect data. Validity is the extent to which the instruments to be used during the study measure the issues they are intended to measure. The validity of the instrument used was based on construct, content and face validity. According to Mugenda and Mugenda (1999), incorporation of positive comments makes the questionnaire to capture appropriate, useful and dependable data whose finding and inferences can be a true reflection of the study population.

3.7 Instrument of the Study

Structured questionnaire was used as an instrument to collect data to determine the availability of climate forecasting data, sources of this data, accuracy of this data, timely of this data and the relevance of this information as well as its utilization to smallholder farmers in Masinga Sub County in Machakos County. (Appendix A and B)

3.8 Data Analysis

Data from the questionnaire survey was organized and prepared for analysis using Statistical Package for Social Science (SPSS) version 21. SPSS database capturing all elements of the questionnaire was created. All data collected was cleaned and screened to eliminate errors using CsPro software. Eliminating errors ensured that subsequent analysis will not be affected. Responses were coded and arranged thematically using SPSS. Tables and figures were developed for graphical representation and visual comparison. Frequencies and percentages were used to characterize the demographic data, farmer's knowledge on the availability of climate forecasting data and its utilization.

3.8.1 Descriptive Statistics

Quantitative data was analyzed using descriptive statistics, which include the mean, standard deviation, percentages, frequency tables and pie charts.

3.8.2 Inferential Statistics

Pearson's correlation coefficient was used to describe the strength of the relationship between the independent and dependent variables. The correlation coefficient is a measure that determines the degree to which two variables are associated. The range of values for the correlation coefficient is -1.0 to 1.0. If a calculated correlation is greater than 1.0 or less than -1.0, a mistake has been made. A correlation of -1.0 indicates a perfect negative correlation, while a correlation of 1.0 indicates a perfect correlation. A value of exactly 1.0 means there is a perfect positive relationship between the two variables. For a positive increase in one variable, there is also a positive increase in the second variable. A value of exactly -1.0 means there is a perfect negative relationship between the two variables. This shows the variables move in opposite directions; for a positive increase in one variable, there is a decrease in the second variable. If the correlation is 0, this simply means there is no relationship between the two variables. The strength of the relationship varies in degree based on the value of the correlation coefficient. It should be noted that, the nearer the value is to zero, the weaker the relationship. Table 3.1 shows variables of analysis and statistical methods used in the study.

Table 3.1 Summary of Data Analysis

Objective	Research Question	Variables	Data Required	Statistics
• To determine dissemination channels of climate forecasts information to small holders farmers in Masinga Sub county	• What are the dissemination channels of climate forecast information in Masinga Sub County?	• Sources of Seasonal climate forecasts • Access to seasonal climate forecasts	Household surveys	• Descriptive statistics. e.g. percentages, mean, standard deviation.
• To establish satisfaction levels of seasonal climate forecasts among small holder farmers of Masinga Sub County	• To what extend are smallholder farmers of Masinga Sub County satisfied with the different types of seasonal climate forecast	• Types of forecasts (i) Indigenous knowledge of climate forecasting (ii) Scientific forecasts a) Daily b) Decadal c) Monthly d) Seasonal • Level of satisfaction (i) Very satisfied (ii) Moderately satisfied (iii) Very unsatisfied (iv) I don't know • Accuracy	• Household surveys • Seasonal climate forecast of OND 2016	• Descriptive statistics. e.g. percentages, mean, standard deviation. • Pearson's correlation coefficient
• To examine the influence of socio-economic characteristics on utilization of seasonal climate forecasts information by household farmers	• What is the influence of socio-economic characteristics on utilization of seasonal climate forecast among smallholder farmers of Masinga Sub County?	• Socioeconomic characteristics (i) Age (ii) Gender (iii) Education level (iv) Income • Utilization of seasonal climate forecast (i) Indigenous knowledge (ii) Scientific forecasts (iii) Indigenous knowledge and scientific forecasts	Household surveys	• Descriptive statistics. e.g. percentages, mean, standard deviation. • Pearson's correlation coefficient

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Demographic Characteristics of Respondents

4.1.1 Gender of the Household

Out of 274 respondents who were interviewed majority were male, consisting of 69% while female represented 31%. Findings from this study demonstrate that adult family members including spouses participated in agriculture and also contributed their ideas in terms of making farm decisions and sharing of knowledge. This is shown in the figure 4.1

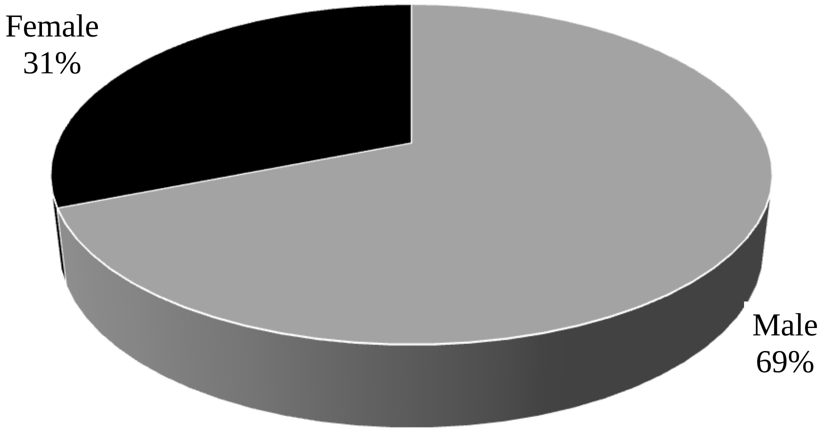


Figure 4.1: Household Respondents by Gender

Source: Author, 2018

The higher percentage of male-headed households in Masinga Sub County was attributed to the fact that culture in the region dictates that men should be the heads of the household. In addition, men have a better access to land, assets, education and other critical services such as credit, technology and input supply. This therefore qualifies them to be the main decision makers in the household (FAO, 2010).

4.1.2 Age of the Respondents

The respondent's ages ranged from 20-80 years with mean being 50 years and standard deviation of 14.68. Majority of the respondents (38%) were between 50-59 years. The aged people who had 80 years and above were the least representing (3 %.) The distribution of years is shown in Figure 4.2

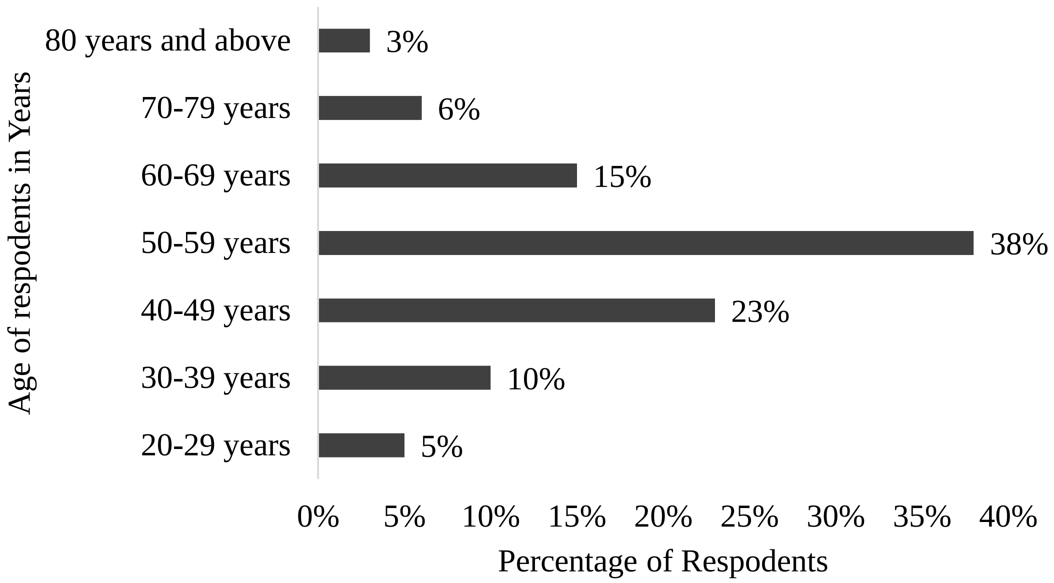


Figure 4.2: Age of Respondents

Source: Author, 2018

Age group system historically played an important role in the ownership and management of land among Kenyans, where customarily, elders remain leaders with youth having little independent authority until they get married (Smucker and Wisner 2008). However, this could also be attributed to the fact that most youth are pursuing higher education and looking for formal employment in urban areas.

The average age for all respondents was 50 years. The constitution of Kenya defines a youth as a person above 15 years and below 34 years (GoK, 2010), the study therefore finds very few youths engaging in agriculture. According to the Institute of Economic affairs (IEA, 2010), up to 80 percent of Kenyans are below 34 years old. The current study agrees with World Bank (2013) report that indicates very low involvement of the youth in agriculture. Various reasons have been fronted on why agriculture is not attractive to the youth, in the current study; it could be attributed to the uncertainty of weather thus venturing in other economic activities.

4.1.3 Education Levels

Analysis of education level indicated that 33% had attained primary school education followed by 28% who had attained secondary education. A few, 3% had attained university education. The levels of literacy in the area are quite low as illustrated in figure 4.3. Farmers level of education and personal characteristics influence the way he/she acts upon information received. Patt and Gwata (2002) argued that young and educated farmers are more prepared to take risks in order to try new ideas than elderly farmers. Education level is important to understand basic concepts in forecasting and making choices of what and when to plant. Patt and Gwata (2002) noted that those who are illiterate and who have primary education have more confidence in indigenous forecast than the scientific forecasts, a situation that could arise from their inability to understand the scientific forecast concepts.

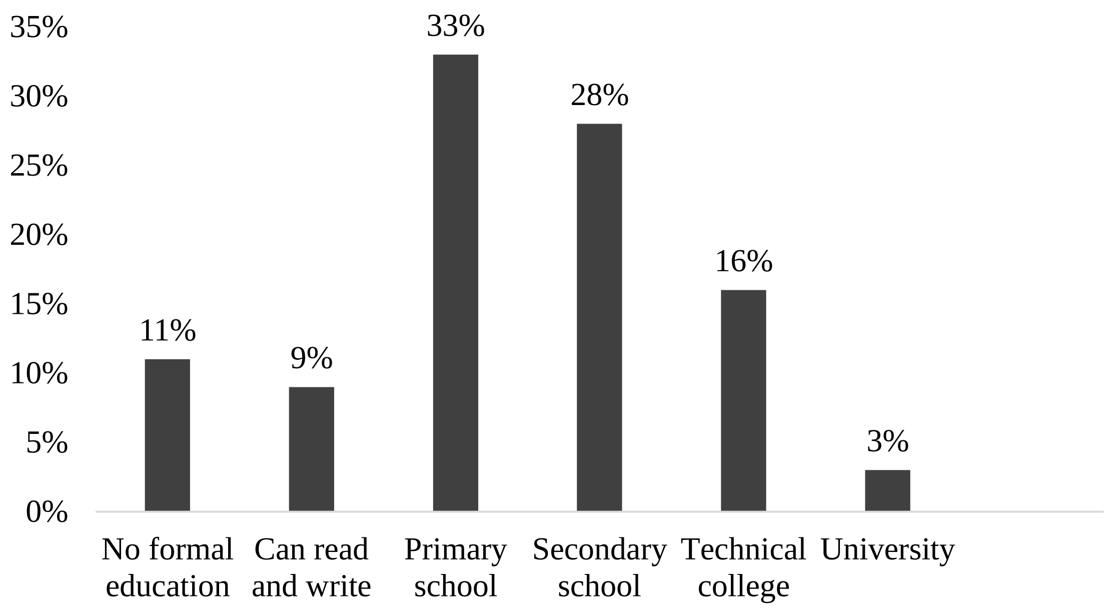


Figure 4.3: Education Level

Source: Author, 2018

A few farmers (11%) had no formal education while 9% were able to read and write. Cumulatively, this result indicates an overall literacy rate of 80% when considering literacy skills from primary school level and above. If only considering minimum literacy skills as being able to read and write, this figure is higher than the adult literacy rate in Kenya of 61.5% (Wandiga, 2008). Lin (1991) mentioned that higher levels of literacy are associated with access to information and adoption of improved technologies.

A study carried out in Lesotho to evaluate the up-take of agricultural information was observed that farmers who had some form of formal education find relevance in the information that they get than those who did not go to school (Mokotjo and Katusopa, 2010). Similarly, farmers who did not have formal education do not find climate forecast information contributing to increased production in their agricultural activities (Wandiga,2008). High literacy level (if we consider literacy levels from primary levels to university) in the sub county is an indication that if farmers are supplied with the right information they have the potential of increasing agricultural production.

In 2000 prior to the policy of free primary education in Kenya, the gross enrollment rate in primary school was 87 percent (World Bank, 2004) while World Bank (2009) estimates a net enrollment rate of only half of the population in secondary schools in Kenya. The position of level of education among the farmers is closely similar to the national figures. Education is poised to influence a household’s understanding of climate dynamics and therefore improve decisions to make.

Education is related to ignorance level and development; the more educated a society is the less the level of ignorance and hence the more developed. In agricultural production, education is an important factor in adoption of improved technologies in increasing crop yield

4.1.4 Marital Status of Respondents

Marital status was a factor the study considered to be vital in understanding the nature of households in terms of household headship and decision making. The results indicated that 73% of the respondents were married. The widowed were the least representing 7% as shown in figure 4.4. Marital status has an influence on decision making with regards to the response strategies to be taken after any weather forecast is made. Men were rated as the heads of the households (table 4.1) who were responsible for all farm decisions on when to prepare land, what to plant and where.

The head of the household was to decide on when to harvest, the mode of storage and all that appertains farming. Women were viewed as helpers and implementers of what their husbands decided. Female headed households and their children are generally perceived to be more vulnerable to the risks of climate on agricultural productivity than their counterpart's households with both spouses. Single or divorced women could manage their own farm but financial constraints were noted as setbacks to maximum use of the forecasts.

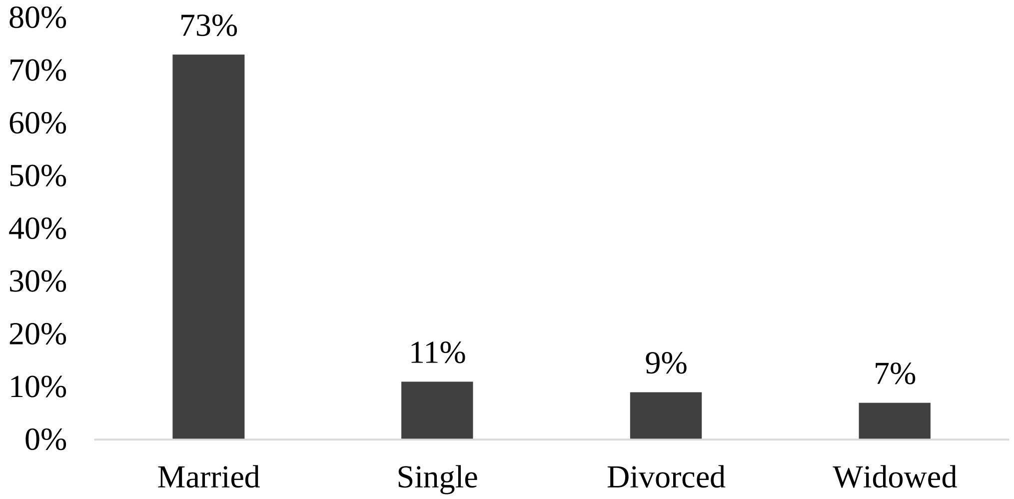


Figure 4.4 Marital status

Source: Author, 2018

Results show that majority (56%) were husbands, 35% were wives while 9% were children (table 4.1). Albeit, this does not imply that wives do not participate in agriculture. According to Ngugi (2001), adult family members including spouses participated in agriculture and also contributed their ideas in terms of making farm decisions and sharing of knowledge

Table: 4.1 Position of Respondents in the Household

Position of the respondents in the household	Frequency	Percentage
Husband	155	56
Wife	95	35
Child	24	9
Total	274	100

Source: Author, 2018

Households headed by women are more vulnerable to extreme events of climate, potentially leaving them dependent on relief food. Those without any of the parents were headed by first-borns or a relative. The main reason for lack of either of the parents or both parents was death with a few cases of divorce or separation and away for rural employment.

4.2 Socio Economic Characteristics

4.2.1 Primary Occupation

The study sought to establish different primary economic activities that respondents engaged in. This information was used to identify and differentiate respondents whose economic activities revolved within the agricultural sector from those who relied on other non-agricultural economic activities. The distribution of the responses are shown in Table 4.2

Table 4.2: Primary Occupation

Primary occupation	Frequency	Percentage
Farming	207	76
Employed(outside agriculture)	20	7
Employed (Agriculture)	28	10
Own Business (Outside agriculture)	11	4
Students	8	3
Total	274	100

Source: Author, 2018

The study established that most of the respondents were primarily farmers. This is represented by a total of 76 %. Students were the least, being only 3 %. Respondents who were employed outside the agricultural sector were 7%, those who were employed within the agricultural sector were 10%, and those who owned businesses outside the agricultural sector were 4%. From this data, most of the respondents had their primary occupations within the agricultural sector. This group of persons is represented by a cumulative percentage of 86% of the total valid sample size. The finding is also comparable with that of Machakos District Development Plan 2008-2012 Report, which observed that agriculture is the major mainstay of the economy and livelihood of the people in Machakos District and, it is estimated that 80% of the population depends on farming (GOK, 2008).

4.2.2 Major Source of Income

The interest was to find out which sector was the main contributor to the income of the respondents in this study. The sectors were divided into two; off farm and on farm. The results of their responses are illustrated in figure 4.5

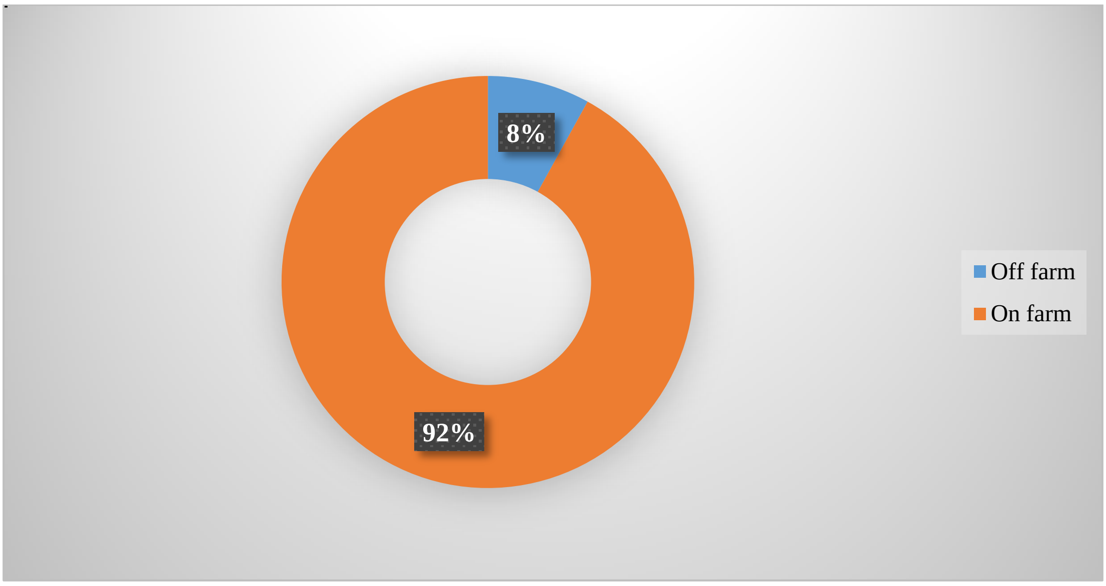


Figure 4.5: Major Source of Income

Source: Author, 2018

From the data collected, it was observed that 92% of the households earned their income from on farm activities, thus agriculture is the major source of income. The over reliance on agriculture indicates the vulnerability to weather variability by these small-scale farmers. On the other hand, only 8 % earned their major income from off farm activities. It was therefore observed that most of the respondents sampled engaged in on farm income generating activities. This on farm activities formed the major contributor of income to the respondents and their households. In order for these people to realize livelihood sustainability then, use of forecasts is inevitable. KMS should issue forecasts early enough, to give time for preparation in terms of finances from CBOs, NGOs and other credit facilities institutions. KMD should give advance information on the outlook of the expected season so that farmers can decide on whether to borrow money to invest in farming or not. Green-acre fund; an NGO that gives credit facilities in terms of farm inputs in this region could bridge this problem by solving the farmers income problem but most farmers do not dare borrowing for fear of uncertainties in weather, as a result they end up lacking capital to purchase farm inputs and hire labor hence underutilizing the forecasts.

The distribution of income in figure 4.6 showed that most of the respondents (55%) earned a total of Kshs.10.000 - 20, 000 while few (6%) smallholders earned an income of more than Kshs. 40,000 per month. However, the average monthly income of the household was not only calculated on the basis of agriculture, but from all household sources of income. This type of distribution of income could impact the coping capacity of smallholder farmers and reduce their resilience in case of extreme climate events such as droughts. It was observed that most of the households operated on low budgets given by their relatively low monthly income. With low budgets the farmers may not afford agricultural inputs especially fertilizers, which they need to boost their agricultural yields.

