DETERMINANTS OF ACCESS AND USE OF CLIMATE INFORMATION SERVICES AMONG SMALLHOLDER FARMERS IN MAKUENI COUNTY, KENYA

EMILY MBAIKA MUEMA

A thesis submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in Agricultural and Applied Economics, University of Nairobi

November 2018

DECLARATION

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

Emily Mbaika Muema A56/83705/2015

Signature………………………….. Date………………………….

Approval:

This thesis has been submitted with our approval as supervisors:

Prof. John Mburu

Department of Agricultural Economics

University of Nairobi

Signature……………………………… Date…………………………………….

Dr. Jeanne Coulibaly

World Agroforestry Centre, Nairobi

Signature……………………………… Date…………………………………

Dr. Jane Mutheu Mutune

Wangari Maathai Institute for Peace and Environmental Studies

University of Nairobi

Signature……………………………… Date…………………………………

ACKNOWLEDGEMENT

Foremost, I am grateful to the Almighty God for good health, wisdom and provision. My gratitude also goes to my supervisors; Prof. John Mburu, Dr. Jeanne Coulibally, Dr. Jane Mutune for their continued support and timely feedback during the entire study period. Moreover, I acknowledge the Agricultural Economic Research Consortium (AERC) and the Government of Kenya for sponsoring my studies and research work.

The University of Nairobi and International Livestock Research Institute (ILRI) Info center were also very resourceful in providing literature sources and internet for my study. I also appreciate Ms Marygoretti Simon, Ms Aidah Chausiku, Mr Simon Munyasya, Mrs Serah Mutindi, Ms Catherine Manthi and Ms Mary Mueni who assisted in data collection, Makueni County Agricultural officer, area chiefs and village elders for their assistance in area logistics and data collection and the respondents who participated in the survey.

Lastly, I am indebted to my husband Zacheus Kuria and my entire family for their continued support during my study.

DEDICATION

I dedicate this thesis to my husband Zacheus Kuria Mungai, Son Israel Mungai Kuria, my parents; Justus Muema, Eve Muema, Joseph Mungai and Margaret Mungai and siblings.

ABSTRACT

Globally climate change has been a major constraint towards achieving food security, poverty reduction and sustainable agricultural development. Therefore, adaptation to climate change is imperative to reduce farmers' vulnerability to climate-related risks. Climate information services have been recommended as prerequisite tools towards the adoption of adaptation strategies to curb climate vagaries in Africa. While the production and provision of climate information services (CIS) in Kenya has increased, their accessibility and application in farm decision making against climate risks have been limited. Although addressing the various constraints that limit the use of this information could increase farmer's adaptive capacity, the factors that affect both access and use of CIS in arid and semi-arid areas of Kenya have not been comprehensively documented. Therefore, this study analysed the determinants of access and the utilisation of CIS among smallholder farmers in Makueni County. Primary data was collected using semi-structured questionnaires administered on 250 households. Descriptive statistics were used to analyse the socio-economic characteristics of smallholder farmers, the various climate information services accessed, their dissemination channels and usefulness in farm decision making. Heckprobit model was used to analyse both the determinants of access and use of CIS in farm decision making. The results showed that majority of households interviewed relied on mixed farming as the main source of livelihood. 77.4 percent of households interviewed had access to climate information services and radio was the main dissemination channel followed by television and newspapers. The main climate information services accessed by farmers were seasonal climate information, the forecast of extreme events and indigenous forecast. Seasonal climate information services were considered most useful in farm decision making against climate-related risks. Among the households that accessed CIS, only 40.4 percent utilised it. Majority of farmers who did not utilise climate information confirmed that lack of trust was the main constraint. The results of the selection equation of Heckprobit model showed that age of household head reduced the likelihood of access to CIS while monthly income, television ownership, major income activity, household size, farm size and group membership increased the likelihood of access to CIS. On the other hand, the results of outcome equation showed that age, gender and frequent exposure to drought reduced the likelihood of using CIS while monthly income, radio ownership, major income activity and access to improved seed increased the likelihood of using CIS in farm decision making. The high level of access to climate information services among the farmers interviewed implied that there is a high potential for timely and reliable information to enhance climate-informed farm decisions. To enhance farmer's trust in climate information services, the providers should ensure that the information is accurate and incorporate it with the indigenous knowledge that farmers have previously been using. The findings of this study also suggest that the provision of improved seed at subsidized prices would increase farmers' utilisation of climate information services. Additionally, promotion of farmer groups to ensure the flow of climate information and discussions among smallholder farmers would increase the access of CIS.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACMAD	African Centre for Meteorological Application and Development
ASAL	Arid and Semi-Arid Lands
CIS	Climate Information Services
CCAFS	Climate Change Agriculture and Food Security
CGIAR	Consultative Group for International Agricultural Research
GoK	Government of Kenya
GHA	Great Horn of Africa
GHG	Greenhouse Gas
GHACOF	Greater Horn of Africa Climate Outlook Forum
GDP	Gross Domestic Product
GFCS	Global Framework for Climate Services
ICPAC	IGAD Climate Prediction and Application Centre
IPCC	Intergovernmental Panel for Climate Change
NCCAP	National Climate Change Action plan
NCCRS	National Climate Change Response Strategy
NMAs	National Meteorology Agencies
NMHS	National Meteorological and Hydrological Services
SCIS	Seasonal Climate Information Services
UN	United Nations
WMO	World Meteorological Organisation

CHAPTER 1: INTRODUCTION

1.1 Background

Negative impacts of climate change pose a far-reaching threat to global social, economic and ecological systems. According to the Intergovernmental Panel on Climate Change (IPCC), annual temperatures in Africa have increased steadily by 0.5 degrees Celsius with the drier subtropical regions warming more compared to moist tropics (Eriksen and Rosentrater, 2008). The increase in temperature in Sub-Saharan Africa is higher compared to global mean temperature increases which are accompanied by a decline in precipitation levels in some regions (IPCC 2007). These changes amplify water scarcity and unprecedented threats to the region's rain-fed agriculture which is the main source of livelihood and major contributor of the Gross Domestic Product (GDP) (World Bank, 2007; World Bank, 2016).

Africa is more prone to harsh impacts of climate change such as drought compared to other continents. This is because more than 70 percent of people living in arid and semi-arid areas have low adaptive capacity and are highly dependent on natural resources and rain-fed agriculture for livelihood (Kirui et al., 2012). This will result in competition for resources, food insecurity, heightened poverty levels and food price shocks. The International Panel on Climate Change has predicted a 50 percent decline in rain-fed agriculture yields by 2020 and 90 percent drop in crop net revenues by 2100 in Africa (IPCC, 2007). Moreover, Schlenker and Lobell (2010) predicted 8 to 22 percent decline in maize, sorghum, millet, groundnut and cassava production by 2050 attributed to climate change.

Persistent climate-related risks constrain socio-economic development in Africa's agro-based economies which are dependent on rain-fed agriculture for domestic food, raw materials for industries and employment. Boko et al. (2007) reported that negative impacts of climate change on agriculture will result in 2 to 7 percent decline in contribution of agriculture to

GDP in Sub-Saharan Africa by 2100. Similar to the majority of Sub-Saharan Africa countries, Kenyan agriculture plays a central role in the economy whereby it contributes a third of GDP, 75 percent employment and 65 percent of export earnings (World Bank, 2016). Following the challenges of sustainable economic growth in the face of climate change, Kenya launched the National Climate Change Response Strategy (NCCRS) in 2010 and Kenya National Climate Change Action plan (NCCAP 2013-2017) in 2013 to enhance resilience and adaptation to climate change.