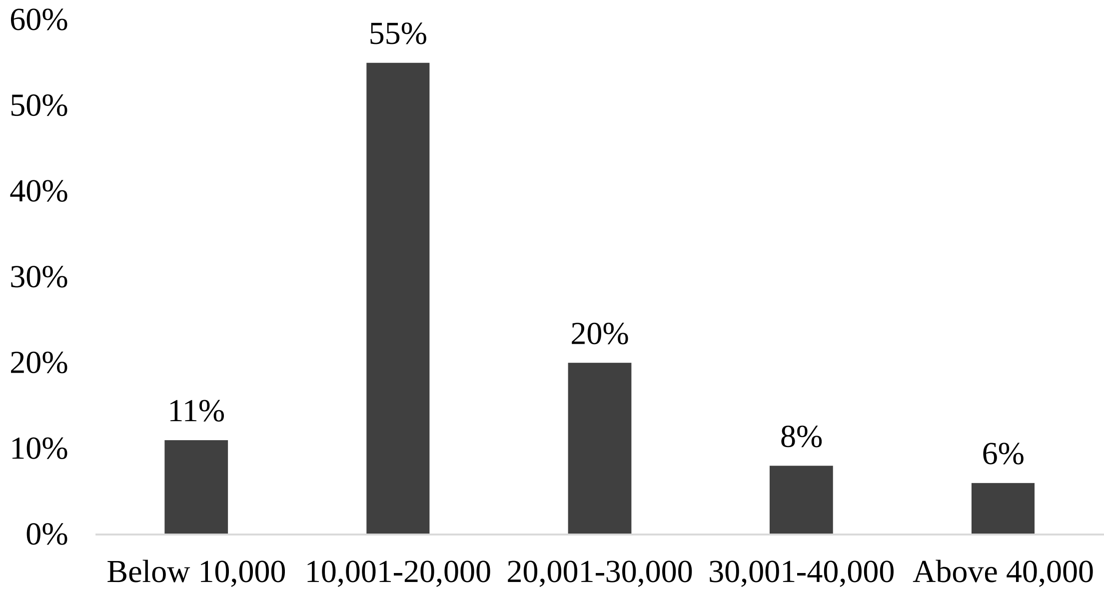


Figure 4.6: Total Average Monthly Income of Households

Source: Author, 2018

In Masinga Sub County, income from agriculture is generally low. This could be attributed to few agricultural institutions in the area. Agricultural institution such as Ministry of Agriculture, KALRO, KEFRI and the Meteorological center play vital role in climate forecast dissemination. It is the responsibility of ministry of agriculture to provide extension services while KALRO and KEFRI are involved in research. Meteorological center facilitates meteorological and climatological services to agriculture. Shortage of extension staff and lack of adequate infrastructure could also contribute low-income levels from agricultural activities

4.2.3 Average Farm Size

Majority of the households (38%) had farms which are 5 hectares and above. Though the farmers had very large farms, most of them were underutilized and others were neglected. If these farms could be put in to maximum agricultural use, agricultural production would be boosted in this region. Few respondents (5%) had an average farm size below 0.5 hectares. Those respondents who had farms measuring between 0.5 and 1 hectare were 11%, those who had farms measuring between 1 and 2 hectares were 20% while those with farms measuring between 3 and 5 hectares were 26%, thus there was possibility for extensive farming activities hence, climate forecast information would be relevant and useful to the people of this area. Small land inhibits increase in area in case of a good forecast in order to take advantage of the season and maximize the yield. Therefore, intensified farming should be encouraged to optimize the yield.

Table 4.3: Average Farm Size

Average farm size	Frequency	Percentage
Below 0.5 ha	14	5
0.5-1 ha	30	11
1-2 ha	55	20
3-5 ha	71	26
Above 5 ha	104	38
Total	274	100

Source: Author, 2018

Majority of household own land through inheritance- an attestation that land ownership has shifted from customary tenure system to individual ownership (Smucker, 2003). The implication is that individual ownership can encourage optimization of the land resource than under customary ownership.

4.2.4 Type of Crops Grown and the Average Annual Income per Crop.

The type of crops grown on the farms cited by respondents and the average annual income earned from each of the crops grown were given. The results of their responses are outlined in table 4.4a for MAM and table 4.4b for OND

Table 4.4a: Type of Crops grown, Time of the Year, number of Farmers who cultivate those Crops and the Average Income of Crops Annually.

Time of the Year	Crop name	Frequency of farmers	%	Average income per crop per year in Kenya Shillings
MAM season	Maize	261	95	68,278
	Beans	180	65	89,423
	Cow peas	84	31	30,990
	Pigeon Peas	76	28	27,800
	Peas	156	57	76,700
	Green grams	106	40	84,211

Key: MAM – March April and May

Source: Author, 2018

Table 4.4b: Type of Crops grown, Time of the Year, number of Farmers who cultivate those Crops and The Average Income of Crops Annually.

Time of the Year	Crop name	Frequency of farmers	%	Average income per crop per year in Kenya Shillings
OND season	Maize	261	95	68,278
	Beans	180	65	89,423
	Millet	124	45	79,640
	Cassava	84	31	30,990
	Sweet potatoes	76	28	27,800
	Peas	156	57	76,700
	Sorghum	106	40	84,211
	Cow peas	120	44	62,115
	Pigeon peas	85	31	58,668
	Pumpkins	60	32	20,780
	Green grams	70	27	35,450

Key: OND – October-November-December

Source: Author, 2018

Results showed that maize was grown by majority of the farmers, being (95%) in both seasons while pumpkins were grown by few farmers (22%). Beans had the highest average annual income of 89,423 Kenya shillings in both seasons, despite not being cultivated by many farmers unlike maize. Pumpkins had the lowest average annual income of 20,780 Kenya shillings. This income could be attributed to the fact that there is low production due to the low demand that might be existing in the region. Farmers plant more than one crop in every season. This is important in minimizing risks of climate, pests and diseases, when one-crop fails a farmer does not incur total loss. Crops failure in the area is common thus seasonal climate forecast are inevitable since any slight climate anomaly greatly affects the yield, exposing the population to food insecurity. For instance, in 2015, beans were affected by too much rain during the long rains and maize affected by poor distribution of rain during the fruiting stage thus great losses in both seasons (KMD, 2016). The types of crops grown in the area have an influence on the response to seasonal climate forecast in such a way that most farmers would not wish to have change of cultivar as a response strategy, because of the tradition of planting specific crops in that area. Even if the season is not promising for maize and beans, they would still plant these very crops because they are not used to other crops which would do well with little rainfall. Maize and beans usually takes shorter period in the farm generally up to three months making them more preferable than other crops.

Other crops grown were millet, cassava, sweet potatoes, peas, sorghum, pigeon peas green grams and cow peas. Despite this area being an arid area there is low emphasis on growing drought resistant crops. For example, only 45% of the respondents grow millet while 31% grow cassava. A study carried by Hornetz *et al*., (2001) revealed that in lowland areas characterized by high temperatures green grams does best, thus farmers should be encouraged to plant green grams in lowland areas of Masinga. In addition Odeny, (2007) in his study found that pigeon peas is the only crop that gives grain yield during dry spells when other legumes have wilted. Unfortunately, pigeon peas is among the least cultivated in Masinga. There is therefore need to promote this crop to the farmers to create awareness of its benefits.

Results of table 4.4 a-b further show that smallholder farmers of Masinga Sub County cultivate more crops (b) during the OND season than during MAM (a). The findings suggest that OND is the most preferred growing season for the people of this semi-arid area. It would therefore imply that dissemination of seasonal climate forecasts should pay attention to OND season. This would help in alleviating any risks in times of extreme climatic events and maximize benefits when the forecasts are favourable a fact acknowledged by Hansen and Indeje (2004). However, opportunities should be explored on how to maximize the MAM season because the seasonal climate forecasts has a major part to play.

4.2.5 Membership in Social or Agricultural Groups and Frequency of Attending Meetings

Social and agricultural groups provide an avenue for farmers to share knowledge, gain new knowledge, insights and skills as well as keep abreast with technology and weather changes. The respondents interviewed gave the responses summarized Table 4.5

Table 4.5: Respondents' Membership in Social or Agricultural Groups and Frequency of Attending Meetings

Membership in Social/Agricultural Group			
No	%	Yes	%
78	28	196	72
Frequency of Attending Meeting			
Sometimes	Once a week	More than a week	
71%	17%	12%	

Source: Author, 2018

From Table 4.5, it was noted that 72% respondents were members of social and agricultural groups while 28% respondents were not members in these groups. Of those who were members, 71% of the respondents noted that they attended meetings in these groups sometimes while 17% attended meetings once a week. On the other hand, 12% of the respondents attended meetings in these social and agricultural groups more than once a week. Group membership and frequency of attending meetings has significance in enhancing farmers' exchange of ideas and it has a potential use in terms of disseminating climate forecast information. Findings indicated that none of these groups were involved in providing climate forecast information to farmers. These groups can be used as discussion support systems, where farmers and meteorological officers can discuss about climate information needs in order to increase the acceptance and utilization of climate forecast needs.

4.3 Dissemination Channels of Seasonal Climate Forecasts among Households in Masinga Sub-County

4.3.1 Sources of Climate Forecast Information

Climate forecast information in this area was from different sources. The distribution of the sources such as Televisions, KALRO, Agricultural Extension Officers, Newspapers, Radio, Internet, and meteorological department are shown in the Table 4.6

Table 4.6: Sources of Climate Forecast Information

Source	Frequency	Percentage (%)
Meteorological department	20	7
Consultant Rainmaker	0	0
Radio	104	38
Internet	2	1
Newspapers	8	3
Extension officers	20	7
KALRO	5	2
Television	54	20
Observations	61	22
NGOs in the area	0	0
Other sources	0	0
Total	274	100

Source: Author, 2018

From Table 4.6, it was established that radio was the most common source of climate forecast information. This represented 38% of the respondents. This implies that improvements in use of climate information have to target radio as the main source of climate information. Radio still remains the most widely used medium in the rural areas this study alone showed that more than two thirds of the respondents interviewed owned radios. Rainmakers and NGOs working in the area did not provide any climate information. Personal observation as a source of climate forecast information represented 22% of the respondents, 20% got climate information from television while agricultural and extension officers and the meteorological department were represented by 7%. This information concurs with the findings of Phillip *et al*, (2001), and Ngugi (2002) which showed that radio is the leading source of weather forecast information. The question is that, how effective is radio to a small holder farmer? When they get the information are they able to understand? In addition, Isabirya, (2003), found that, majority of small scale farmers receive climate forecast information however its dissemination is the critical problem in forecast application.

No information was obtained from rainmakers. The absence of rainmakers can be attributed to the advanced technology and Christianity which has dominated the local culture. This concurs with Egeru (2012) who noted that diviners among the Teso community have lost their central role in community affairs due to rise in Christianity, modernity and education.

4.3.2 Access to Climate Forecast Dissemination Channel

Access to climate forecast information has potential to reduce impacts of climate variability and enhance household's adaptive capacity. From figure 4.7, it was observed that radio was the most accessed channel with a total of 246 respondents representing 90%. Radio as a foremost source of accessing climate forecasts by farm households can be strongly linked to its affordability, portability and low maintenance cost. Chavas (2015) noted that radio is among the major channels for reaching farmers with several technology-driven pieces of information. This was followed by mobile phones with 60% respondents and television with 48% of the respondents. Chief's Barraza's and bulletins were the least accessed channels with 5% and 3% respectively. However, majority of respondents (94%) are not able to access bulletins.

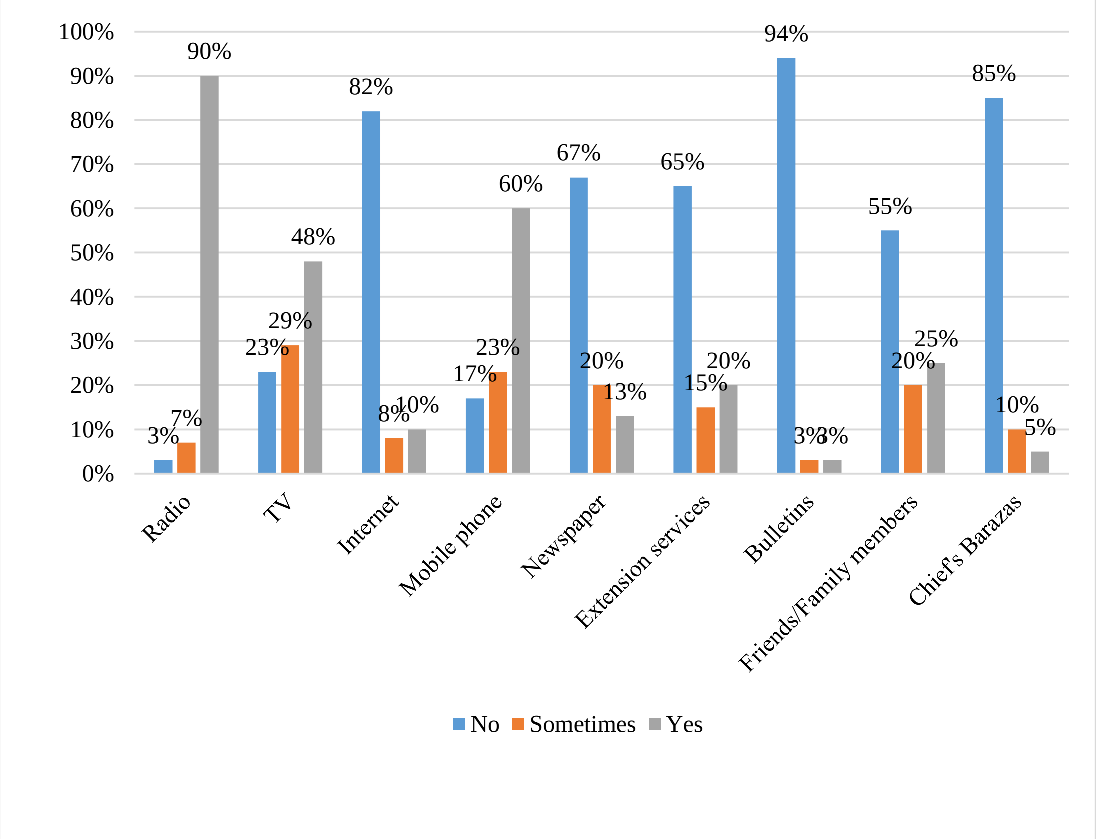


Figure 4.7: Access to Dissemination Channels

Source: Author, 2018

Studies in Sub-Saharan Africa indicate radio and television as traditional mechanisms for transmitting current climate observations and climate forecasts to the general public, including agricultural stakeholders, and they have played a prominent role in disseminating climate forecast information. The study also indicates relative importance that the various forms of media varies greatly by region and country, but radio receives most attention as the key means for delivering climate information to rural communities (Feleke,2015). This study revealed that besides accessing weather forecast information through radio and television, the accessibility through other channels is very low. More than 60% of respondents indicated that they could not access climate forecast information through bulletins, newspapers, internet, extension and Baraza's. This result was even lower among the pastoralists in Kenya and Ethiopia suggesting that radio is by far the most common medium through which pastoralists receive seasonal climate forecasts (Luseno *et al*., 2003). No other external source (television, printed media, and extension agents) reaches more than 3% of the pastoralist population (Luseno *et al*., 2003). Findings by Curry (2001) among institutions that make use of climate forecasts in Kenya, Tanzania and Ethiopia indicated that more than 70% received their information electronically either by e-mail or through the web. However, this could be attributed to the fact that most farmers have limited access to internet and cannot afford to subscribe specific information from the climatic information provider.

Majority of the respondents (65%) mentioned that extension officers as source of forecast information were not accessible despite the current structure of forecast dissemination through the Ministry of Agriculture and Ministry of State for Special Programs (ASAL Department) (Odingo *et al*., 2002). Extension officers offer a better opportunity to accurately interpret forecasts to farmers during field visits. Their absence in the climate forecast dissemination pathway can be attributed to its none-prioritization. The limited role of extension agents in the dissemination of forecast information is a critical concern. KMD needs to train extension agents in the use, interpretation, strength and weaknesses of climate forecast information. In the opinion of extension officers, dissemination of seasonal climate forecast at the County and Sub county levels would ensure forecasts reach users on time.

4.3.3 Frequency of Access to Dissemination Channels

From the results, 80% of the respondents had access to radio on daily basis followed by television with 40%. Extension services, bulletins and chief's Barraza's were not accessed on a daily basis by respondents. These channels were accessed weekly, monthly and seasonally as illustrated in figure 4.8. While progress is being made in the generation of more detailed forecasts, a lot still needs to be done to promote wider dissemination and use by vulnerable groups. It is imperative that those responsible for the generation and dissemination of seasonal forecasts collaborate and pursue strategies to remove barriers associated with dissemination of climate information to ensure food security for the area and the country as a whole. Specific barriers to wider dissemination and use of climate forecasts need to be addressed, including lack of clarity on how climate information can contribute to better development practice, variable usability of the available climate information, and misconceptions about the demands and needs of users of climate information. (Blench, 1999).

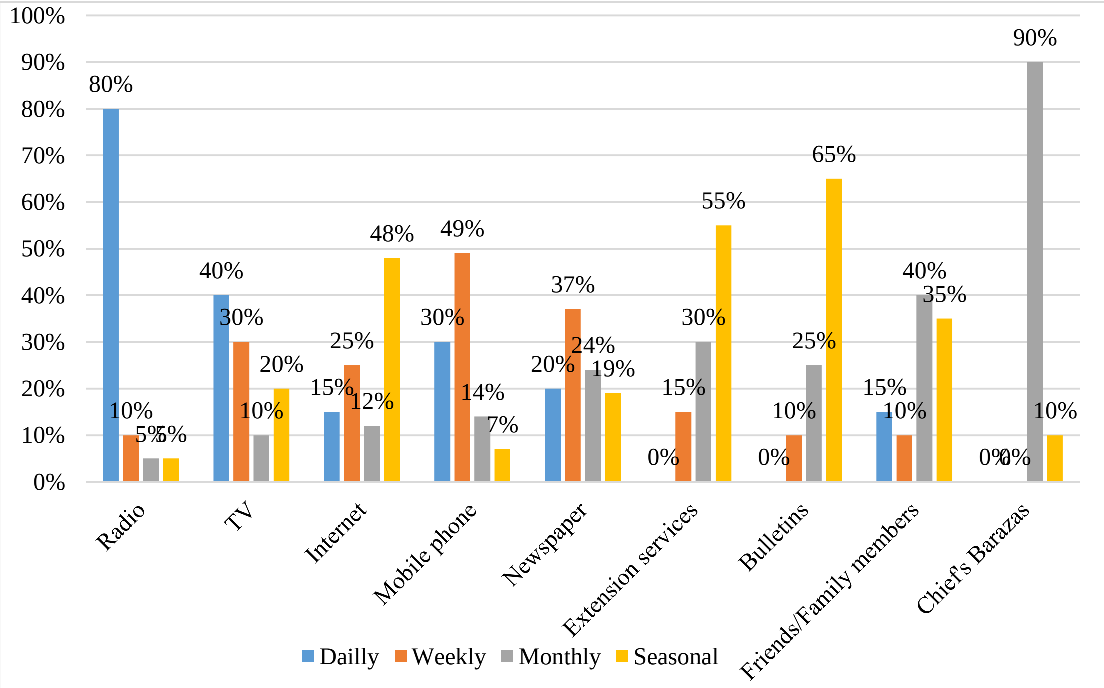


Figure 4.8: Frequency of access to dissemination channels

Source: Author, 2018

Radio plays a very important role in disseminating daily weather forecasts but the type of reports are very short and covers a wider area. Ani and Baba (2007) mentioned that radio transcends across all the literacy barriers required in accessing written information. Radio in essence does not require higher educational qualifications to be effective. For those with access to internet, (48%) have access to internet seasonally. On a monthly basis, Baraza's had the highest percentage (90%) and extension services and bulletins were the major dissemination channels for seasonal forecasts. These results demonstrated how all the dissemination channels are important and how they complement each other in terms of the frequency and type of content that can be used to pass climate forecast information to farmers. Institutions involved in disseminating climate forecast information can also take advantage of the several organizational groups to disseminate information on monthly and seasonal basis.

4.3.4 Effectiveness of Dissemination Channels

As shown in figure 4.9, most of the respondents (above 50%) perceived the information they received from the available dissemination channels to be not effective. Information obtained from friends were considered most ineffective. Very few household farmers (15%) cited internet as the most effective source of information.

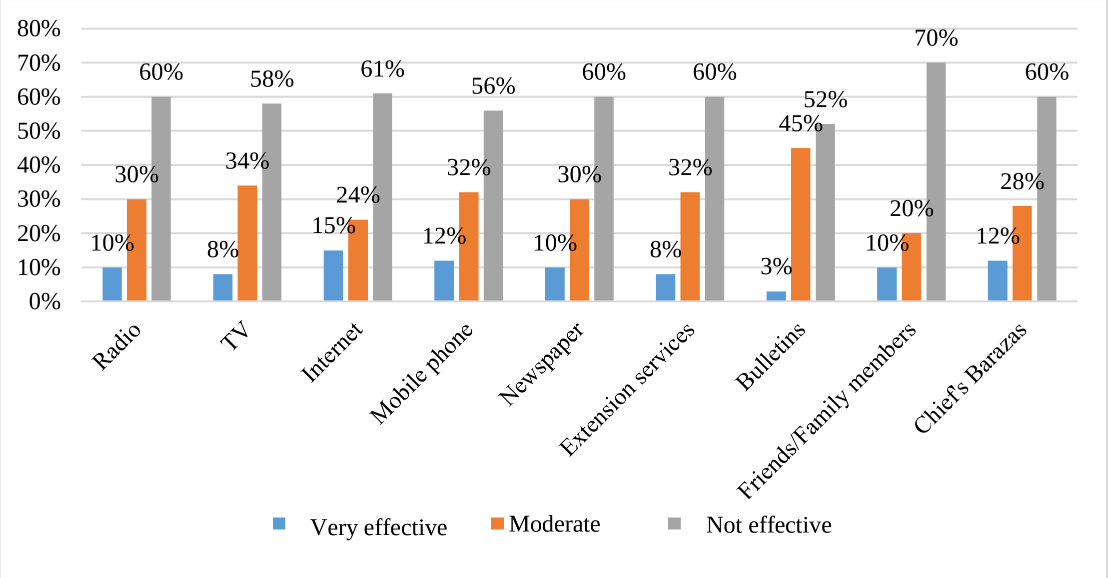


Figure 4.9: Effectiveness of Dissemination Channels

Source: Author, 2018

Recha *et al*. (2008) found out that 37% of the farmers in Machakos and Makueni districts had no confidence in scientific forecasts and they attributed the lack of confidence to ineffective forecasts. Majority of the farmers consider scientific forecasts ineffective which limits trust. The reason for these responses could be the fact that the information is not really location specific and because of the probabilistic nature of the generation of climate forecast information. Patt and Gwata (2002) argued that farmers may become suspicious of scientific forecast if they tend to contradict it with their local traditional indicators.

Some disseminating channels were perceived to be ineffective. Information received from friends and relatives was perceived to be most ineffective (70%) while information obtained from the internet was considered to be the most effective (15%). Although more than half the respondents interviewed cited radio as the most common source of weather and climate information it was not cited as the most effective dissemination channel. This is because forecasts presented in this radio are coarse scaled thus difficult to apply. There was also a dominant perception that making decisions based on forecast was risky, based on past failure of forecast to materialize which were presented through the radio. Having access to information is important but effectiveness, reliability and usefulness of that information may be more important. Unreliable information may lead to loss due to wrong choice of practice thus became less useful in farmers' decisions

Figure 4.10 shows results on how respondents would like to receive weather forecast information in future and their rating of the most reliable and adequate channel.

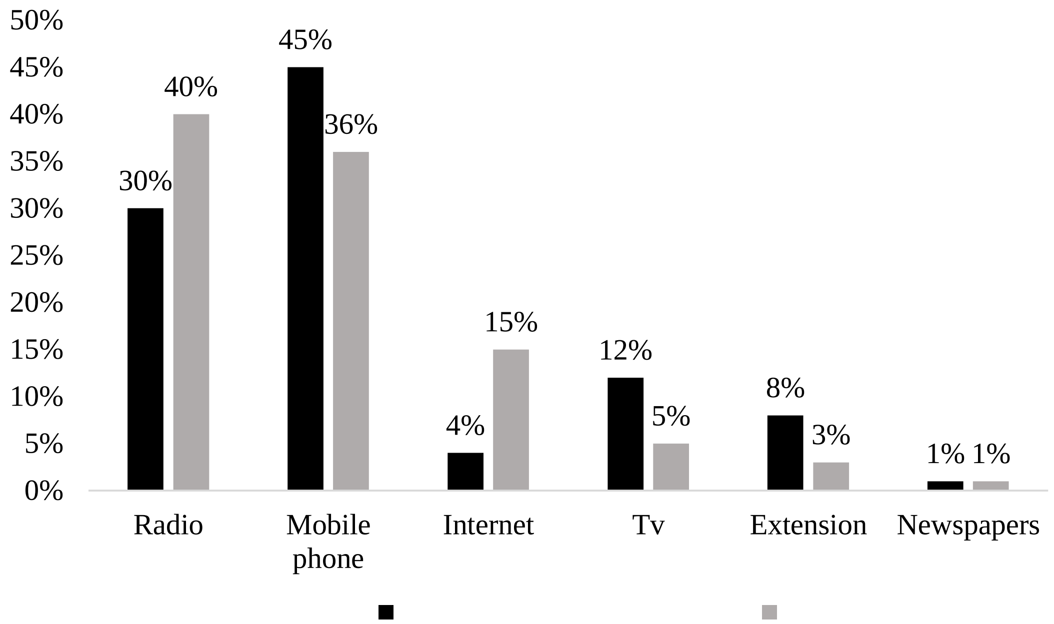


Figure 4.10: Respondents perception of channel of dissemination
Source: Author, 2018

From the data collected, most respondents would like to use mobile phone to receive climate forecast information in the future. This is because a total of 45% of the total valid sample noted that mobile phone was their favorite choice for receiving climate forecast information in the future. 30% respondents cited radios, 4% respondents cited the internet, 12% were for television, 8% were for extension officers while 1% preferred newspapers. In the context of future forecast dissemination to rural farmers, mobile phones can potentially offer two significant increases in efficiency. First, they eliminate space as a barrier and thus significantly reduce information access costs by connecting the farmer directly to the consultant and facilitating two-way interaction between them without requiring the consultant to physically visit the farmer's village.

The second major advantage that should not be overlooked is that the use of mobile phones is inherently a demand-driven process. One of the major issues with all current methods of forecast information dissemination to farmers is the complexity and the cost-prohibitive nature of proper evaluation. If information dissemination is driven by demand, however, evaluation is internalized: "innovators" and "early adopters" will seek the service that most efficiently provides access to the information, and "laggards" will follow, particularly in the rural context where social networks (i.e. word of mouth) play such a prominent role. How can mobile phones be used within the forecast dissemination framework to maximize efficiency? In Kenya, where a large majority of farmers now own mobile phone, several demand-driven options have emerged, with strong support from the media. First, radio and television talk shows now exist that take telephone calls to answer questions and obtain feedback directly from farmers. Second, farmers in some villages have self-organized and will use their phones to call a meeting with extension officer in order to explain the climate forecast (i.e. to help unpackage the message) and facilitate discussion. Finally, some villages have organized their own climate fora (Ogallo 2007). This has helped drive the creation of a network of extension officers as consultants in dealing with the forecast message to further address the growing farmer demand for forecast information.

4.3.5 Factors Affecting Access to Climate Forecast Information

From figure 4.11, it was noted that majority of the respondents (84%) reported inadequate extension as the leading factor affecting access to weather forecast information. This was followed by inadequate radio or television in households among 80% of the respondents, no access to internet (78%) and late arrival of print media 74% of the respondents. Time of dissemination was the least affecting factor as it was reported by 56% of the respondents while 60% of the respondents indicated language as a factor affecting access to climate forecast information

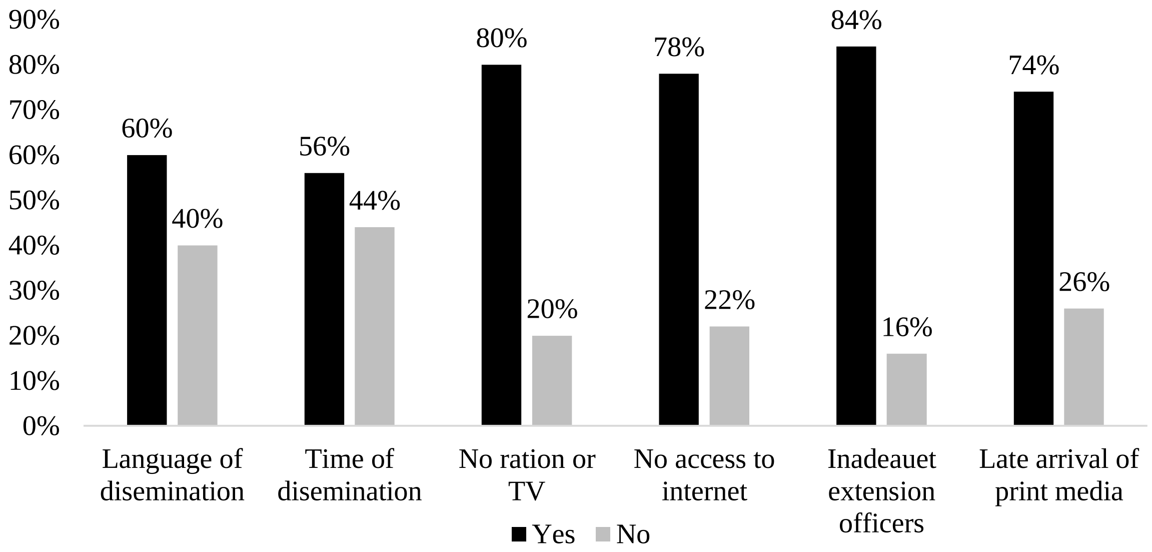


Figure 4.11: Factors Affecting Access to Climate Forecasting Information

Source: Author, 2018

Several agricultural development specialists concur that extension contact gives farmers information that promotes their adaptability to changes in agricultural development (Qamar, 2002; Ochieng, 2004; Kamau, 2006). Farmers would prefer to get information from experts rather than reading through newspapers and bulletins on their own. Stone and Meinke (2006) argued that for uptake of more complex climate and weather information farmers need to contribute to the development of appropriate response strategies.

Internet can play a major role in climate forecast information either through direct or indirect access. In developing countries, telecentres can be used as focal points for many types of information. These telecentres can be sources of climate forecast information that can be further disseminated through other channels such as extension services, local radio stations and newsletters in local languages (Weiss *et al*., 1999).

Although radio and television were the most preferred and accessed cannel of information dissemination when conducted oral interviews, majority of the respondents declared that they were not able to listen to weather and climate reports at time of dissemination. This means timings is a challenge to disseminating of climate forecast information. Furthermore, misinterpretations of forecasts by the media not only spread "incorrect" forecasts, but also detract the credibility of the KMD's performance.

In 2004, press reports communicated forecasts, which were different from those intended by the KMD. The Daily Nation of 9 September 2004, for example, reported;

> *"Hopes of alleviating hunger dashed as weather experts predict doom", although "a worsening food crisis" had not been the message communicated by the KMD, but "near-normal to above-normal" and "near-normal to below-normal" rainfall.*

4.3.6 Packaging of Information by Dissemination Channels

A majority of the respondents opined that information relayed through chief barazas (56%), friends and family (54%), extension services (50%), and radio (50%) was in the simplest language. Forecast information in bulletins (62%) was considered to be written in complicated language. Figure 4.12 gives a detailed distribution of the results.

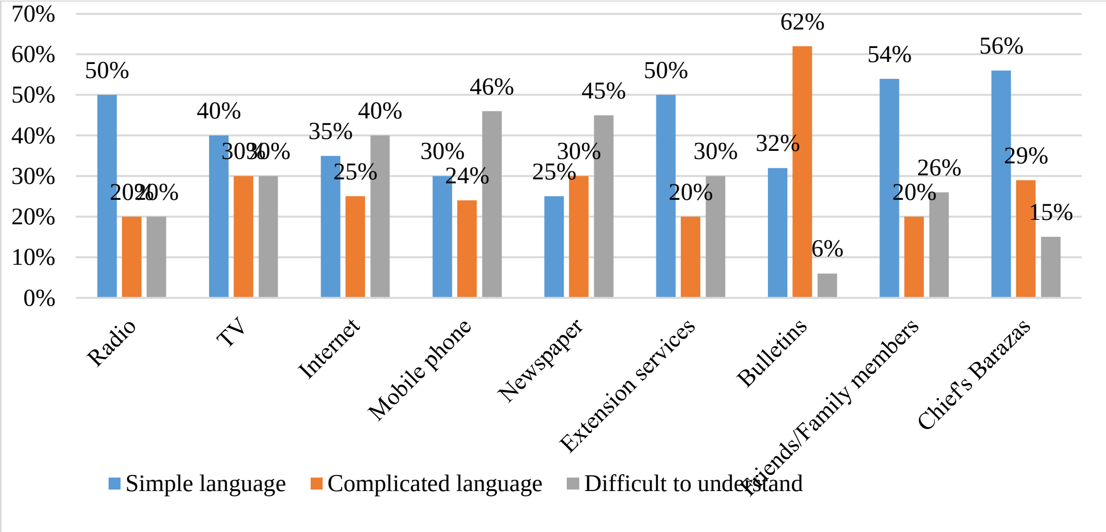


Figure 4.12: Packaging of Information by Dissemination Channel

Source: Author, 2018

The difficult question we can ask is whether the message is properly unpackaged in order to extract the information in a form that the farmer can use. It is widely acknowledged that a participatory interactive process is essential for the farmer to use the information successfully (Jagtap *et al*. 2003). Stigter (2002) notes that one of the primary bottlenecks to proper unpackaging is the vital importance of interaction to deal with farmer-to-farmer variability and the need for an appropriate support system that accounts for actual conditions in the livelihood of farmers. Furthermore, the context of information delivery is very important, in particular the credibility of the source delivering the information and the opportunity for farmers to discuss, ask questions, and learn by doing. Thus, to unpackage the forecast message, it is critical for the farmer to interact with a "consultant" for this case, simply anyone capable of answering the farmer's questions in order to understand the forecast. The consultant should be very familiar with the forecast message and the information that it does and does not contain. The consultant may be from government, private sector, media, etc. With access to this mechanism, farmers can determine for themselves or discuss with each other or the consultant (if possible) on how best to adapt individual decision-making strategies.

A critical distinction must be made between the “information” and the “message” within which the information is “packaged”. In the context of seasonal climate prediction, the message is a categorical-probabilistic forecast (3 categories: “above normal,” “normal,” and “below normal” growing-season rainfall each with a percent probability attached) rather than deterministic to account for significant underlying uncertainty. However, farmers generally do not fully understand probabilistic information, although they are used to uncertainty in markets (WMO 2013), and are not adept at interpreting scientific terminologies (Mokssit 2007; Tarakidzwa 2007). Thus, the message must be “unpackaged” into a form that the farmer can understand in order to apply it to his particular situation; otherwise, the farmer ignores the message and does not benefit.

4.3.7 Climate Forecast Information Needs

Figure 4.13 shows results of access to information required by farmers in Masinga Sub County. It is observed that information on onset, rainfall amount, timing and frequency and agronomic recommendations were occasionally received as reflected by high percentage of sometimes. Most respondents (39%) opined that they did not at all access cessation dates. Nevertheless, despite farmers not receiving important forecasts they regard the forecast as important for farming activities. Patt and Gwata (2002), and Mwinamo (2001), give evidence that climate forecast predictions do not trickle down to the user, especially resource poor farmers. This has played a role in making farmers to lack confidence in such forecasts

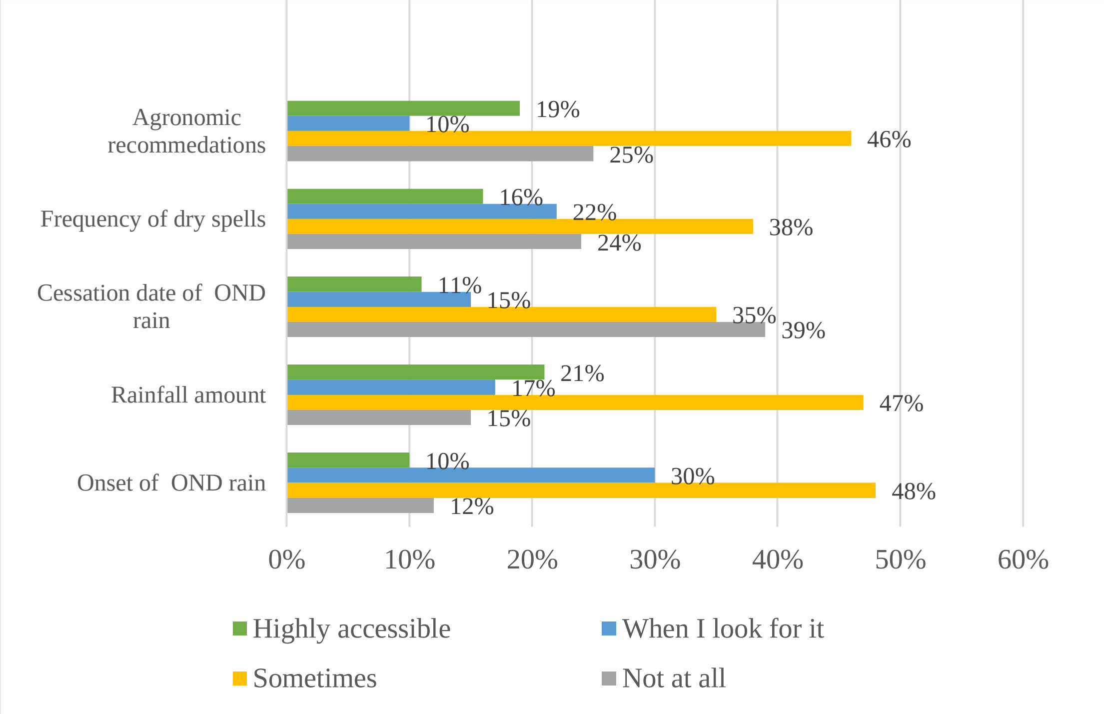


Figure 4.13: Access to Information needed by Farmers

Source: Author, 2018

When farmers were interviewed on the type of forecast they needed most, they reported that the most vital information they needed was access to timely and accurate forecast on onset of major rains. To them more specific information about the length of the rainy season (beginning and ending dates). Short-range forecasts and medium rage forecasts are vital in making tactful and strategic decisions with regards to productivity. This was also echoed in the UNDP/UMO, (2000) report which stated that farmers needed more specific forecast information, for instance within 24hours or 5-10 days that would enable them make decisions on farm management practices.

4.3.8 Perception Regarding Spatial Coverage of Climate Forecasts

Majority of the respondents (82%) felt that climate forecasts cover a wide area. Only 3% of the respondents felt that climate forecasts cover relatively small area. This makes it difficult for them to relate the reports to their particular areas. The study has revealed that scientific forecasts are sometimes regarded inaccurate due to the large geographical coverage. Moreover, once the forecast is made and the event does not occur to the expected magnitude, farmers lose confidence and therefore the use of the forecast is compromised. The results concur with Patt and Gwata (2002) who argued that probabilistic forecast that cover a wider area can generate confusion and discourage users from incorporating the forecast in decision-making.

Table 4.7: Forecast Spatial Coverage

Forecast Spatial Coverage	f	(%)
Cover wide area (Eastern Region)	224	82
Cover specific areas (Makueni, Machakos and Kitui Counties)	41	15
Cover small area (Machakos County)	9	3
Total	274	100

Source: Author, 2018

4.4 Types and Use of Seasonal Climate Forecast and Satisfaction Level of the Household Farmers

4.4.1 Types of Forecast being used

The study focused on establishing the specific types of forecast that farmers in this region used. Figure 4.14 illustrates the distribution of types of forecast being used by the farmers.

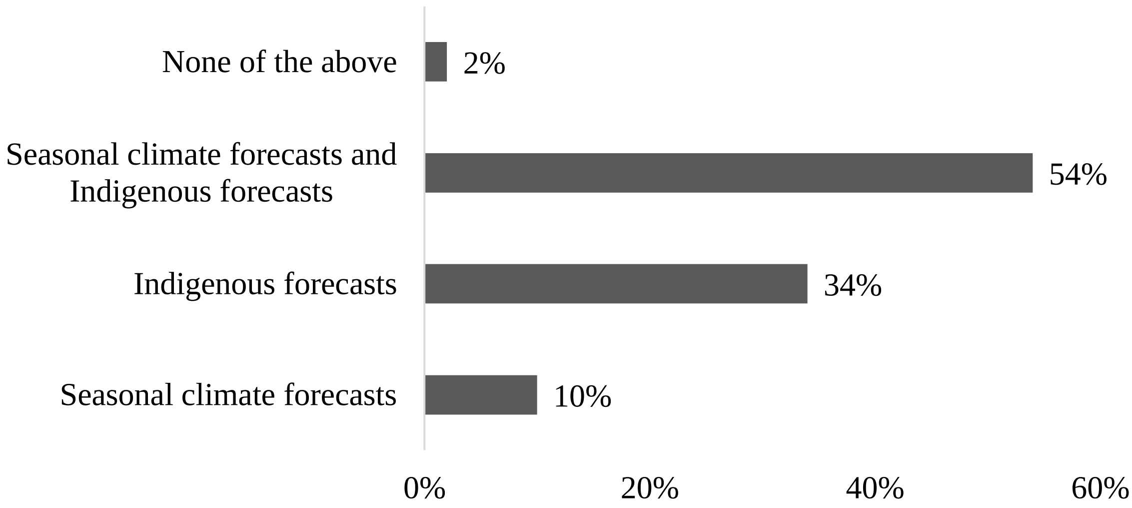


Figure 4.14: Type of Forecast being used

Source: Author, 2018

As shown in Figure 4.14, a combination of both seasonal climate forecast and indigenous forecasts were being used by 54% of respondents. Those who used indigenous forecasts alone were 34%, those who used seasonal climate forecasts were 10% while 2% did not report any of the above types of forecasts. Combining indigenous and modern seasonal forecasting is one of the ways of dealing with challenges faced in the development, communication and use of seasonal forecasts. Many farmers already make use of indigenous forecasts for their farm level decision-making and may only need certain information to complement what they already know.