Action against climate change and its impacts are one of the Sustainable Development Goals (SDGs) of the United Nation. Adaptation is a response strategy which entails adjustments to enhance preparedness and response to current and future climate change adversities. Adaptation measures reduce farmer's vulnerability to negative impacts of climate change (Thornton et al., 2006). Vulnerability to impacts of climate change depends on exposure, sensitivity and adaptive capacity of societies, ecosystems and economies affected. Variable adaptation options exist based on diversified agricultural practices which are determined by environmental variables and economic, institutional, cultural and demographic factors. The most appropriate adaptation options in Kenya are: adoption of drought-tolerant varieties, soil conservation, crop and livelihood diversification and use of climate information (Nganga, 2006).

One of the major barriers to effective adaptation to climate change is the lack of relevant climate information. According to Jones et al. (2000) and World Bank (2016), timely and accurate climate information of approximately three to six months prior to an adaptation initiative is a prerequisite for agricultural production and risk minimisation. Climate information entails the provision of daily, weekly, seasonal, medium and long-term projections on temperature and precipitation parameters, wind, soil moisture and ocean conditions. The climate information alone is not enough to influence farm decision since not all farmers can interpret the technical terms. Therefore, this information should be accompanied by meaningful agronomic advice to enable farmers to understand and use the forecast to manage climate risks (Kadi et al., 2011). Climate information with agronomic advice is referred to as climate information services which enable farmers to decide on the technologies and adaptation strategies favourable to respond to climate variability (Tall et al., 2014; Wood et al., 2014). These climate information services are important to smallholder farmers in Kenya, who are highly dependent on rain-fed agriculture to reduce their vulnerability to chronic impacts of climate change and enable them to capture the benefits associated to favourable climatic conditions.

In Kenya, the Kenya Meteorological Department is the national source of climate information services which are provided from a network of national weather stations on daily, weekly, monthly, seasonal and decadal timescales. It is also supported by international development agencies, Non-Governmental Organisations (NGOs), community-based organisations, private organisations and research institutions. Drought Monitoring Centre Nairobi (DMCN) that was formed in 1989 is a regional source of climate information and prediction products for ten countries in the Greater Horn of Africa (Singh et al., 2016). The climate information from DMCN entails prediction of onset and severity of rainfall and drought, socio-economic conditions and seasonal forecast which is offered twice a year. These climate information services are communicated through various dissemination channels that include radio, television, newspapers, mobile phone text messages, online, farmer workshops and agricultural extension agents.

Climate information and advisories are considered a useful tool in influencing farmer decisions to achieve sustainable agricultural production in the presence of climate change. However, the potential benefits can only be realized if the climate information services are accessible, accurate and relevant for decision making, the presence of institutional support to provision and actual use to manage climate risks (Hansen, 2002).

Although the provision of climate services in Kenya is promising, their access and application to manage climate risks is limited (World Bank, 2016). The government should not only lay emphasis on production of climate information but also on the holistic implementation of farm decisions to manage climate risk and reduce household vulnerability (Jones et al., 2000; Roncoli, 2006). Both access and use of climate information services are fraught with technical, social, economic and psychological challenges which compromise their benefits in climate change adaptation (Serra and Mckune, 2016). Therefore, understanding the socio-economic factors that inhibit access and use of climate services is imperative to enhance their application in farm decisions.

1.2 Statement of the Problem

Limited access and utilisation of climate forecast have been reported in Sub-Saharan Africa (Amissah-arthur, 2003; Vermeulen et al., 2011). Moreover, according to the Great Horn of Africa Climate Outlook Forum (GHACOF) 2010 report, Kenya has scanty integration of climate information in climate change adaptation. Inaccessibility of climate information services by smallholder farmers has been a major constraint in managing climate-related risks (Kiem and Austin, 2013).

According to Herrero et al. (2010), climate change not only poses negative effects on agriculture but has also positive impacts. For instance, increase in temperatures in the highlands overcome maize and beans growth constraints while in the arid and semi-arid areas it increases evapotranspiration which reduces soil moisture, thus resulting in reduced crop productivity. Therefore, access to location-specific climate services enhances farmers' decisions to mitigate negative impacts or take advantage of the benefits from the positive outcomes of climate change. This information should be readily available, accurate and useful to enable farmers to utilise it on their farms.