It is therefore important that forecasters target existing gaps if they are to add value to communities working on the ground. Participatory approaches offer opportunities through which indigenous and modern approaches to seasonal climate forecasting can be harmonized and user needs integrated. Indeed, participatory dissemination of climate forecasts has shown positive impacts on farmers' response but as Roncoli *et al*. (2009) observed, focusing exclusively on how climate forecasts affect yield misses out on the contextual interaction that shapes how farmers understand and use climate forecasts. It is also worth noting that participatory processes are not necessarily equitable and all inclusive. O'Brien and Vogel (2003), caution against over reliance on official networks for forecast dissemination, as they may lead to intentional or unintentional exclusion of some groups from receiving information. This strengthens the case for using informal systems (local/indigenous) of dissemination even where formal institutions seem to be working well.

Cumulatively 88% of the respondents used indigenous forecasts. A study in Kenya by Speranza *et al*. (2010), which investigated farmers' use of indigenous knowledge of climate forecasts and the adaptation to climate change and variability in semi-arid areas of the East African country, found that farmers possess knowledge on the use of local indicators in predicting climate particularly rainfall. The study further established that the farmers believe in and rely on the efficacy of indigenous forecasts as the basic knowledge system within which they interpret climate forecasts and make decisions pertaining to their agricultural practices.

Majority of the respondents (58%) indicated that they had used scientific climate forecasts for more than five years while 28% have used scientific forecasts for less than five years. This shows that forecasts have been in use for quite some time by the farmers.

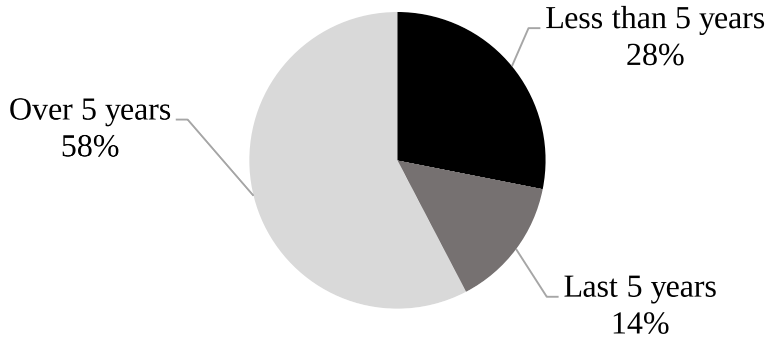


Figure 4.15: Duration of using Forecasts

Source: Author, 2018

4.4.2 Level of Satisfaction of Scientific Forecasts

In regard to the level of satisfaction, most of the respondents were very unsatisfied with the forecasts used. This was observed in a total of 167 respondents representing 61%. Those who were moderately satisfied were 23%, those who were very satisfied were 5% while 11% did not know their level of satisfaction. (Figure 4.16). A chi square tests were conducted to find out whether there exist any association between satisfaction levels and utilization of scientific forecasts (Appendix C)

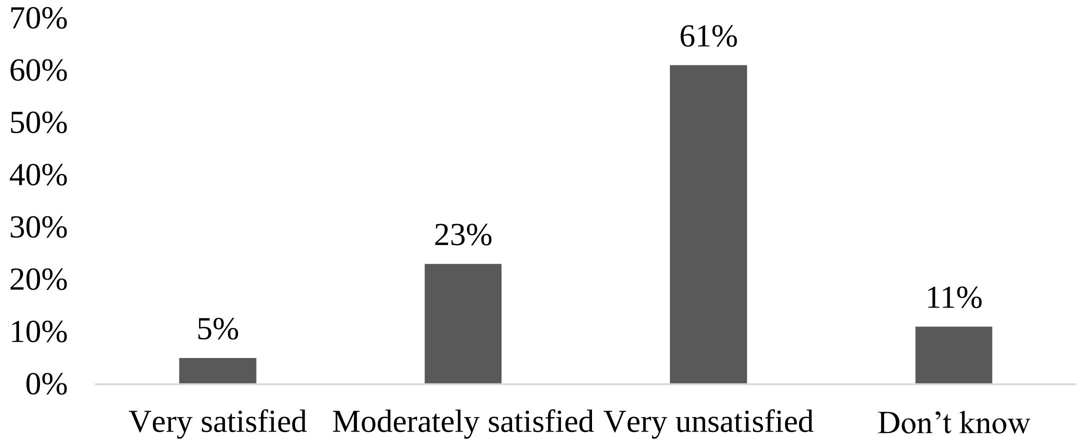


Figure 4.16: Level of Satisfaction with Forecasts

Source: Author, 2018

Table 4.8 Relationship between Level of Satisfaction and Utilization of Scientific Forecasts

	Chi square tests		
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi Square	20.778	4	.000
Likelihood Ratio	16.848	4	.001
Linear -by -linear Association	4.445	1	.002
N of valid cases	274		

From the results, majority of the respondents were not satisfied with climate forecasts because of shortcomings accompanying the forecasts, such as difficult and technical language, although they reported forecasts as important in averting agricultural risks. Roncoli *et al*. (2009) argued that quality of the information is the level of confidence placed in it by the receiver, and affects acceptance and use. Thus, until KMD down scales forecasts at a reduced geographical scale as a way of improving accuracy it is unlikely that farmers will believe and use climate forecast. Cases of farmers rating climate forecasts useful and not using it are common and concurs with the findings of Mwinamo (2001). Results from chi-square showed that, there is a significant relationship between satisfaction levels and utilization of scientific forecasts. A p-value of .000 is observed which is less than the level of significance $\alpha=0.05$. This therefore implies that if smallholder farmers are not satisfied with scientific forecasts, they are not likely to use forecasts again.

4.4.3 Use of Climate Forecast in Farm Level Decision Making

It is evident that most of the respondents followed usual seasons in making decisions to plant. A total of 115 respondents representing 42% noted that they followed usual seasons to make planting decisions. Those who used traditional forecasts were 28%, those who waited for rains were 10%, and those who followed their neighbors' decisions were 10% while those who made decisions to plant after receiving forecasts were 10% (Figure 4.17). It was thus observed that there was laxity in using scientific climate forecast information in making decisions to plant among most of the respondents. According to FitzGerald (1994), people make decisions in the light of what is perceived and not what actually is. Farmers who do not believe in climate forecast attribute it to inaccuracy, a fact that could emanate from errors due to generating forecasts of large geographical area coverage. According to Lemos *et al*.

(2002), farmers' inability to respond to climate forecasts (irrespective of quality and precision) leaves them vulnerable to climate variability

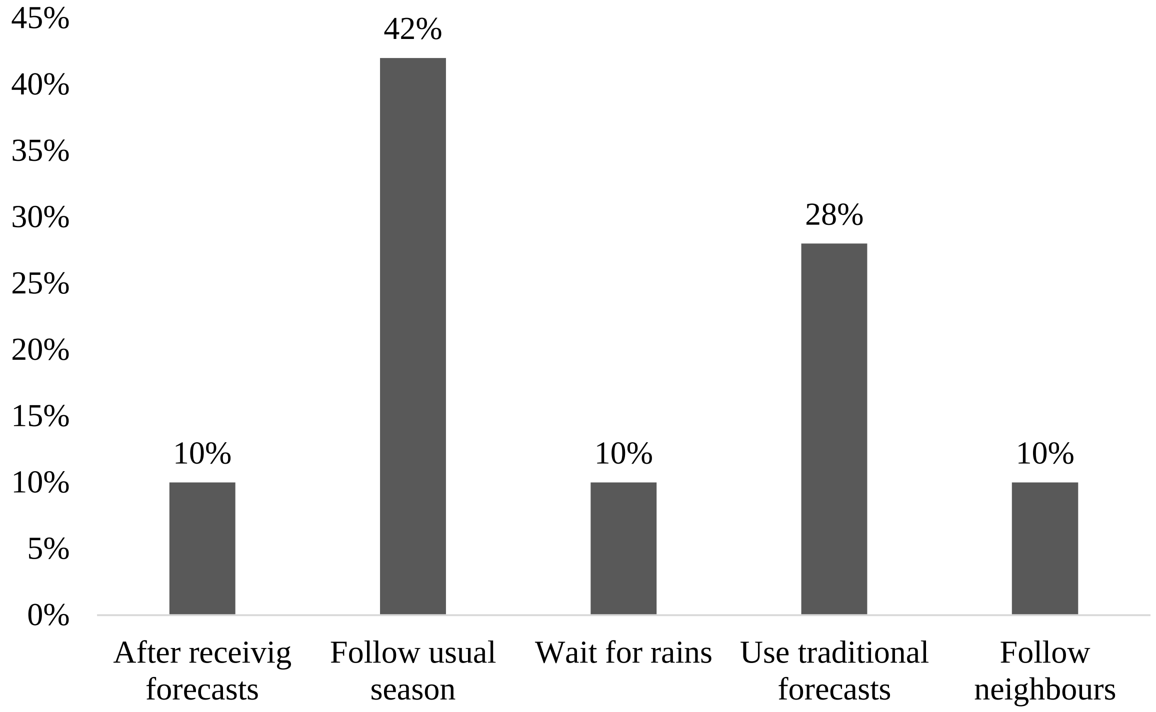


Figure 4.17: Time of making Decisions

Source: Author, 2018

Access to various dissemination channels (figure 4.7) indicates that there is potential for reliable and timely information to reach households in time in order to positively influence agricultural decision-making at the farm household level. However, this potential remains largely untapped because as currently packaged and delivered, climate information does not cater to the needs of smallholder farmers. Benefits from such high access to dissemination channels can only be realized if the forecast is turned into information to support operational decision, especially minimizing risks associated with variability and uncertainty. If farmers could receive and anticipate advance information about climate for the upcoming growing season and of this information could be delivered in a timely, accurate and reliable manner through widely available media with extended interaction between farmers and researchers then farmers would be able to use such information make better management decisions that would reduce their losses, minimize the use of costly farm inputs and as a result, maximize yield.

4.4.4 Utilization of Indigenous Climate Forecasts

Despite quite a number of respondents claiming to receive the scientific forecasts they do not put it to use. From the results, 74% of the respondents concurred that they used indigenous methods of climate forecasting while 26% did not use indigenous methods of climate forecasting (Figure 4.18). This means most of the respondents had preference for traditional forecasts in farm level decision making. This concurs with Onyango *et al*. (2014) who noted that the use of indigenous methods of climate forecasting was a major practice among the small-scale farmers. Some of the indigenous methods of climate forecasting used include stars and moon observation, croaking of frogs, flowering of plants, wind direction, appearance of certain clouds, bird's movement, animal behavior, bees' movement and honey production and some sounds made by insects. These results confirm findings by Egeru (2012) that the traditional climate forecasting practices of using moon characteristics, tree phenology and particular animal behavior patterns are still being utilized. Farmers should be educated on the benefits of climate forecasts and how to use them. Farmers using own knowledge to determine rainfall on set to plant are most likely dependent on traditional rainfall indicators (Ngugi, 2001; DMCN, 2004). Traditional forecasts and indicators can predict onset but not distribution and cessation of rainfall.

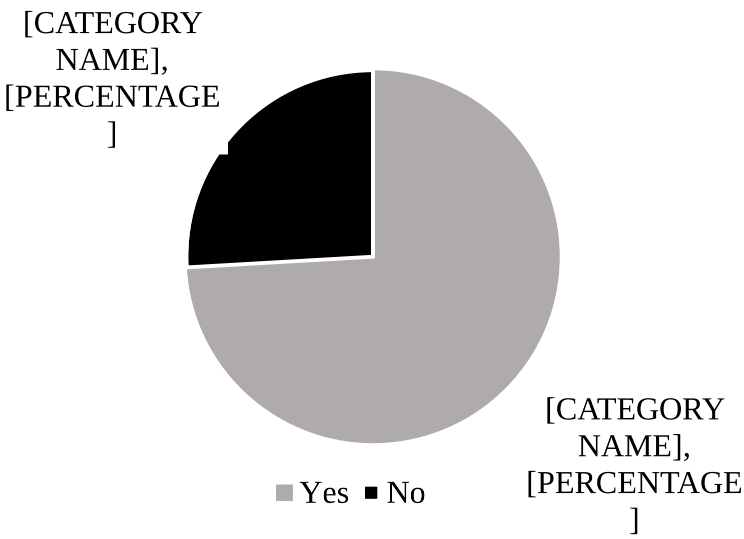


Figure 4.18: Utilization of Indigenous Climate Forecasts

Source: Author, 2018

Although climate forecasts are received through the radio, lack of skill in interpretation and application of these forecasts becomes a hurdle as this requires meteorological and Agricultural Extension officers. Therefore, people need simple and easy language to apply agro- meteorological products, which are not readily available. Hence these residents are then left with no choice but to use their indigenous climate forecasts as decision making tools in planning their livelihoods. This concurs with Shoko and Shoko (2011) who pointed out that while farmers did not have the scientific climate forecasts in time, they had an idea about the expected season by observing traditional climate indicators.

4.4.5 Perception of Indigenous Knowledge and Scientific Climate Forecasts

Most of the respondents held the opinion that scientific climate forecasts were not reliable. This was represented by 48% of the respondents against 5% who felt that indigenous climate forecasts were not reliable. 38% of the respondents felt that indigenous forecasts were sometimes reliable while 26% felt that scientific climate forecasts were sometimes reliable. 43% of the respondents felt that indigenous forecasts were always reliable against 14% who held the opinion that scientific climate forecasts were always reliable. An almost equal number of 14% and 12% respondents felt that they did not understand traditional weather forecasts and scientific climate forecasts respectively (Figure 4.19). Small scale farmers’ perception on the forecasts greatly determines the response they put to it. The biggest challenge in the use of scientific forecast is the fact that famers view it as unreliable and always untimely. Patt and Gwata (2002) have argued that access and use of climate forecast remain the greatest challenge to climate scientists. Many a time climate forecast have suffered a credibility problem and people have shown mistrust for it (Hobbs, 1980) an attitude that comes from the previous forecasts being perceived as inaccurate, as a result, users end up ignoring the forecast

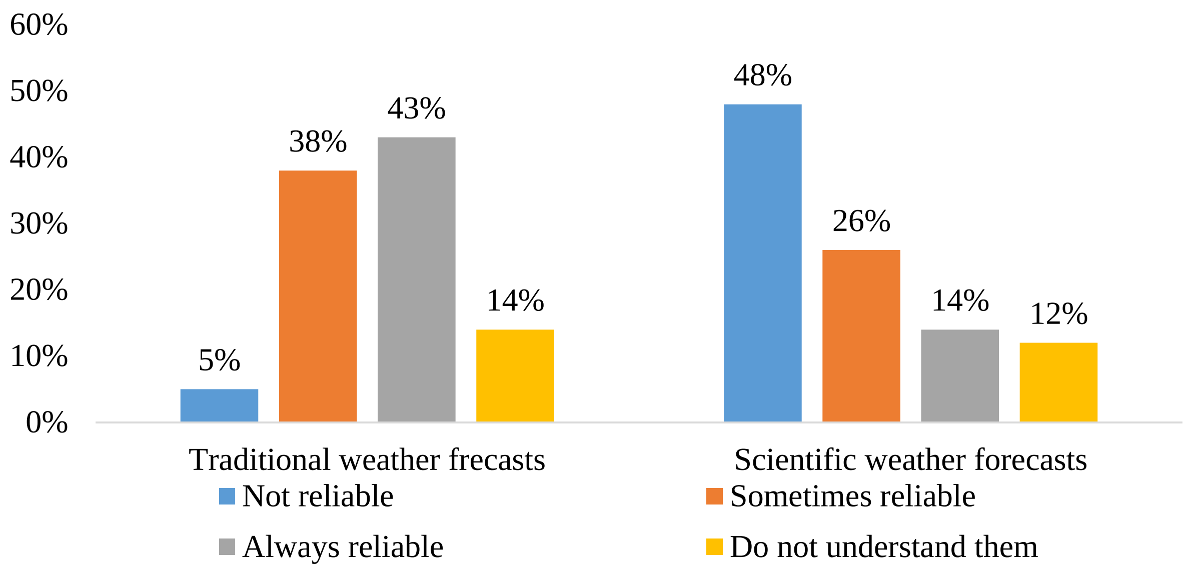


Figure 4.19: Perception of Climate Forecasts by Respondents

Source: Author, 2018

In the study area, seasonal forecast was regarded not only as important but also necessary for any meaningful decisions to be made in terms of agricultural productivity. This means that timely access to this information is vital to all farmers' therefore, there is need for well-developed mechanisms of dissemination to enhance its usability by the farmers. Both indigenous forecasts and scientific forecast are evident in the study area. While scientific forecast uses the known methodology of study of sea surfaces temperatures, wind patterns and past weather events to predict the state of the atmosphere, indigenous forecasts is given in line with experience of living in close contact with the environment and nature. Scientific forecasts are disseminated in a formal way. There are hierarchical channels of dissemination, which makes the forecasts not to reach farmers on time for them to make timely decisions. Indigenous forecasts on the other hand are disseminated in an informal way thereby available and accessible to farmers. There is need therefore to ensure scientific forecasts are readily available when required by the users.

4.4.6 Understanding of climate Forecast Terms

Climate forecast information comes in different forms and sometimes, it uses terms that some people find challenging to comprehend or differentiate. This was to find out how well the respondents were conversant with several climate forecast terms. The findings are shown on Table 4.9

Table 4.9: Respondents' Understanding of Climate Forecast Terms

	Forecast term					
	Normal Rainfall		Near Normal Rainfall		Above normal rainfall	
Explanation	f	%	f	%	f	%
Extremely High rainfall	22	8	11	4	38	14
High rainfall	11	4	30	11	52	19
Moderate rainfall	85	31	57	21	41	15
Low rainfall	57	21	71	26	27	10
Don't know	99	36	105	38	116	42
Total	274	100	274	100	274	100

Source: Author, 2018

From Table 4.9, it was noted that most of the respondents were not well versed with definitions and explanation of the climate forecast terms they were presented with. From the results 36% respondents did not know the explanation for below normal rainfall, 38% respondents did not know the explanation for near normal rainfall while 42% did not know the explanation for above normal rainfall. Only 21% respondents knew the explanation of the term below normal rainfall, citing it to be low rainfall. Another 21% of the respondents cited near normal rainfall to be moderate rainfall while a total of 32% respondents noted that the term above normal rainfall denoted either high rainfall or extremely high rainfall. Therefore, it was observed that most of the respondents were not conversant with climate forecast terms and that in case they were presented with climate forecast information that bore these terms, it would be difficult for them to make the right and appropriate sense out of the information on their own. This concurs with Oduor *et al*. (2002) who observed that the current nature of scientific forecast terminologies of near normal, above normal and below normal may not assist much a small-scale farmer who has limited resources to cope with the eventualities of extreme weather events. The jargons used in the communication of seasonal climate forecast are a stalemate to the end users of the information. This has highly compromised the use of such forecasts for any meaningful farm decisions in the area. Gigerenzer and Hoffrage (1995) also pointed out that, the communication of uncertainty constitutes a related problem of quality. Forecasts are presented in the language of probabilities, but are often not perceived as such. Probabilistic information is difficult to assimilate because people do not think probabilistically nor do they interpret probabilities easily (Gigerenzer & Hoffrage, 1995, cited by Stern and Easterling, 1999). From a purely technical or statistical perspective, an unlikely event, one with a low probability of occurrence, can in fact occur. But for farmers and policy makers to use forecast information as a risk-reducing tool, they must have an appropriate understanding of the meaning of a probabilistic forecast (Gigerenzer & Hoffrage, 1995). This is lacking.

4.5 Socio Economic Factors Influencing Utilization of Seasonal Climate Forecast

The ability of smallholder farmers to utilize climate forecast information is influenced by many factors including socio-economic characteristics of a household. Some of the socioeconomic factors that influence utilization of seasonal climate forecast are discussed below.

4.5.1 Influence of Socio Economic Characteristics on Utilization of Seasonal Climate Forecast Information

Socio economic characteristics of smallholder farmers may influence utilization of seasonal Climate forecasts. This include gender, age, education level, income and land size. Pearson Correlation was used to test the relationship socioeconomic characteristics and utilization of seasonal climate forecast. The results are shown in Table 4.10

Table 4.10: Correlation between Socio Economic Characteristics and Utilization of Climate Forecast information

Variable	Pearson Correlation Coefficient	Significance
Gender	.836**	.007
Age	.666**	.000
Education level	.744**	.005
Income	.628**	.000
Land Size	.596**	.003

** Significant at 0.01 level * significant at 0.05 level

The study found that 69% of the respondents were male while 31% of the households were female (Figure 4.1). A Spearman's correlation coefficient analysis was carried out to find out the relationship between gender and utilization of climate forecast information. Results showed that there is a strong, positive correlation between the two variables (Gender and utilization of climate forecast information) ($r= .836$, $p=.007$, $\alpha=.01$) as represented in table 4.10. From the results, female respondents (31%) were more likely to make use of climate forecast information than their male counterparts (Figure 4.1). Gender has an effect on access to information from different sources. It influences the information seeking behavior and ability to make decisions. Nhemachena and Hassan (2007) argued that female households are more likely to utilize climate forecasts when issued and received in good time since they are responsible for much of the agricultural work hence have greater experience than men.

Respondents ages range was from 20- 80 years with a mean of 50 and standard deviation of 14.68. Majority of the respondents aged 50-59 years represented 38% (Figure 4.2). On calculating a Spearman's correlation coefficient analysis between age and utilization of seasonal climate forecast information, positive significant correlation ($r= .666$, $p=.000$, $\alpha=.01$) was found (Table 4.10). This therefore means age has an effect on utilization of seasonal climate forecasts. Young farmers are more likely to utilize seasonal climate forecast information when received compared to old people. According to Ziervogel and Zermoglio (2009), older farmers are perceived to have more knowledge on indigenous methods of climate forecasting and their agricultural decision are based on indigenous knowledge. In addition, age increases experience and perception of climate forecasts hence likelihood to utilize. Therefore, seasonal climate forecasts might be of less significance if passed to the old generation who might not utilize them. Shirferaw and Holden (1998) argued that older farmers may be less willing to take risks associated with scientific climate forecasts issued. More so, younger farmers have more access to education and exposure thus making them more receptive to change (Vogel & O'Brien, 2006). Patt and Gwata (2002) reported that majority of the younger farmers are more active and receptive to information and could withstand the test and scientific climate forecasts when dissemination is done on time. This means to increase utility of scientific climate forecasts age must be taken in to account

Findings from the study showed that 33% had primary education, 28% attained secondary education, 16% have attained technical colleges while 4% are university graduates (Figure 4.3). A few farmers (11%) had no formal education while 8% were able to read and write. Results from correlation coefficient (Table 4.10) shows that there is a strong, positive correlation between the two variables (education level and utilization of seasonal climate forecasts) ($r= .744$, $p=.005$, $\alpha=.01$). This means education level has a positive effect on utilization of seasonal climate forecast. Thus, access to formal education can increase the likelihood of utilizing climate forecast information for farming purposes. Formal education therefore can make a person to make informed decisions of when and what to plant in relation to the anticipated weather patterns. Uddin *et al*., (2014) found that more educated farmers are better able to utilize climate forecast when given to them and even forecast future scenarios.

Majority of the respondents (55%) earned a total of Ksh. 10,000-20,000 while a few (6 %) earned more than Ksh. 40,000, some 11% earned below Ksh. 10,000 while 20% earned between Ksh. 20,000 and 30,000. Results from correlation coefficient showed a positive significant relationship ($r= .628$, $p=.000$, $\alpha=.01$). This means income has a positive effect on utilization of seasonal climate forecasts. Income increases the capacity to make choices and access to information. It also reduces risk averseness and discount rate hence greater willingness utilize information. This finding is in agreement with Nhamachena and Hassan (2007) who observed that a higher income farmer may be less risk averse, have more access to information, and are more willing to utilize climate forecasts. Property ownership increases the propensity of a farmer utilize climate forecasts for agricultural purposes. This is also in agreement with Smucker and Wisner (2008) who found that rural households with diverse income sources are most able to maximally make use of climate forecasts. Conway (2009) also notes usability of scientific climate forecasts can be enhanced through diversification of rural livelihoods by increasing their on-farm and off farm income opportunities.

Very few residents (5%) had a land of average size 0.1-0.5 hectares. However, majority of the respondents (38%) had a large land size exceeding 5 hectares. Some 26% of the households had 3-5 ha, 20% had 1-2 ha while only 11% had land size of

1-2 ha (Table 4.3). A Spearman's correlation coefficient analysis was conducted and results showed that a positive relationship (r= .596, p=.003, α=.01) between the variables. This indicates that land size has a positive effect on utilization of seasonal climate forecasts. Households who have large farm sizes are more likely to consult on climate forecasts before making any decisions. This is consistent with the finding by Orindi and Murray (2005), who found out that in Central Kenya, utility of climate forecasts was influenced by land size. This is because such large land sizes require a lot of capital investments for any viable agricultural purposes and as such, farmers felt that it was inappropriate to gabble with climate uncertainties thus consulting climate forecasts on the likelihood of a certain season.

A study by Egeru (2012), found that large-scale commercial farmers used climate forecasts more rapidly than small holders. This is because large-scale farmers were willing to experiment them with new farming techniques and technologies

4.5.2 Perception on Usefulness of Climate Forecast Information

The researcher further ventured in to understanding whether climate forecasts and information influenced crop related decisions as well as the usefulness of climate forecast and information. The results are presented in Table 4.11

Table 4.11: Influence and Usefulness of Climate Forecast Information.

	Climate forecast and information influenced crop related decisions			Usefulness of weather forecasts and information		
	Yes	No	Don't know	Extremely useful	Useful	Not useful
Frequency	89	153	32	23	54	197
Percentage	32%	56%	12%	8%	20%	72%

Source, Author, 2018

It was noted that most of the respondents (56%) felt that climate forecasts and information did not influence crop related decisions. Only 32% of the respondents were positive that climate forecast information influenced crop related decisions while 12% did not know. Similarly, 72% of the respondents were of the opinion that climate forecasts and information were not useful. 20% of the respondents felt that climate forecasts and information were useful while only 8% noted that climate forecasts and information were extremely useful. Forecasts are important in averting agricultural risks. Patt and Gwatta (2002) argue that quality of the information is the level of confidence placed in it by receivers and it influences its acceptance and use. Therefore, KMD should downscale forecasts at a reduced geographical area as a way of improving accuracy, before this is done, it is unlikely that a farmer will believe and use weather forecast information.

It was observed that majority of respodents though accessed weather information majority don't use it at all. For instance, majority of respodents (55%) do not use information related to rainfall amount even if they received it. Very few respodents (7%) use information on the onset of rain when they receive it (Figure 4.20).

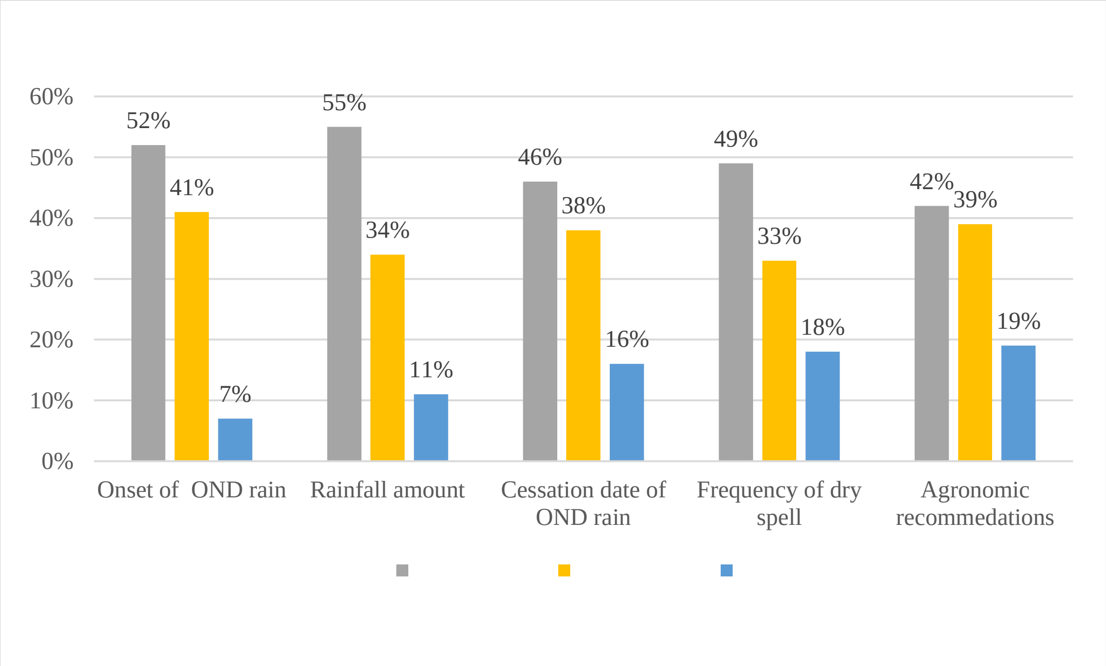


Figure 4.20: Information use by Farmers

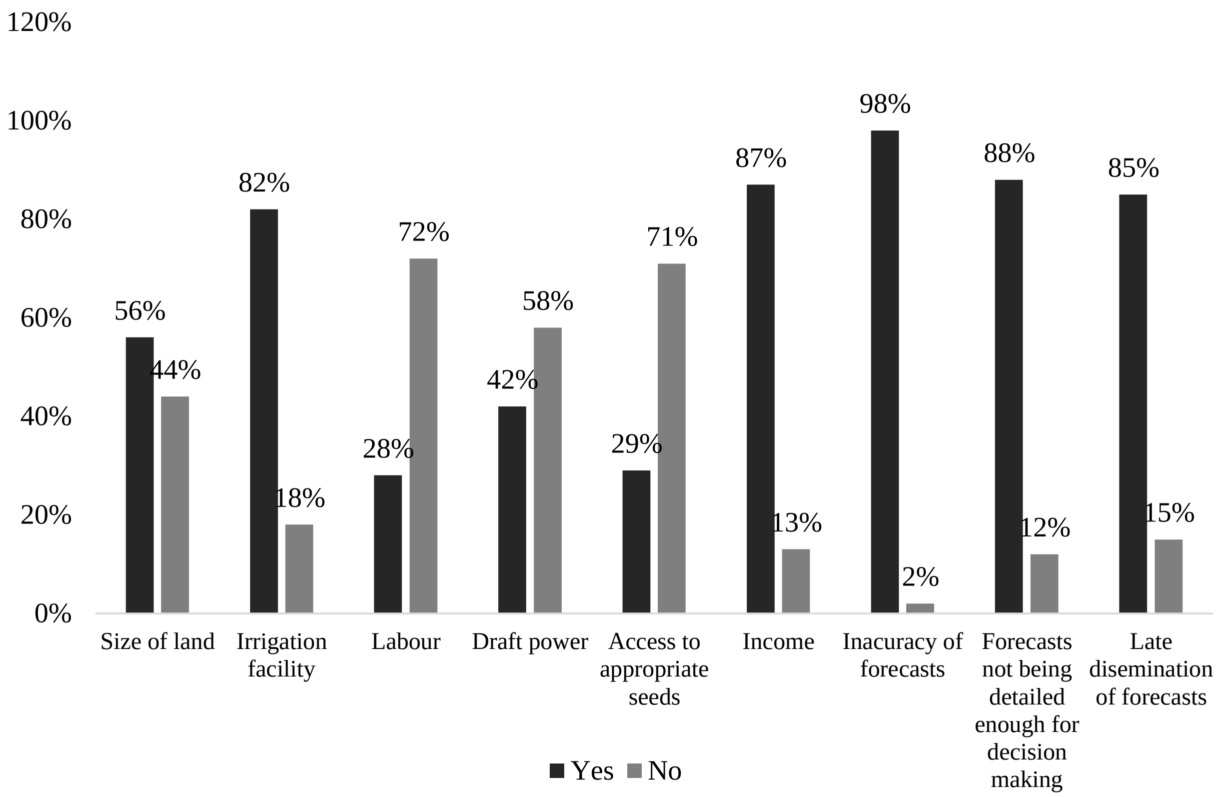
Source, Author, 2018

Usability of climate forecasts is affected by the way the forecast supports or contradicts local beliefs about the climate. Local beliefs are based on the notion that a deity controls weather and climate. Communities routinely offer prayers for rains, especially when there is a prolonged drought. Artikov *et al*. (2006) noted that attitude had the most profound positive influence on use of climate forecasts in decision-making followed by norms. Therefore, a focus on changing both the farmers' and their societies' beliefs and values, and perceptions of climate forecasts will in turn greatly affect their use and influence. Improved credibility may therefore depend on improved forecasts. More importantly, modeling limitations and the chaotic nature of the atmosphere imply a probabilistic climate forecast, as opposed to a deterministic forecast. What is needed therefore is communication that emphasizes the probabilistic nature of the forecast. Furthermore, credibility and trust may depend on better communication and more careful use of language, especially where translation from English into local languages is involved. Other possible reasons that could also contribute to non-optimal utilization of the available climate forecasts is the relatively low education levels amongst the small-scale farmers, where a larger proportion possess only basic primary education. According to Hu *et al*. (2015) education could be a barricading factor to farmers' ability to accurately introspect, estimate, and report the actual influence or weighting of forecasts upon their decisions. Similar studies by (Vinocur, 2001) also showed a strong correlation between the education level of the farmer and management operation decisions they make on a day to day basis.

Hansen, (2002) reported that, despite the availability of relatively reliable forecasts from the Kenya Meteorological Department, farmers seldom use this information for farm level decision making. This is mainly due to lack of adaptability of the information to the local needs and difficult in accessing the information on time and in a format that farmers can easily understand. For instance, 55% do not use information related to rainfall amount even if they received it. If weather information on onset of main rain is given, less than 7% use the information to make decisions. (Figure 4.20). The low percentage of farmers who made use of scientific forecasts to decide on their planting dates makes the majority of farmers more vulnerable to unfavorable climatic conditions. Farmers fail to take advantage of a good season and they risk losing their crop if the rains do not come during the expected beginning of the rain season. Agrawala *et al*. (2001) has decried the fact that only a few examples of seasonal climate forecasts are being used successfully by vulnerable groups, despite international efforts to improve societal responses. O'Brien *et al*. (2000) has indicated that one of the primary reasons for this scenario is that forecast information does not specifically target vulnerable groups, which results in poor availability of information and therefore a barrier to ease of access to the information. The forecast information is often not tailored to suit target farmers in content and delivery style, which means that they may end up not being able to access it even if it was availed to them (Broad & Agrawala, 2002).

4.5.3 Factors Affecting Adoption of Climate Forecast Information.

Agricultural decision makers currently fail to optimally use available climate information and forecasts (Changnon *et al*. 1995) suggesting that increased accuracy of forecasts and other climate information will not translate automatically into increased influence on farmer decisions. As shown in Figure 4.21, 98% of the respondents reported inaccuracy of forecasts as the most prominent factor affecting the adoption of scientific climate forecast information, 88% believed that forecasts were not being detailed enough for decision making, while 85% felt that climate



forecasts are disseminated late.

Figure 4.21: Factors Affecting Adoption of Climate Forecasts Information

Source, Author, 2018

Therefore, it was noted that factors related to the source and dissemination channels were the most influencing factors that hindered adoption of climate forecasts information. For example, In December 2009, wheat farmers of Narok District threatened to sue the KMD for predicting that the El Niño rains would start in late September. However, they did not begin until almost the end of December 2009 leading to harvest losses for the farmers concerned. (Parita Shah *et al*., 2014). The biggest challenge in the use of scientific forecast is the fact that famers view it as unreliable and always untimely. Patt and Gwata (2002) have argued that access and use of climate forecast remain the greatest challenge to climate scientists. Many a time climate forecast have suffered a credibility problem and people have shown mistrust for it (Hobbs, 1980) an attitude that comes from the previous forecasts being perceived as inaccurate, as a result, users end up ignoring the forecast.

Quite a number of farmers (87%) mentioned income as a constraint that affected their adoption of climate forecast information. Recha *et al*. (2008) also reported that 85% of the farmers indicated income as a major constraint to the application of seasonal climate forecasts. Farmers experienced income shortages especially if they were coming from a bad season and they indicated that they had limited loan facilities. Farmers were unlikely to respond to seasonal forecast especially if they had to purchase inputs. Lack of income will go a long way in affecting farmer's response to forecasts especially if one does not have his own machinery. Those with their draft will quickly employ a response strategy but those who do not have will wait until their counterpart's finish on their farms before they have mercy on them. This highly exacerbates their vulnerability to hunger, because they may delay to take advantage of a good season or to respond to a bad season. This information is in agreement with the findings of Phillips *et al*. (2001).

The research carried out in Zimbabwe has shown that just under 42% of communal farmers had access to income and had their own animal power implying that 58% have to wait for their turn to have their fields ploughed (Phillips *et al*. 2001). Although forecasting information may be readily available to communal farmers, lack of income and resources limit its effective use. Planting opportunities are missed as farmers look for money to buy planting materials and prepare their fields. They therefore recommended that communal farmers should have access to income to buy inputs and hire draft power in order to capture the benefits of seasonal forecast information by making timely and appropriate decisions. The other critical factors mentioned by farmers were lack of irrigation facilities (82%) and forecast not being detailed enough to make informed decisions (88%).

Labour shortages (28%) was also indicated to affect adoption of climate forecast information. From the interview it was observed that most famers use family labor, and where it is not enough they have to supplement it with hired labor. The challenge is still income and this could be a hindrance to any response to the forecasts. This is in line with the UNEP report (2006), the report pointed out that socio-economic factor such as labor could affect use of forecasts by farmers. For example, in a good rain year, farm households which are limited by labor, may decide to reduce the cultivated area, use more manure and focus on weeding to maximize yield while households that have more labor can expand the cultivated area to maximum use of good rainfall conditions. In a drier year the behavior of both sets of households would be different. This information concurs with the findings of Kamal and Subbiah (1999). They argued that socio-economic constraints form a critical gap between climate forecast information and its application at farm level decision making. The other factors are; failure to access quality seed (29%) and draft power shortages (42%). Literature points out to a number of similar factors that influence adoption of climate forecast innovations. These factors include accessibility and usefulness of the information (Roncoli *et al*., 2002), and the socioeconomic position of the household among others (Ziervogel *et al*., 2006).

Successful use of forecasts requires on one hand a deeper understanding of the characteristics and needs of specific user groups and a clear understanding of what the forecasts mean on the other hand. However, studies carried out in West and Southern Africa show limited adoption of forecasts by farmers due to serious resource limitations such as lack of land, labor, income, limited exposure to the use of forecasts and inaccuracy of forecasts (Shoko Shoko, 2011). It is therefore important that the needs and concerns of users, in particular vulnerable groups, also inform the content and forecast dissemination approaches. The fact that many small-scale farmers are unable to take advantage of forecasts due to resource constraints necessitates that socio-economic and political needs are also addressed along with climate forecasts needs in adaption and planning. Access of the forecast does not necessarily translate to forecast application. There are quite a number of factors that determine forecast use by farmers for their farm management.

The study also carried out Pearson correlation analysis between factors affecting adoption of climate forecast information and utilization of forecast. The findings based on these factors are summarized on Appendix D. According to appendix D, utilization of seasonal climate forecasts is significantly correlated to late dissemination of forecasts, undetailed forecasts, inaccuracy of forecasts, and income at $p<0.01$ Significant level. However, size of the land and irrigation facility has a weak but significant correlation to utilization of climate forecast at $p<0.05$ significance level. In addition labour, draft power and access to appropriate seeds is not significantly correlated to utilization of climate forecasts. This implies that if the climate forecasts are accurate, detailed enough and disseminated on time then farmers will adopt and utilize seasonal climate forecasts. These findings are in agreement with those of Oyekale and Gedion (2012) whose study findings established that accuracy and timely dissemination of forecasts are vital determinants of utility of seasonal climate forecasts for positive agricultural decision-making.

CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

One of the great challenges of climate science is estimating the probability of the occurrence, severity and duration of an extreme event, as well when and where the event will take place. This uncertainty poses major threats to small-scale farming in Africa, especially in East Africa where about 80% of the population depend on rain-fed agriculture. Over time, they have adjusted their planting patterns and farming calendar to the onset, duration and end of the rainy seasons. However, with changing rainfall due to climate change, their planting patterns and farming calendar no longer match seasonal rainfall distributions, which often leads to crop losses. Seasonal climate forecasts are thus crucial for the provision of early warning information and, if used by farmers, can enable them to adjust their planting seasons and farming calendar. The study examined access and utilization of seasonal climate forecast among household's farmers and summary of the findings are given per objective.