Access and use of climate information services are linked in that farmers need to access the information to utilise it in farm decision making. Provision of climate information services to farmers is not enough for climate change adaptation if not accompanied with actual utilization. Thus, an understanding of the socio-economic aspects that shape farmers ability to use CIS in farm risk management decisions is important (O'Brien et al., 2000).

Various studies have assessed the state of access and use of climate information in Africa using different methods. For instance, Mudombi and Nhamo (2014) used descriptives to analyse access to weather forecast in Zimbabwe, Oyekale (2015) used probit models to analyse factors explaining access and utilisation of extreme climate forecast in Sub-Saharan Africa and Coulibaly et al. (2017) used descriptive analysis to analyse the access and use of CIS in Rwanda. However, the findings of these studies are country specific and given the heterogeneity of the countries, the parameter estimates are of little importance to guide policymakers on ways to promote the application of climate information services in Kenya. Therefore, the need for more country specific studies and particularly Kenya where literature on CIS is still scarce.

1.3 Overall Objectives

The general objective of the study is to analyse the determinants of access and use of climate information services among smallholder farmers in Makueni County.

Specific Objectives

1. To characterise the climate information services accessed by smallholder farmers in Makueni County.

2. To analyse the usefulness of climate information services in farm management decisions.
3. To analyse the determinants of access to climate information services.
4. To analyse the determinants of the use of climate information services.

1.4 Research Questions

1. What are the characteristics of climate information services accessed by smallholder farmers?

2. How are climate information services useful in farm decision making?

3. What are the determinants of access to climate information services?

4. What are the determinants of use of climate information services?

1.5 Justification of the Study

Unpredictable weather parameters expose smallholder farmers in Africa to various uncertainties which compromise food and water security, income and health. This has negatively affected development efforts through redirection of planned resources to relief and recovery activities. Therefore, action against climate change is imperative to ensure sustainable economic development in Africa.

Application of climate information services in smallholder agriculture is limited in Kenya. One of the main constraints is lack of access to climate information and limited capacity to utilise this information in farm decisions against climate risks. This study analysed the characteristics of climate services accessed by farmers and the determinants of both access and use of the information. The findings from this study will provide insights to the national and county policymakers to address the various challenges that limit farmer's access and utilisation of climate information services. Moreover, this study will contribute to the call by IPCC to prioritize research that improves farmer's adaptive capacity in Africa.

Finally, the research findings have added on to existing literature on determinants of access and use of climate information services. This information will serve as a reference for other researchers who will study various aspects of climate information services.

CHAPTER 2: LITERATURE REVIEW

2.1 Climate change in Kenya

Climate change is a major constraint towards sustainable economic development in Kenya. Both minimum and maximum temperatures in Kenya have increased by a margin of 0.7 to 2.0 degrees Celsius since 1960s (Bernard et al., 2012). The increase in temperatures has been associated with global warming which has contributed to 20 percent of rainfall variability (Kabubo and Karanja, 2007). Temperature and rainfall variability have been linked to unpredictability in short and long rains, receding range lands threatening pastoralists livelihood, drought, food insecurity and reduced river volumes in arid and semi-arid lands (World Bank, 2015). Moreover, change in these climate parameters has resulted to increase in health risks, such as malaria, water-borne diseases, rift valley fever, dengue fever and tuberculosis.

Kenya is highly susceptible to impacts of climate change because of high dependence on rain-fed agriculture for livelihood and low adaptive capacity. The economy is highly dependent on agriculture which significantly contributes 26 percent directly and 25 percent indirectly to the national Gross Domestic Product (GDP). It is also a major source of raw materials for industries and source of livelihood contributing 18 percent to formal employment and food security for eighty percent of the total population (Bernard et al., 2012). According to the World Bank (2015) report, the agricultural sector growth has been below the stipulated target of 6 percent and this has resulted in a high reliance on food imports to feed the growing population.