5.1.1 Dissemination Channels of Climate Forecasts Information to Small Holders Farmers in Masinga Sub County.

It was revealed that, household farmers get climate information from extension services, radio, television, newspapers, internet, and meteorological department. However, majority of the respondents (38%) reported radio as the most common source of climate forecast information. Radio was foremost source of accessing climate forecasts by farm households (90%) and this can be strongly linked to its affordability, portability and low maintenance cost. This was followed by mobile phone (60%). Majority of the respondents has access to radio daily (80%) followed by television (40%). Household farmers are often undecided whether to follow the recommendations of climate forecasts. This is due to uncertainty about their reliability, the limited ability of many households to comprehend the technical language used by meteorologists and the lack of access to detailed forecast information. Key actors in the communication of seasonal climate forecasts to farmers include the Kenya Meteorological Department, the Ministry of Agriculture (MoA), the Ministry of Livestock Development (MLD), the Ministry of Information and Communication and the media. These actors are beginning to address some of the challenges, but they should step up their efforts. Seasonal climate forecasts were perceived to be generalized and coarse, providing little or no detail on the local characteristics of a season. Moreover, the terminology used in forecasts limit their usability and usefulness to farmers and other users. The study found that farmers do not understand the technical terms, which continue to be difficult to translate into local languages. Furthermore, misinterpretations of forecasts by the media not only spread "incorrect" forecasts, but also detract from the credibility of the KMD's performance.

5.1.2 Satisfaction Levels of Seasonal Climate Forecasts among Smallholder Farmers of Masinga Sub County

Different types of seasonal climate forecast which were used include; indigenous forecasts, seasonal climate forecasts and a mixture of both seasonal and indigenous forecasts. However, results have shown that majority of farmers prefer indigenous forecasting knowledge (34%) more than contemporary forecasting. Their reasons are that indigenous information is more compatible with local culture and it has been tested, tried and trusted. In addition, it is more specific and is in a language that can be understood better by communities passing clear message that integration of indigenous forecasting knowledge into science based climate forecasting will promote effective use and create ownership by communities. Majority of the respondents (58%) had used forecasts for more than five years, and indicated that they were very unsatisfied with scientific forecasts. As a result, it was noted that majority followed usual season (42%) in making planting decisions while (28%) used indigenous forecasts. Although some respondents receive scientific climate forecasts, majority do not put them in to use. Some 74% of the respondents used indigenous climate forecasts in farm level decision making. Small-scale farmer's perception on forecasts greatly determines the response they put to it with majority (48%) viewing scientific forecasts as unreliable and always untimely.

5.1.3 Influence of Socio-Economic Characteristics on Utilization of Seasonal Climate Forecasts Information by Household Farmers

There was a significant relationship between farmers' use of climate forecast information and gender, level of education, age, income and land size. Females were more likely to make use of climate forecast information than males. The results show that access to formal education can increase the likelihood of utilizing climate forecast information for farming purposes. Further, the study revealed that most of the respondents (56%) felt that climate forecasts and information did not influence crop related decisions. Only 32% of the respondents reported that climate forecast information influenced crop related decisions while 12% did not know. Inaccuracy of forecasts, delays in releasing forecasts, forecasts not detailed enough, and income were the major factors affecting farmers' adoption of climate forecast.

5.2 Conclusions

In regard to this study, the following conclusions are made per the objective.

5.2.1 Dissemination Channels of Climate Forecasts Information to Smallholders Farmers in Masinga Sub County

Radio was found to be the major source and dissemination channel of climate forecast information for smallholder farmers in Masinga Sub County. A mix of media is important for disseminating climate forecast information at different periods and content. Dissemination channels were mobile phones, bulletins, chief Barraza's, friends, extension officers, newspapers and internet. Bulletins, extension officers and internet were considered best seasonally. However, despite radio being the most accessed channel, it is not effective. Information received from internet was found to be the most effective.

In order to develop strategy for better ways of delivering services, there is a need for branding, exploiting faster modes of delivery at low cost using appropriate Media (mobile phone technology, TV, social media, radio, SMS services, Updated websites). There has been a lack of connection in disseminating services to users hence need to translate the products into local languages. The services should be timely with continuous evaluation and feedback from users. Mobile phones could be an effective tool for communicating messages to poor small-scale farmers in developing countries.

Even if there is at least one person with a mobile phone in a village, this person can be made the focal point and convey messages on actions to be taken to the others in the area.

5.2.2 Satisfaction Levels of Seasonal Climate Forecasts Among Smallholder Farmers of Masinga Sub County

The study found that smallholder farmers of Masinga Sub County majorly rely on both indigenous and scientific climate forecasts. Both scientific and indigenous climate forecasts can therefore be harmonized to incorporate consumer needs in order to reap positive impacts of the forecasts. There is a mismatch between the information that is useful to farmers and what is actually provided for public consumption. Majority of the respondents were very unsatisfied with the scientific forecasts. This has resulted to forecasts not used by vulnerable groups because information does not specifically target this vulnerable groups. This has been due to poor availability of information and therefore a barrier to ease of access to the information. The forecast information is often not tailored to suit target farmers in content and delivery style, therefore not able to access it even if it was availed to them. Seasonal climate forecasts are crucial for the provision of early warning information and, if used by farmers, can enable them to adjust their planting seasons and farming calendar. If the communication of forecasts is not improved, most farmers will continue to ignore them and the resources invested in their improvement will have been wasted.

5.2.3 Influence of Socio-Economic Characteristics on Utilization of Seasonal Climate Forecasts Information by Household Farmers

Results showed a positive relationship between utility of climate forecast information and various socio economic characteristics such as education level, age, gender, and income. If this socioeconomic characteristics are observed in the entire process of climate forecast production and dissemination, there is likelihood of increasing utility of climate forecasts by the households hence reaping benefits of this information

5.3 Recommendations

The study makes the following recommendations

i. Most common source of seasonal climate forecast was radio. In addition, radio was the most accessed channel of forecast dissemination. Although majority of the respondents interviewed cited radio as the most common source of climate information it was not cited as the most effective dissemination channel. This can be attributed to the timing in which the forecasts are released. It is therefore recommended that, seasonal climate forecasts be issued in the evening between 6 p.m. and 9 p.m. to reach a large audience. Extension agents' participation in the dissemination of climate forecast information should be increased.

ii. From the results, majority of the respondents were not satisfied with scientific climate forecasts because of shortcomings accompanying the forecasts. Combination of both seasonal climate forecast and indigenous forecasts were being used by the majority of respondents. It is therefore, recommended that, combining indigenous and modern seasonal forecasting should be one of the ways of dealing with challenges faced in the development, communication and use of seasonal forecasts.

iii. Age, education level, gender, income and land size had significant correlation and relationship with respondent's utilization of seasonal climate forecasts. These factors have not yet been sufficiently prioritized as a fundamental instrument to enhance access and utility of climate forecasts. It is highly recommended that these factors need to be considered in the entire process of forecasts access and dissemination in order to reap benefits of climate forecasts.

5.4 Suggestions for Further Research

There is need for further research to assess the relationship between scientific and local climate forecasts and come up with possible ways of integrating the two.

REFERENCES

Agrawal, A. (2002). Common Resources and Institutional Sustainability. In Ostrom, *et al* (Ed.). *The drama of the Commons*. National Academy Press

Ajibade, L.T., & Shokemi, O. (2003). Indigenous Approaches to Weather Forecasting in ASA L.G.A. Kwar state, *Nigeria. African Journal of Indigenous Knowledge*.

Amissah-Arthur, A. (2003*). Targeting climate forecasts for agricultural Applications in Sub-Saharan Africa:* Situating Farmers in User Space. *Climatic Change 58(1-2):7392.*

Ani, A.O., & Baba, S.A. (2007). *Utilization of Selected Mass Media and Utilization of Agricultural Information in Northern Taraba State, Nigeria*. Tropical Agricultural Research and Extension 12 (1): 17-22

Artikov, I., Hoffman, S.J., Lynne, G.D., PytlikZillig, L.M., Hu, Q., Tomkins, A.J., Hubbard, K.G., Hayes, M.J., & Waltman, W. (2006). *Understanding the Influence of Climate Forecasts on Farmer Decisions as Planner Behaviour*. J. App. Meteor. Climatol. 45:1202-1214.

Awuor, C.B. (2008). *Information for better Planning*. Sakai pilot Project Report. Centre for Science and Technology Innovations, Nairobi, Kenya

Aldrian, E., Oludhe, C., Garanganga, B.J., Pahalad, J., Corradi, M.R., Boulahya, M.S., Dubus, L., Ebinger, J., Fischer, M. (2010). *Regional climate information for risk Management. Procedia Environ. Sci., 1, 369–383*

Agrawala, S., Broad, K., & Guston, D.H. (2001). *Integrating Climate Forecasts and Societal Decision Making: Challenges to an Emergent Boundary Organization*. *Sci. Technol. Hum. Val., 26:454–477*

American Meteorological Society. (1991). *Weather forecasting*: A policy statement of the American Meteorological Society as adopted by the Council on 13 January 1991. Bull. *Amer. Meteor. Soc., 72, 1273–1276.*

Bert, E.F., Satorre E.H. Toranzo, Podesta, G.P. (2006). *Climatic information and decision-making in maize crop production systems of the Argentinean Pampas*. Agricultural systems 88:180-204.

Blench, R. (1999). Seasonal climate forecasting: Who can use it and how should it be disseminated? *Natural resource perspectives 47:1-5 Hampshire, UK. Ash gate*.

Broad K., Agrawala S. (2002). *The Ethiopia food crisis:* Uses and Limits of Climate forecasts. *Science. 289:1693–1694*

Bryan, E., Deressa, T., Gbetibouo G. & Ringler, C. (2009). *Determinants of Adaptation to Climate Change in Ethiopia and South Africa. South African Centre for Environmental Economics and Policy,* International Food Policy Research Institute.

Cardwell, M., & Cardwell, M. (1999).Complete *AZ psychological handbook*: London: Hodder and Stoughton Educational.

Celia, M., Sonny, R., Christian, N.D., Mina D., & Gonzales, K.G. (2009). *Climate variability, seasonal climate forecasts and corn farming in Isabela Philippines.* Ashgate Publishing Limited Hampshire, England.

Central Bureau of Statistics (CBS) (2007). *Central Bureau of Statistics, Economic Survey*. Ministry of Planning and National Development. Republic of Kenya. Nairobi

Chang'a, L.B., Yanda, P.Z., & Ngana, J. (2010). Indigenous knowledge in seasonal rainfall prediction in Tanzania*:* a case of the south-western highland of Tanzania. *Journal of Geography and Regional Planning.*

Changnon, S., Pielke, R.A., Changnon, R. T., Sylves, G.K., &. Pulwarty, R. (1995). Human factors explain the increased losses from weather and climate extremes. Bull. Amer. Meteor. Soc., 81, 437–442

Changnon, S.A. (2002). Impacts of the Midwestern drought forecast of 2000. *Journal of applied meteorology 41. 1042-1052. (cross ref)*

Chavas, D.R. (2015). Seasonal climate prediction dissemination to rural farmers in sub-
Saharan Africa: A "bottom-up" perspective and the emergence of the mobile phone. Available online: http://www.princeton.edu/~dchavas/download/ CHAVAS_SSA_Seasonal_Climate_Forecast_D iscussion_Paper.pdf (accessed on 6 August 2017)..

Conway, G. (2009). The science of climate change in Africa: Impacts and adaptation. *Imperial College Discussion Paper No. 1,* London

Curry, J. (2001). *Use of climate information in the Greater Horn:* Assessing the needs of Institutional users. International Research Institute for Climate Prediction. Technical Report 01-02, IRI, Palassade, New York

Das, H. P., F.J. Doblas-Reyes, A. Garcia, J. Hansen, L. Mariani, A. Nain, K. Ramesh, L., Rathore, and R. Venkataraman (2007). *Weather and Climate Forecasts for Agriculture*. In WMO Guide to Agrometeorological Practices (ed. Das, H.P.and K. Stigter). 3rd Edition (WMO-No.134) World Meteorological Organisation (Switzerland)

Delecluse, O., Davey, M. K., Kitamura, Y., Philander, S. G. H.,Suarez, M. & Bengettson, L.(1998). 'Coupled general circulation modelling of the tropical Pacific'*, Journal of Geophysical Research, C7-14,357–14,373*

DMCN (Drought Monitoring Centre, Nairobi). (2004). Traditional indicators used for Climate. Monitoring and prediction by some rural communities in Kenya. A contribution to the harmonization of traditional and modern scientific methods of climate prediction in Kenya. DMCN, Nairobi, Kenya

Egeru, A. (2012). *Role of indigenous knowledge in Climate Change adaptation*: A case study of the Teso Sub-Region, Eastern Uganda, 11 (2), 217-224.

Encyclopedia of the Nations/Africa/Kenya (2009). http://www.nationsency clopedia.com/Africa/Kenya-AGRICULTURE.html (Accessed on 10/02/2016)

FAO. (Ends). (2010*). Gender Sensitive Indicators for Natural Resources Management*. Rome, Italy: FAO

Feleke, H.G. (2015). Assessing Weather Forecasting Needs of Smallholder Farmers for

Climate Change Adaptation in the Central Rift Valley of Ethiopia. *J Earth Sci Clim Change. 6: 312. doi:10.4172/2157-7617.1000312*

Fitzgerald, B.P. (1994). Science in geography I: development in geographic method, Oxford University, London

Goddard L., Barnston, A., & Mason S. (2001). Evaluation of the IRI's "net assessment" seasonal climate forecasts: 1997-2001. *Bulletin of the American Meteorological Society 84(12): 1761–1781*

Gommes, R., H. Das, L., Mariani, A., Challinor, A., Tychon, B., Balaghi, R., & M.A.A.

Dawod. (2007). *Agro meteorological Forecasting. In Guide to Agrometeorological Practices.* (Ed. Stigter K.). 3rd Edition (WMO-No.134) World Meteorological Organisation (Switzerland).

Government of Kenya. (2010). *Kenya population and housing census, Vol. 1a: Population by administrative units*

GOK. (2008). *A Globally Competitive and Prosperous Kenya:* Ministry of State for Planning National Development and Vision 2030. Nairobi: Government Printer.

Government of Kenya. (2010). *Kenya population and housing census, Vol. 1a: Population by administrative units*

Gigerenzer, G., & Hoffrange, U. (1995). How to improve Bayesian reasoning without Instruction: frequency formats. *Psychology review 102: 684-704*

Hammer, G., Nicholls, N., & Mitchell, C. (Eds.). (2001). *Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems*: The Australian Experience. Kluwer Academic Publishers, Dordrecht.

Hammer, G. L., Nicholls, N., & Mitchell. C. (2000). *Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems*. Kluwer Academic Publishers. 469

Hansen, J.W., Mason, S.J., Sun, L., & Tall. (2011). A Review of Seasonal Climate Forecasting For Agriculture in Sub-Saharan Africa. *Exp. Agr. , 47, 205–240.*

Hansen, J.W., Mishra, A., Rao, K.P.C., Indeje, M., & Ngugi, R.K. (2009). Potential value of GCM-based seasonal rainfall forecasts for maize management in semiarid Kenya. *Agric. Syst. 101, 80–90.*

Hansen, J.W., Baethgen, W., Osgood, D., Ceccato, P. & Ngugi, R.K. (2009). Innovations in climate risk management: Protecting and building rural livelihoods in a variable and changing climate. Journal of Semi-Arid Tropical Agricultural Research 4(1): published online at http://www.icrisat.org/ Journal/SpecialProject/sp13.pdf

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

Hansen, J.W. (2002). Realizing the potential benefits of climate prediction to agriculture: issues, approaches, challenges. *Agric. Syst., 74:309–330*

Harvey, C.A., Rakotobe, Z.L., Rao, N.S., Dave, R.., Razafimahatratra, H., Rabarijohn, R.H., Rajaofara, H., MacKinnon, J.L. (2014*). Extreme vulnerability of smallholder farmers to agricultural risks and climate change in Madagascar*. Phil. Trans. R. Soc. B.doi:10.1098/rstb.2013.0089.

Hammer, G. (2000). *A general systems approach to applying seasonal climate forecasts*. In:Hammer, G., Nicholls, N., Mitchell, C. (Eds.), Applications of Seasonal Climate

Hobbs, J.E. (1980). *Applied climatology:* A study of Atmospheric Resources, Dawnson Westview Press. England

Hornetz, B., Shisanya, C.A., Gitonga, N.M. (2001). Crop water relationships and thermal adaptation of kathika beans (Phaseolus vulgaries L.) and green grams (Vigna radiataL. Wilczek) with special reference to temporal patterns of potential growth in the drylands of SE Kenya. *Journal of Arid Environments, 48, 591-601*

Howden, S.M., Soussana, J., Tubiello, F.N., Chhetri, N., Dunlop, M., Meinke, H. (2007). Adapting Agriculture to Climate Change. *Proc. Natl. Acad. Sci. USA., 104, 19691–19696.*

Hu, Q., PytlikZillig, L.M., Lynne, G.D., Tmokins, A.J., Waltman, W.J., Hayes, M.J., Hubbard, K.G., Artikov, I., Hoffman, S.J., & Wilhite, D.A. (2015). *Understanding farmers' forecast use from their beliefs, values, social norms and perceived obstacles*. J. Appl. Meteorol. Climatol. 45(9):1190-1201.

Hudson, J. and Vogel, C. (2003). The use of seasonal climate by livestock farmers in S.A. In coping with climate variability: use of seasonal climate forecast in S.A, 75-76 (Eds O'Brien, K and Vogel, C.) *Aldershot: Ashgate press*

Hooke, W. H., & R. A. Pielke Jr. (2000). *Short-term weather prediction*: An orchestra in search of a conductor. Prediction: Science, Decision Making and the Future of Nature, D. Sarewitz, R. A. Pielke Jr., and R. Byerly, (Eds.), *Island Press, 61–83.*

IPCC. (2007). *Climate change 2007 synthesis report: Contributions of working group I, II and III to the fourth assessment report of the intergovernmental panel on climate change.* Geneva, Switzerland: IPCC

Isabirya, R.(2003).“*Promoting and integration of indigenous knowledge in seasonal climate forecast".* Consulting report submitted to drought monitoring centre. Harare, Zimbabwe. The Pilot Project Research.

ISDR. (2003). Disaster Reduction in Africa. ISDR informs issues 2, UN/ISDR Africa UNEP HQ UN complex Gigiri. Nairobi. Kenya.

Jagtap, S.S., & Jones, J.W. (2005). *Decision support system for agricultural applications of climate forecast in West Africa Progress Report* 2004-05 NOAA Office of Global Programs.

Jagtap,S.S., Jones,J.W., Hildebrand, P., Letson, D.,O' Brien, J. J., Podesta, G., Zierden, D., & Zazueta, F. (2003). Responding to stakeholder's demands for climate information: from research to applications in Florida. *Agric.Syst.74:415–430*

Jones, J.W., Hansen, J.W., Royce, F.S., Messina, C.D. (2010). Potential benefits of climate forecasting to agriculture. *Agr. Ecosyst. Environ*.

Kadi, M., Njau, L.N., Mwikya, J., & Kamga, A. (2011). *The state of climate information services for agriculture and food security in East African countries*. CCAFS Working Paper No. 5. Copenhagen, Denmark. Available online at: www.ccafs.cgiar.org.

Kamau, F.K. (2006). *An overview of extension services in Kenya*. A paper presented during the Animal Production Society of Kenya Annual conference held in Isiolo 8-10 March 2006.

Kathuri, J.N., & Pals, D.A. (1993). *Introduction to educational research.* Njoro: Egerton. University Press.

Katz, R., & Murphy, A. (1997). Economic value of weather and climate forecasts. Cambridge University Press.

Kenya Metrological Services, (2017). Seasonal climate outlook https://www.niwa. co.nz/climate/seasonal-climate-outlook accessed on 10/11/2017

Kenya Meteorological Department (KMD) (2009a). *Climate outlook for March-April-May* 20009*.* Press Release. Ref. No. Met/ 7/23

Kenya Meteorological Department (2009b). *Agro meteorological Services for Farmers.*
www.meteo.go.ke/obsv/agro.html. (Accessed on 12/01/2016)

Kombo, D.K., & Tromp, I. A. (2009). *Proposal and thesis writing*, Nairobi. Kenya

Kinuthia, S. (2006*). Agro meteorological Aspects in Sustainable Agricultural Development.* Review of the Agro-metrological Applications to conserve and Manage Natural Resources for the Benefit of Agriculture, Range Lands, Forestry, Fisheries and other Natural Resources in Kenya. Kenya Meteorological Department.

Kimenia, C. & Oyare, E. (2006). *The Status of Organic Agriculture Production in Kenya.* Report of the Initial background study of the National Integrated Assessment of Organic Agriculture Sector –Kenya.

Klopper, E., Vogel, C.H., Landman, W.A. (2006). *Seasonal climate forecasts –* Potential Agricultural-risk management tools? *Climatic Change 76, 73–90.*

Lemos, M.C., Finan, T.J., Fox, R.W., Nelson, D.R., & Tucker, J. (2002). The use of seasonal climate forecasting in policymaking: *lessons from Northeast Brazil. Climate Change, 55, 479-507*

Lin, J. (1991*). Education and Innovation Adoption in Agriculture Evidence from Hybrid Rice in China*. Ameriacan Journal of Agricultural Economics 73 (3). 713-723.

Luseno, W. K., McPeak, C. B., Barrett, P. D., Little J.G., & Gebru, G. (2003*). "Assessing the value of climate forecast information for pastoralists:* Evidence from Southern Ethiopia and Northern Kenya." World Development 31(9): 1477-1494.

Mannava, V., Sivakumar, K., & Motha, R. (2007). Managing weather and climate risks in Agriculture. *Agricultural Meteorology 60: 525-528*

Manyatsi, A.M. (2011). *Application of indigenous knowledge systems in hydrological disaster management in Swaziland,* Current Research Journal of Social Sciences

Marshall, G. R., Parton, K. A & Hammer, G. L. (1996). Risk attitude, planting conditions and the value of seasonal forecasts to a dry land wheat grower. *Australian Journal of Agricultural Economics 40 211–33*

Meinke, ,H., Nelson, R., Kokic, P., Stone, R., Selvaraju, R., & Baethgen, W. (2006*). Actionable climate knowledge:* from analysis to synthesis. Clim Res 33(1):101

Meinke, H. & Stone, R.C. (2004). Seasonal and inter-annual climate forecasting: The new tool for increasing preparedness to climate variability and change in agricultural planning and operations. *Climatic Change, in press*

Meinke, H., Baethgen, W.E., Carberry, P.S., Donatelli, M., Hammer, G.L., Selvaraju, R., & Stöckle, C.O. (2001). Increasing profits and reducing risks in crop production using participatory systems simulation approaches. *Ag Systems, 70: 493-513.*

Madzwamuse, M. (2010). *Climate governance in Africa: Adaptation strategies and institutions;* Unity Press: Cape Town, South Africa.

Meza, F.J., Hansen, J.W., & Osgood, D. (2008). Economic value of seasonal climate Forecasts for agriculture*:* review of ex-ante assessments and recommendations for future research. J. Appl. Meteorol. *Climatol. 47, 1269–1286.*

Michalakes J., Dudhia J., Gill D., Henderson T., & Klemp J. (2004*). The weather research and forecast model:* Software Architecture and Performance.

Mokssit, A. (2007). *End-user liaison*: role of interfacing mechanisms climate change issues for Northern Africa and Mediterranean region presented at WMO Climate Information and Prediction Services RA I Training Workshop, Tunis 8 November

Mokotjo, W., & Katusopa, T. (2010). Evaluation of the Agricultural Information Service (AIS) in Lesotho. *International Journal of Information Management* 30 (4): 350-356

Mugenda, O.V & Mugenda, A, G. (2003). *Qualitative and Quantitative approaches*. Research Methods

Mugenda, O.M., & Mugenda, A.B. (1999). *Research methods. Quantitative and qualitative approaches. Nairobi:* African Centre for Technology Studies (ACTS) Press.

Murphy, S., Washington R., Downing, T. E., Martin, R. V., Ziervogel, G., Preston, P., Todd, M., Butterfield, R., & Briden J. (2001). Seasonal forecasting for climate hazards: *prospects and responses Natural Hazards 23 171–96*

Msangi, S., Rosegrant, M.W., & You, L. (2006.) Ex post Assessment Methods of climate forecast impacts. *Clim. Res. 33, 67–79.*

Mwinamo, J.M. (2001*). Investigation on utility of weather and climate forecast on farming activities in Kwale Districts, Kenya.* Silver Spring, MD, USA: NOAA Office of Global programs.

Nassiuma, D.K., & Mwangi, J.W. (2004). *Statistical Methods For information analysis*. An Introduction. Egerton University Press. Kenya.

NCCRS, (2010). *Climate Change Response Strategy,* Nairobi: Government Printer.

National Snow and Ice Data Center (2009). http://nsidc.org/arcticmet/glossary/meteorogical_climate.html. (Accessed on 28/05/16)

Newman, J. (2005). Ethical issues in consultation. *Journal of counselling and development, 72 (2), 148-156*

Ngugi, R.K. (2002). *Climate forecast information: The Status, Needs and Expectations*
among Smallholder Agro-Pastoralists in Machakos Districts Kenya. IRI, Technical Report 02-04, IRI, Palassade, New York.

Ngugi, R. K. (2001). *"Climate Forecast Information*: The Status Needs and Expectations among Smallholder Agro-Pastoralists in Machakos Districts Kenya. IRI, Palisade, New York.".

Njau, L.N. (2010). *Seasonal-to-inter-annual climate variability in the context of development and delivery of science-based climate prediction and information services worldwide for the benefit of society.* Procedia Environ. Sci., 1 (2010), pp. 411-420

Nhemachena, C., Hassan, R. (2007). Micro-level analysis of farmers' adaptation to climate change in Southern Africa; *International Food Policy Research Institute: Washington, DC, USA, 36*

Nyakwada, W., Ocholla, A.B.C., Mango, C., Onyango, M., Musembi, D.K., & Nyakwada, C. (2003). *The traditional rainfall indicators used to monitor and predict rainfall in Kenya, Drought Monitoring Centre,* Nairobi, and DMCN Report.

O'Brien. K., Sygna L., Næss, L.O., Kingamkono,R., & Hochobeb,B. (2010). *Is information enough?* User responses to seasonal climate forecasts in Southern Africa CICERO report no. 2000–03

O'Brien, K.L., Vogel, H.C. (editors). (2003). *coping with climate variability*: the use of seasonal climate forecasts in southern Africa. Ashgate Publishing, Aldershot, U.K.

O'Brien, K., L., Sygna, L. O., Næss, R., Kingamkono & B. Hochobeb. (2000). "*Is information enough?:* user responses to seasonal climate forecasts in Southern

Africa: report to the World Bank, AFTE1-ENVGC adaptation to climate change and variability in Sub-Saharan Africa, phase II." *Report/CICEROSenter for klimaforskning*

Ochieng, O. (2004). *Kenyan initiatives to take sciences to its farmers*. http//www.scidev.net/en/news/Kenya-initiative-to-take-science-to-its-farmers.html. SciDev.Net. (Accessed on 02/12/2017)

Odeny, D.A. (2007). The potential of pigeonpea (Cajanus cajan (L.) Millsp) in Africa. *Natural Resource Forum, 31, 297-305*

Oduor, J.E., Mutea, J.A. and Karanja F.K. (2002). Perception and use of climate forecast amongst small holder farmers in semi-arid Kenya. Reata Printers Nairobi

Ogallo, L. (2007). "Relationships between seasonal rainfall in East Africa and the Southern Oscillation." *Journal of Climatology* 8(1): 31-43.

Ogallo L. (2007). CLIPS: RCOFs, Regional networking and consensus building, and user liaison for targeted climate service delivery *presented at Public Weather Services Symposium, Geneva, Switzerland 4 Dec*

Odingo, R., Nyakwada, W., & Njihia, J.K. (2002). *Weather and climate sector. In IGAD and DMCN, Factoring of weather and climate information and products into disaster management policy*: A contribution to strategies for disaster management (pp1-26), Nairobi, Kenya

Onyango., E, Oduor, J.E., Mutea, J.A. and Karanja F.K. (2002*). Perception and use of climate forecast amongst smallholder farmers in semi-arid Kenya*. Reata Printers Nairobi

Orindi, V. A. & Murray, L. A. (2005). *Adaptation to climate change in East Africa: A strategic approach, international institute for environment development*. Gatekeeper Series 117. [Online]. http://pubs.iied.org/pdfs/9544IIED.pdf (Accesed:20 February 2016).

Oyekale, A.S., & Gedion, K.E. (2012). Rural households' vulnerability to climate-related income shocks and adaption options in Central Malawi. J. *Food Agric. Environ. , 10, 1505–1510.*

P. Roudiera,B., Muller., I.P., d'Aquino, C.,Roncoli, M.A.,Soumaré, L.Battég, R. (2014)
Forecasts for resource-poor farmers in Zimbabwe. In: Rosenzweig, C. (Ed.), Impacts of El Nino and Climate Variability in Agriculture. American Society of Agronomy Special Publication, Madison, Wisconsin, pp. 87–100.

Palmer T. N., & Anderson, D. (1994). The prospects for seasonal forecasting – *A review paper Quarterly Journal of the Meteorological Society 120 755–93*

Parita Shah, Romanus Opiyo, Joshua Ngaina. (2012). *Options for improving the communication of seasonal rainfall forecasts to smallholder farmers – The Case of Kenya*: German Development Institute / (DIE)

Patt A., Gwata C. *(2002).* Effective seasonal climate forecast applications: Examining constraints for subsistence farmers in Zimbabwe. *Global Environ. Change.12:185–195. doi:10.1016/S0959-3780(02)00013-4*

Patt, A., L. Ogallo and M. Hellmuth. (2007). "*Sustainability*: Learning from 10 Years of Climate Outlook Forums in Africa." *Science* 318(5847): 49.

Patt, A., Suarez, P.; Gwata, C. (2005). *Effects of seasonal climate forecasts and participatory workshops among subsistence farmers in Zimbabwe*. Proceedings National Academy of Sciences USA, 102:12673–12678.

Patt, A.G., Ogallo, L.B., & Hellmuth, M. (2007). Learning from 10 years of climate outlook forums in Africa. Science, 318, 49 50.

Philips J.G., Unganal, L., & Makaudze, E. (2001). *Current and potential use of seasonal Climate forecast for resources poor farmers in Zimbabwe*. In impacts of El Nino and climate variability on agriculture. ASA special publication no 63, 87-100 (Eds Rosenzweig, C. Boote, K. J, Hollinger, S. Iglesias, A. and Philips, J.)

Phillips, G. (2003*). Determinants of forecast use among communal farmers in Zimbabwe*. In K. O'Brien & Vogel (Eds), Coping with Climate Variability (pp.111-127), *Ashgate, Burlington, USA.*

Phillips, J. G., Deane, D., Unganai, L., & Chimeli, A. (2002). Implications of farm-level response to seasonal climate forecasts for aggregate grain production in Zimbabwe. *Agric. Syst. 74 (3): 351–369*

Phillips, J.G. (1998). *Comparing optimal use of ENSO forecast information in two socioeconomic contexts.* Invited Talk at the American Association of Geographers Annual Meeting, Boston, MA, March 1998.

Phillips, J.G., *et al*. (2001). Current and potential use of climate forecasts for resource-poor farmers in Zimbabwe. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, USA. Impact of El Nino and Climate Variability on Agriculture. *ASA Special Publication no. 63*

Pielke, R. A., Jr. (1997). Asking the right questions: Meteorological research and societal needs. Bull. Amer. *Meteor. Soc., 78, 255–264*.

Pielke.,R, A. (1999b). Who decides? Forecasts and responsibilities in the 1997 Red River flood. Amer. *Behav. Sci. Rev., 7, 83–101*.

Pratt, C. (2001).*Traditional early warning system and coping Strategies for drought among pastoral communities*. Fletcher School of Law and diplomacy. Tuff University, Medford, United States.The role of climate forecasts in smallholder agriculture: Lessons from participatory research in communities in Senegal: *Climate Risk Management 2 42–55*

Qamar, M.K. (2002). *Global trends in agricultural extension*. Challenges facing Asia and the Pacific Region. FAO, Rome, Italy.

Ramamasy, S. (2007). *Climate variability and change:* Adaptation to Drought in Bangladesh. A Resource Book and Training guide (FAO).

Rathore, &. Venkataraman, R. (2007*). Weather and climate forecasts for agriculture. In WMO Guide to Agrometeorological Practices* (ed. Das, H.P.and K. Stigter). 3rd Edition (WMO-No.134) World Meteorological Organization (Switzerland)

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

Regis, C. (2006*). An assessment of the effectiveness of school guidance and counselling Services in Zimbabwean secondary schools*. University of south Africa.

Republic of Kenya (2004). *Small Scale Horticulture Development Project*. Appraisal report. African Development Fund.

Republic of Kenya (2007). *Small Scale Horticulture Development Project*. Appraisal report. African Development Fund.

Roebber, P. J., & L. F. Bosart. (1996). The complex relationship between forecast skill and forecast value: A real-world comparison. *Wea. Forecasting, 11, 544–559.*

Roger Blench. (1999). Seasonal climatic forecasting: who can use it and how should it be disseminated? *Natural resource perspectives number 47*, November 1999 issn: 1356–9228

Romisio, G., A. Garcia, & R. Nieto (2007). Climate and weather risk assessment for Agricultural planning. *In guide to agrometeorological practices*. (Ed. Stigter K.). 3rd Edition (WMO-No.134) World Meteorological Organisation (Switzerland).

Roncoli, C, Just C., Kirshem, P. & Hongerboom, G. (2009) *Risk management and social learning in farmers response to seasonal climate forecast in three agro-*

ecological zones of Burkina Faso. In American Association of geographer. August meeting, Denever, Colorado

Roncoli, C., Ingram, K., & Kirshen, P. (2002). *Reading the rains: Local knowledge and Rainfall forecasting among farmers of Burkina Faso.* Society and Natural Resources, 15: 411–430

Roncoli, C., Jost, C., Kirshen, P., Sanon, M., Ingram, K.T., Woodin, M., Somé, L., Ouattara, F., Sanfo, B.J., Sia, C., *et al*. (2009). From accessing to assessing forecasts: An end-to-end study of participatory climate forecast dissemination in Burkina Faso (West Africa). *Climatic Change 92, 433–460*.

Roncoli, C., Just C., Kirshem, P., & Hongerboom, G. (2009) *Risk management and social learning in farmers response to seasonal climate forecast in three agro-ecological zones of Burkina Faso*. In American Association of geographer. August meeting, Denever, Colorado

Roncoli, M. C., Ingram K.T., Jost, C., Kirshen, P.H., & Yaka, P. (2001). *"Farmers' behavioral responses to seasonal rainfall forecasts in the Sahel-Sudan." Department of Crop and Soil Sciences*, The University of Georgia

Salack, S. (2011*) Intra-seasonal to seasonal variability of simulated rainfall in the perspectives of agricultural impact assessment studies for the Sahel*. M. Sc. Research Dissertation, University Cheikh Anta Diop of Dakar, Senegal. p. 60

Salack, S. B., & Muller, A.G. (2011). Rain-based factors of high agricultural impacts over Senegal. *Part I: integration of local to sub-regional trends and variability. Theoret. Appl. Climatol., 106 (2011), pp. 1-22*

Salack, S. B., & Muller, A.G. (2011). Rain-based factors of high agricultural impacts over Senegal. *Part I: integration of local to sub-regional trends and variability. Theoret. Appl. Climatol., 106 (2011), pp. 1-22*

Sarewitz, D., R. A. Pielke Jr., & R. Byerly, (Eds). (2000). Prediction: Decision-making and the Future of Nature. Island Press, 405 p

Schultz, T. W. (eds) (1982). *Investing in people University of California Press*, Berkeley farmer decision-making: Implications for adaptation policy and practice in developing countries. *Land Use Policy, 59, 329–343 Meteorological Applications 13- 7-20.*

Sci-Tech-Encyclopedia (2005). McGraw-Hill. http:// www.answers.com / topics on the Agricultural meteorology. (Accessed on 05/05/ 2016)

Seo, N., Mendelsohn, R. (2008). Animal husbandry in Africa: Climate change impacts and adaptations. Afr. J. Agr. *Resour. Econ.* ***.*** *2, 65–82.*

Shiferaw, B. & Holden, S. (1998). *Resource degradation and adoption of land conservation technologies in the Ethiopian highlands*. Agricultural Economics 27, 739-752

Shoko .K. & Shoko, N. (2011). A comparative analysis of perception of levels of accuracy for indigenous weather forecast and meteorological forecasts: the case of ward 12 and 13, Mberengwa district, Zimbabwe

Singh, C., Dorward, P., & Osbahr, H. (2016). Developing a holistic approach to the analysis of farmer decision-making: Implications for adaptation policy and practice in developing countries. *Land Use Policy, 59, 329–343*

Sivakumar, M., (2006). Climate prediction and agriculture: current status and future challenges. *Clim. Res. 33, 3–17.*

Sivakumar, M.V. (2006). Dissemination and communication of agro meteorological information global -perspective. *Meteorological Applications 13: 21-30.*

Skees, J.R., Hazell, P., & Miranda, M. (1999). *New approaches to crop yield insurance in developing countries*, EPTD Discussion Paper No. 55.

Smucker, T. (2003). *In search of the sustainable miracle: land reforms, agricultural intensification and changing livelihoods in semi-arid Tharaka, Kenya (PhD thesis, Michigan University*, (USA), ProQuest Information and Learning Company, USA

Smucker, T., & Wisner, B. (2008). Changing household responses to drought in Tharaka, Kenya: Vulnerability, persistence and challenge. *Discussion*, *32(2),* 190-215

Southgate, C. & Hulme, D. (2000). *Uncommon property: The Scramble for Wetland in*

Agrometeorological Practices. (Ed. Stigter K.).3rd Edition (WMO-No.134) World Meteorological Organization (Switzerland).

Speranza, C. I., Kiteme, B., & Wiesmann., U. (2010*). "Droughts and famines: the underlying factors and the causal links among agro-pastoral households in semi-arid Makueni district, Kenya."* Global Environmental Change 18(1): 220-233

Sterm, P., & W., Easterling (Eds). (1999). *Making climate forecast matter*. Washington D.C: National Research council, National Academy Press.

Stigter, C., Mohammed, A.E., Nasr Al-amin, N.K., Onyewotu, L., Oteng'i, S., & Kainkwa, R. (2002). "Agroforestry solutions to some African wind problems." *Journal of wind engineering and industrial aerodynamics* 90(10): 1101-1114.

Stigter, C.J. (2002). The establishment of needs for climate forecasts and other agromet information for agriculture by local, national and regional decision-makers and users communities *AGM-7/WCAC-1, WMO/TD-No. 1223, 76-83* World Meteorological Organization Geneva, Switzerland

Strachan, K. (2008). Predicting weather with science and spider webs. The IUCN World Conservation Congress.http://www.ipsterraviva.net/tv/IUCN2008/ currentNew. aspx?new=1224. (Accessed on 17/01/2016)

Strachan, K. (2008). *Predicting Weather with Science and Spider Webs*. The IUCN World Conservation Congress. http://www.ipsterraviva.net/tv/ IUCN2008/ current New.aspx?new=1224. (Accessed on 01/04/2017)

Sultan, B., Barbier, B., Fortilus,J., Mbaye,S.M., & Leclerc,G. (2010). Estimating the potential economic value of the seasonal forecasts inWest Africa: A long-term ex-ante assessment in Senegal. Weather *Clim. Soc. 2, 69–87.*

Syngenta East Africa. (2010). Kilimo Salama. http://www.syngentafoundation.org/

Tarakidzwa, I. (2007). *Use and dissemination of seasonal climate forecasts in agricultural production in Africa* CagM Report No. 102, WMO/TD No. 1344, 29-40 WorldMeteorological Organization Geneva, Switzerland

Traore, S.B., Ali, A., Tinni,S.H., Samake, M., Garba,I., Maigari, I., Dieye, P. O. (2014). Agrhymet: A drought monitoring and capacity building center in the West Africa *Weather and Climate Extremes, 3,22 –30*

Traoré P.C.S., Kouressy, M., Vaskmann, M., Tabo, R., Maikano, I., Traoré S.B., & Cooper P. (2014). *Climate prediction and agriculture*: What is different about Sudano Sahelian West Africa? In Sivakumar M V K and Hansen J eds *Climate prediction and agriculture: advances and challenges* World Meteorological Organization 189-203

Traoré P.C.S., Kouressy, M., Vaskmann, M., Tabo, R., Maikano, I., Traoré S.B., & Cooper P.(2007). *Climate prediction and agriculture*: What is different about Sudano Sahelian West Africa? In Sivakumar M V K and Hansen *J eds Climate prediction and agriculture: advances and challenges* World Meteorological Organization 189-203

Thornton, P.K. (2006). *Ex ante impact assessment and seasonal climate forecasts:* Statusand issues. *Clim. Res. 33, 55–65.*

Uddin, M *et al*. (2014). Factors affecting farmer's adaptation to environmental degradation and climate change effects: A farm level study in Bangladesh. *Climate, 2,* 223-241UNDP/UMO (2000). Coping with drought in Sub-Saharan Africa: Better use of climate information. In WMO/TD 1035 Geneva: UN Development programme and world meteorological organization

United Nations Development Program (UNDP) (2004). Enhanced Security Unit. Kenya

Natural Disaster Profile. http://mirror.undp.org/kenya/Kenya Disaster Profile.pdf. (Accessed on 25/5/2016)

United Nation Environment Programme (UNEP) (2006*). Indigenous knowledge in Disaster Management in Africa Nairobi, Kenya*

Unganai, L.S. (2000). *Application of long range rainfall forecasts in agricultural farm*
Management: a review of Africa's experiences. Proceedings of the International Forum on Climate Prediction, Agriculture and Development, International Research Institute for Climate Prediction.

Urombo, K. (2000). *Ethics in counselling (Module CD 104*). Harare: Zimbabwe open University.