Erratic rainfall and frequent droughts are the major climate shocks that constrain agricultural productivity in Kenya. The arid and semi-arid areas that occupy 80 percent of Kenya's total land area are more prone to these climate shocks (Herero et al., 2010). These areas support thirty percent of the country's population and seventy percent of livestock production (World

Bank, 2015). The increase in frequency of drought in these areas has resulted in increased crop failure and reduced herd sizes which aggravate food insecurity in these areas. Moreover, the intensification of agriculture in arid and semi-arid areas and conversion of rangelands to mixed cropping systems has resulted in competition for resources between agro-pastoralists and pastoral communities.

Climate change not only affects agriculture but also infrastructure, tourism, health and other agro-based industries. For instance, the transport industry is affected by frequent floods which prevent movement of commodities and people from one place to another. The agro-based industries are dependent on the agricultural output which is used as raw materials. Moreover, these sectors are dependent on hydroelectric power which is highly affected by frequent drought. The tourism sector is also affected by drought since the wildlife species starve to death due to lack of food and water.

Adaptation to climate change is imperative to address the impacts of climate change. According to IPCC (2007), adaptation entails natural or human adjustments to current or future climate change to reduce the negative impacts and benefit from positive ones. To enhance climate change adaptation and resilience the Kenyan government formed the National Climate Change Response Strategy (NCCRS) in April 2010. The primary focus of this strategy was to strengthen national climate change adaptation and mitigation action plans and integrate them in all national planning and development agendas. Moreover, the National Climate Change Action Plan (NCCAP) was formed to enhance implementation of adaptation and mitigation plans to reduce country's vulnerability to impacts of climate change. The NCCAP advocates for availability and accessibility of climate information to enhance short term and long-term climate change adaptation.

2.2. Climate information services

Climate information services are important tools in initiating climate change adaptation among smallholder farmers in Sub-Saharan Africa (Tall et al., 2014). Climate information entails a projection of short-term climate parameters such as daily weather forecast, monthly and seasonal forecast and long-term projections that include decadal, multi-decadal and centennial time scales (Wilkinson et al., 2015; Singh et al., 2016). Ambiguous climate information terminologies are not enough to influence farmers' decisions but should be interpreted and accompanied by advisory services tailored to meet farmers' needs. When climate information is accompanied by agronomic advice it is referred to as climate information services. The World Meteorological Organisation (WMO) defines climate services as the provision of climate information that is user driven for risk management decisions based on scientific knowledge and effective access mechanism (Graham et al., 2015). Crop choices, market access, plant protection and climate-smart agricultural practices are various types of additional information that should accompany climate information to enhance climate change adaptation (Tall et al., 2013).

Various categories of climate information products and services have been outlined over time. They include: a) Daily weather forecasts which outline predictions on temperate and rainfall variability to farmers on a daily basis. b) Decadal agro-meteorological bulletins which provide climate statistics on temperature, precipitation, relative humidity and wind for the last ten days and forecast for the next ten days for the entire country. Moreover, the bulletin contains a report on the stage of crop development, crop performance and the expected yield. c) Monthly climate outlook which reports temperature and precipitation variability for every climatological zone on a monthly basis. d) Seasonal climate outlook gives climate information to farmers and the public on various rainfall seasons in the year. This information entails the prediction on expected temperatures, crop performance, rainfall onset and cessation dates and their distribution throughout the season. It also gives seasonal information on the probability of occurrence of weather parameters in future. e) Climate alerts which are given when need arises. They entail timely information on climate extremes such as flood and drought and associated impacts based on previous events. f) Tailored information for users (farmers) which provide climate information on onset, cessation and distribution of rainfall accompanied by advice on choice of crops for different regions.

2.2.1 Sources of climate information services

In Kenya, provision of accurate meteorological information and services on a daily, monthly and seasonal basis is the mandate of Kenya Meteorological Department (KMD). According to a report by World Bank (2016), the private sector provides 27 percent of climate information services and this is followed by government agencies at 21 percent, Non-Governmental Organisations (NGOs) and community-based organisations (CBO) at 21 percent, Research institutions and academia at 17 percent and 14 percent from international organisations.