USWRP., (2001). *Report of the USWRP workshop on the weather research needs of the Private sector,* December 2000. USWRP, 42 pp.

Vinocur, M.G., Andrea V. R. & Roberto A. S. (2001*). Current status and future uses of the climate information in the agricultural system of central Argentina*. Paper prepared for Open Meeting of Global Environmental Change Research Community 6-8 October 2001, Argentina

Vogel, C. & O'Brien, K. (2006). Who can eat information? Examining the effectiveness of seasonal climatic forecasts and regional climate-risk management strategies. *Climate research 33-111-122*

Wandiga, S. (2008). *Preparing for Climate change in Kenya. Increasing community resilience to drought in Makueni District*. Nairobi, Government printers.

Walker, S., Mukhala E., van den Berg, J., & Manley C. (2001). *Assessment of Agro-Communication and use of climate outlooks and development of scenarios to promote food security in the Free State Province of South Africa.* Department of Agro meteorology, University of the Free State, Bloemfontein

Warren, D. M. (1999). *The role of indigenous knowledge in facilitating the agricultural extension proces*s. Paper presented at International Workshop on Agricultural Knowledge Systems and the Role of Extension. Bad Boll, Germany.

Warren, D. (1999). *Indigenous knowledge, biodiversity conservation and development.* Nairobi, Kenya.

Warren, D., L. Slikkerveer & D. Brokensha (1995). "*The cultural dimension of development:* indigenous knowledge systems."

Weiss, A., Van Crowder, L. & Bernardi, M. (1999). *Communicating agrometeorological information to farming communities.* Agric. Forest. Met. 103: 185–196.

World Bank. 2004. World Development Report 2004: *Making Services Work for Poor People*. World Bank

World Bank. 2009. World Development Report 2009: *Reshaping Economic Geography*. World Bank.

WMO, (2013) GFCS – Intergovernmental Board on Climate Services. *Special Bulletin 62*.

Zievogel, G., & Zermoglio, F. (2009). Climate change scenarios and the development of adaptation strategies in Africa: Challenges and opportunities. *Climate research*, *40*, 133-146

Ziervogel, G., Bharwani, S., & Downing, T.E. (2006). Adaptation to climate variability: pumpkins, people and pumps. Natural Resources Forum 30, 294-304.

Ziervogel, G., Bithell, M., Washington, R., & Downing, T. (2005). *Agent-based social Simulation:* A method for assessing the impact of seasonal climate forecast applications among smallholder farmers. *Agric. Syst. 83, 1–26.*

APPENDICES

APPENDIX A:

QUESTIONNAIRE

TITLE:

Access and Utilization of Seasonal Climate Forecasting data among Smallholder Farmers in Masinga Sub County, Machakos County Kenya.

Dear respondent,

I am a M.A student at Chuka University and currently carrying out a field research in Masinga Sub County. The focus of the research is on the "**Access and Utilization of Seasonal Climate Forecasting data among Smallholder Farmers in Masinga Sub County, Machakos County Kenya**." Kindly respond to the questions as accurately as possible to make this research a success. The information you provide will be treated with utmost Confidentiality and will be used for academic purposes only.

Yours sincerely,

Gideon Kyalo Masesi.

Identification Number (code) ____

Location____

Date of interview___________________________________

HOUSEHOLD INFORMATION

PART 1

1.1 languages spoken. ____

1.2 Primary occupation

[1] Farmer [ ]

[2] Employed (outside agriculture) [ ]

[3] Employed (agriculture) [ ]

[4] Own business (outside agriculture) [ ]

[5] Unemployed [ ]

[6] Retiree [ ]

[7] Student [ ]

1.3 What is your position in the household?

[1] Husband [ ]

[2] Wife [ ]

[3] Child [ ]

1.4 What is the gender of household head?

[1] Male [ ]

[2] Female [ ]

1.5 What is the age of the household head? ________________________________

1.6 Marital status

[1] Married [ ]

[2] Single [ ]

[3] Divorced [ ]

[4] Widowed [ ]

1.7 languages spoken. ____

1.8 Educational level of household head.

[0] No formal education [ ]

[1] Can read and write [ ]

[2] Primary school [ ]

[3] Secondary school [ ]

[4] Technical college [ ]

[5] University [ ]

1.9 Primary occupation

[1] Farmer [ ]

[2] Employed (outside agriculture) [ ]

[3] Employed (agriculture) [ ]

[4] Own business (outside agriculture) [ ]

[5] Unemployed [ ]

[6] Retiree [ ]

[7] Student [ ]

1.10 Major source of income

[1] Off farm [ ]

[2] On farm [ ]

PART 2: HOUSEHOLD FARMING DECISION MAKING

2.1 Who makes decisions on farming?

[1] Household head [ ]

[2] Spouse [ ]

2.2 What is the gender of the decision maker?

[1] Male [ ]

[2] Female [ ]

2.3 What is the age of the decision maker (years) ________________

2.4 What is his/her main occupation? State income from each and note the main source

[1.] Farming [ ]

[2.] Business (non-farming) [ ]

[3] Employed [ ]

2.5 What is the total average monthly income of the household?

[1.] Below Kshs. 10,000 [ ]

[2.] Kshs. 10,001-20,000 [ ]

[3.] Kshs. 20,001- 30,000 [ ]

[4.] Kshs 30,001-40,000 [ ]

[5.] Kshs. Above 40,000 [ ]

PART 3: FARMER FORECASTS INFORMATION REQUIREMENTS

3.1 Average farm size____

3.2 Types of crops grown

	Crop Name	Time of Year	Average income/crop/year
[1]			
[2]			
[3]			
[4]			
[5]			
[6]			
[7]			
[8]			

3.3 Are you a member of any social or agricultural group?

[1] Yes [ ]

[2] No [ ]

If yes name the group(s)____

3.4 If so how often do you attend meetings?

[0] Not a member [ ]

[1] Sometimes [ ]

[2] One a week [ ]

[3] More than once a week [ ]

3.5 Forecast information needed by farmers

Forecast information useful for farmers	Information access	Information use
1. Agro Forecast information	[0] not at all [1] sometimes [2] when I look for it [3]highly accessible	[0] not at all [1] sometimes [3]make decisions always
2. Onset date of the main rains		
3. Quality forecast of the rainy season (rainfall amount)		
4. Cessation date of the main rains		
5. Timing and frequency of active and dry periods (wet and dry spells)		
6. Agronomic recommendations in terms of which crop varieties to grow and so on		

3.6 With respect to rainfall forecasts explain briefly what you understand by the terms “Normal”, “Near normal” and “Below normal” rainfall

Forecast term	Explanation
Below normal Rainfall	Extremely high rainfall [ ] High rainfall [ ] Moderate rainfall [ ] Low rainfall [ ] Don’t know [ ]
Near Normal rainfall	Extremely high rainfall [ ] High rainfall [ ] Moderate rainfall [ ] Low rainfall [ ] Don’t know [
Above normal rainfall	Extremely high rainfall [ ] High rainfall [ ]

	Moderate rainfall [ ] Low rainfall [ ] Don't know [ ]

3.7 State the various farm decisions that might be influenced by the following forecasts

Above average rainfall	Normal rainfall	Below average rainfall

3.8 Perception of scientific climate forecasts

[0]	Not reliable	[ ]
[1]	Sometimes	[ ]
[2]	Always reliable	[ ]
[3]	Does not understand them	[ ]

3.9 Do you use traditional methods of climate forecasting?

[1] Yes [ ]

[2] No [ ]

If yes which traditional methods do you use for climate forecasts?

[1]	
[2]	
[3]	
[4]	
[5]	
[6]	
[7]	
[8]	
[9]	
[10]	

4.0 Perception of scientific climate forecasts

[0]	Not reliable	[ ]
[1]	Sometimes reliable	[ ]
[2]	Always reliable	[ ]
[3]	Does not understand them	[ ]

PART 4: SOURCES OF CLIMATE FORECASTS AND ACCESS TO DISSEMINATION CHANNELS.

4.1 Do you have any access to climate forecast information?

[1] Yes [ ]

[2] No [ ]

4.2 What type of climate information do you have access to?

[1] Start of rain [ ]

[2] Wind [ ]

[3] End of rain [ ]

[4] Floods [ ]

[3] Amount of rainfall [ ]

[5] Drought occurrence [ ]

[6] Other (specify____)

4.3 Source of information

[1]	Meteorological department	[ ]
[2]	Consultant Rainmaker	[ ]
[3]	Radio	[ ]
[4]	Internet	[ ]
[5]	News Papers	[ ]
[6]	Agricultural/Extension Officers	[ ]
[7]	KALRO	[ ]
[8]	Television	[ ]
[9]	Observations	[ ]
[10]	Other sources	[ ]
[11]	NGOs working in the area	[ ]

4.4 Dissemination channel

	Access	Frequency	Accuracy	Packaging of information

Media	[0] no [1] sometimes [2] yes	[1] daily [2] weekly [3] monthly [4] seasonal	[1] very effective [2] moderate [3] not effective	[1] simple language [2] difficult language [3] difficult to understand
Radio				
TV				
Internet				
Phone/mobile				
Newspaper				
Extension services				
Bulletins				
Friends / family members				
Chiefs Barraza's				

4.5 How would you like to receive climate forecast information in future?

____

____

____

____

From the climate information source mentioned above, which one do you consider most reliable and adequate?

____

____

____

PART 5: FACTORS AFFECTING ACCESS TO AGRO METEOROLOGICAL INFORMATION

5.1 Do the following affect your access to climate forecast information?

Factor	[1] Yes	[2] No
Language of dissemination		
Time of dissemination (Time during the day)		
No radio/TV		
No access to internet		
Inadequate extension		
Print media arrive late		

5.2 What time is the climate report on radio/TV? ________________________________

5.3 Are you able to listen at that time?

[1]	Yes	[ ]
[2]	No	[ ]

PART 6: USE OF FORECASTS IN DECISION MAKING

6.1 Please characterize your use of the following by selecting what applies to you

I am User of:

[1] Seasonal Climate Forecasts [ ]

[2] Indigenous Forecasts [ ]

[3] Seasonal Climate Forecasts & Indigenous Forecasts [ ]

[4] None of the Above [ ]

Type of information I use is:

[1] Daily forecasts [ ]

[2] Weekly forecasts [ ]

[3] 10 day forecasts [ ]

[4] Monthly forecasts [ ]

[5] Seasonal forecasts (3 month) [ ]

[6] Other [ ]

6.2 How long have you been using the forecasts or your choice(s) in 6.1 above?

[1] Less than 5 years [ ]

[2] Last 5 years [ ]

[3] Over 5 years [ ]

6.3 Why did you use the forecasts?______________________________________

____

____

6.4 In your opinion, how best would you describe the accuracy of the forecasts you have been using

[1] Extremely accurate [ ]

[2] Accurate [ ]

[3] Not accurate [ ]

[4] Don't know [ ]

6.5 How satisfied are you with the forecasts you have been using?

[1] Very satisfied [ ]

[2] Moderately satisfied [ ]

[3] Very unsatisfied [ ]

[4] Don't know [ ]

6.6 Do your neighbours make use of forecasts in farm decisions?

[1] Yes [ ]

[2] No [ ]

[3] Don't know [ ]

6.7 Is there anything you would like to suggest regarding the use of forecasts? (E.g. Constraints etc.)

____

____

____

____

6.8 Do you wait for forecasts to decide on which crop to grow?

[1]	Yes	[ ]
[2]	No	[ ]

6.9 When do you make decisions to plant?

[1]	After receiving forecasts	[ ]
[2]	Follow usual season	[ ]
[3]	Wait for rains	[ ]
[4]	Use traditional forecasts	[ ]
[5]	Follow neighbours	[ ]

7.0 Do the following factors affect your adoption of climate forecast information?

Factor	**[2] Yes**	**[1] No**
Size of land		
Irrigation facility		
Labour		

Draft power		
Access to appropriate seed		
Income		
Inaccuracy of forecast		
Forecast not detailed enough for decision making		
Forecast not disseminated on time		

7.1 Does climate forecasts and information influence your crop related decisions?

[1] Yes [ ]

[2] No [ ]

[3] Don't know [ ]

7.2 Judging from experience, letting climate forecasts and information influence your crop related decisions has been:

[1] Extremely useful [ ]

[2] Useful [ ]

[3] Not useful [ ]

Thank You

APPENDIX B

EXTENSION OFFICERS INTERVIEW GUIDELINES

Key Informant Interview Guide for the District Extension Officers

"Access and Utilization of Seasonal Climate Forecasting data among Smallholder Farmers in Masinga Sub County, Machakos County Kenya"

Dear respondent,

I am a M.A student at Chuka University and currently carrying out a field research in Masinga Sub County. The focus of the research is on the "**Access and Utilization of Seasonal Climate Forecasting data among Smallholder Farmers in Masinga Sub County, Machakos County Kenya."** Kindly respond to the questions as accurately as possible to make this research a success. The information you provide will be treated with utmost CONFIDENTIALITY and will be used for academic purposes only.

Yours sincerely,

Gideon Kyalo Masesi.

Identification Number (code) ________________________

Station____

Date of interview__________________________________

1. What organizations in collaboration with your department are involved in helping small scale farmers in in Masinga Sub county achieve access to climate forecast information?

____

____

____

2. Has the cliiimate forecasts had positive impacts towards achieving household food Security?

____

____

____

____

3. What form of education do you offer to the rural farmers?

____

____

4. Are climate forecasts efficient and effective?

____

____

____

____

5. Do farmers consult about climate and forecasts in your offices? If yes what information do they regularly seek?

____

____

____

____

6. Which are the popular indigenous strategies used in climate forecasting in this area

7. Comparing indigenous and conventional knowledge of climate forecasting, which one is more preferred and why?

8. The year 2011 was a severe drought year in Kenya in the recent times.

i) Were farmers in your area affected by this drought? (Provide some evidence, yields, market prices etc.)

ii) Do you remember any other similar drought or extreme events (floods, pests etc.) in your area? Please list as much as you can remember and explain how it affected your farming activities.

9. Are the forecasts you give to farmers accurate? Discuss how you determine the accuracy in the forecast

10. Are there any obstacles or constraints you have experienced regarding use of forecasts in your area? Please list or explain.

____

____

____

____

11. Are you able to tell whether climate forecasts are used by farmers to make decisions? If yes explain how?

____

____

____

____

12. Do you have any other suggestions you want to discuss regarding use of forecasts?

____

____

____

____

======================END========================

THANKYOU.

APPENDIX C

RELATIONSHIP BETWEEN LEVEL OF SATISFACTION AND UTILIZATION OF SCIENTIFIC FORECASTS

Chi square tests			
	Value	**Df**	**Asymp. Sig. (2-sided)**
Pearson Chi Square	20.778	4	.000
Likelihood Ratio	16.848	4	.001
Linear -by -linear Association	4.445	1	.002
N of valid cases	274		

APPENDIX D

CORRELATION BETWEEN FACTORS AFFECTING ADOPTION OF CLIMATE FORECAST INFORMATION AND USE OF FORECAST

Variable	Pearson Correlation Coefficient	Significance
Size of land	.141*	.034
Irrigation facility	.226*	.024
Labour	.118	.105
Draft power	.181	.072
Access to appropriate seeds	.196	.061
Income	.127**	.000
Inaccuracy of forecasts	.298**	.000

Forecasts not detailed enough	.279**	.001
Late dissemination of forecasts	.166**	.008

** Significant at 0.01 level * significant at 0.05 level

APPENDIX E

CHUKA UNIVERSITY ETHICS LETTER

CHUKA UNIVERSITY

Telephones: 020 2310512
020 2310518

P.O. Box 109
Chuka

CHUKA UNIVERSITY

OFFICE OF THE CHAIRMAN
INSTITUTIONAL ETHICS REVIEW COMMITTEE

Our Ref: CU/IERC/NCST/17/05 15th February, 2017

THE CHIEF EXECUTIVE OFFICER
NATIONAL COMMISION FOR SCIENCE, TECHNOLOGY AND INNOVATION
P.O. BOX 30623-00100
NAIROBI

Dear Sir/Madam,

RE: RESEARCH CLEARANCE AND AUTHORIZATION FOR GIDEON KYALO MASESI REG NO AM15/19006/14

The above matter refers:

The Institutional Ethics Review Committee of Chuka University met and reviewed the above MA Research Proposal titled; **Access and Utilization of Weather Forecasting Data by Farmers in Masinga Division Machakos County, Kenya"** The Supervisors are **Prof. Stephen Wambugu and Dr. Dr. Charles Recha**

The committee recommended that after candidate amends the issues highlighted in the Attached research clearance and authorization check list, the permit be issued.

Attached please find copies of the minutes, research clearance and authorization check list for your perusal. Kindly assist the student get the research permit.

Yours faithfully,

Prof. Adiel Magana
CHAIR
INSTITUTIONAL ETHICS REVIEW COMMITTEE
cc: BPGS

APPENDIX F

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

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2241349,3310571,2219420
Fax:+254-20-318245,318249
Email:dg@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/17/90009/16383**

Date: **27th March, 2017**

Masesi Gideon Kyalo
Chuka University
P.O. Box 109-60400
CHUKA.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Access and utilization of weather forecasting data by Farmers in Masinga Division, in Machakos County, Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Machakos County** for the period ending **27th March, 2018.**

You are advised to report to **the County Commissioner and the County Director of Education, Machakos 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.

BONIFACE WANYAMA
FOR: DIRECTOR-GENERAL/CEO

Copy to:

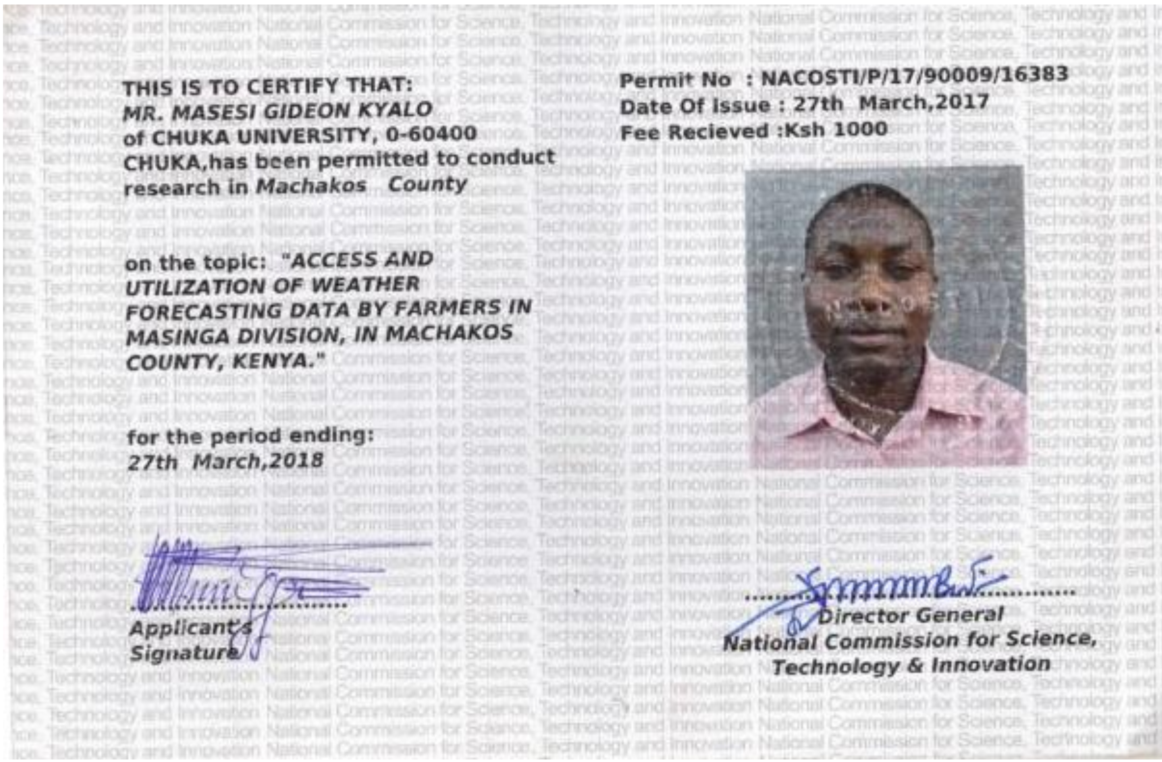
The County Commissioner
Machakos County.

The County Director of Education
Machakos County.

NACOSTI RESEARCH AUTHORIZATION

APPENDIX G

NACOSTI RESEARCH PERMIT



THIS IS TO CERTIFY THAT:
MR. MASESI GIDEON KYALO
of CHUKA UNIVERSITY, 0-60400
CHUKA,has been permitted to conduct
research in *Machakos County*

on the topic: *"ACCESS AND UTILIZATION OF WEATHER FORECASTING DATA BY FARMERS IN MASINGA DIVISION, IN MACHAKOS COUNTY, KENYA."*

for the period ending:
27th March,2018

Permit No : NACOSTI/P/17/90009/16383
Date Of Issue : 27th March,2017
Fee Recieved :Ksh 1000

....
Applicant's
Signature

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