National Meteorological and Hydrological Services (NMHS), IGAD Climate Prediction and Application Centre (ICPAC), Global Framework for Climate Services (GFCS) and African Centre for Meteorological Application and Development (ACMAD) are various regional sources of climate information services in African. GFCS was spearheaded by World Meteorological Organisation (WMO) in partnership with United Nations High Level Task Force with the objective of not only providing climate information but also interpretation and advisory services on climate risk management decisions. GFCS in partnership with Climate Change Agriculture and Food Security (CCAFS) under Consultative Group on International Agricultural Research (CGIAR) and National Meteorology Agencies (NMAs) provide climate services to enhance disaster preparedness, increase in food security and better health in Malawi, Tanzania and rest of African continent (Kadi et al., 2011; Singh et al., 2016.).

African Centre of Meteorological Application for Development (ACMAD) is a Niger-based institution that provides short-term climate forecast and extreme events across Africa. ICPAC, on the other hand, provides climate monitoring and early warning predictions to countries in the Great Horn of Africa.

Smallholder farmers also rely on own developed indigenous seasonal forecasts developed from natural indicators (Vogel and Brien, 2006). Indigenous knowledge, also referred to traditional knowledge, is a body of knowledge built on observation of natural indicators by different communities over a period of time. This information is used for decision making in agriculture, medicine, food production and preservation, soil and water management (Roncoli and Ingram, 2002). The useful knowledge is passed from generation to generation and it varies from one community to another. Among the traditional knowledge used by local communities is indigenous climate forecast which was predicted through observation and interpretation of natural phenomena.

The various natural indicators observed for climate prediction were as follows: clouds, moon, stars, behaviours of animals and insects, flowering and shedding of leaves and direction and strength of the wind. For instance, the pastoral communities in Northern Kenya predicted the occurrence of drought by observing the dark intestines of slaughtered animals, clear sky without clouds very hot weather and shedding of leaves of some trees (Kagunyu, 2016). The Kamba community from Eastern Kenya associated appearance of certain birds such as sparrows, unusual flowering of certain trees, more fruit production and early shedding of leaves with drought occurrence (Speranza et al., 2010).

Although the majority of smallholder farmers in Sub-Saharan Africa rely on indigenous climate forecast for agriculture, this information is fraught with various challenges, for instance, the disappearance of various indicators, such as certain bird species and trees due to deforestation, the demise of older generation and lack of proper and systematic documentation (Chang'a et al., 2010; Ziervogel and Opere, 2010). Moreover, due to highly variable climate over the years, the local communities have lost confidence in indigenous forecast and hence seek scientific seasonal forecast for climate change adaptation (Tall et al., 2012). Both indigenous and scientific climate forecasts have various strengths and weaknesses. Therefore, a combination of both types of information is recommended to enhance farmer adaptation to climate change (Kirui et al., 2012; Russo et al., 2013).

2.3 Access and use of climate information services

2.3.1 Access to climate information services

Access to effective climate information services is expected to support climate-sensitive sectors cope better while improving resilience and livelihoods in Africa (Serra and Mckune, 2016). Sustainable agricultural production in the presence of climate change is impossible without access to climate and early warning information (Mudombi and Nhamo, 2014). This information enables farmers to make climate-informed farm decisions to improve their efficiency and adopt appropriate coping strategies. Timely and accurate climate forecast improve farmer buffering mechanisms against harsh impacts of climate change and enhance agricultural production and food security (Hammer et al., 2001; Hansen, 2002).

The demand for climate information products and services for application in agriculture and food security, health, pastoral systems, water and energy resources is rising in Africa. This has been linked to ineffective and unreliable indigenous local indicators due to increased climate variability and hence high dependence on scientific climate information (Ingram et al., 2002; Luseno et al., 2003).

Although the demand for climate information services is high in Africa, the access of the information by the most vulnerable farmers in semi-arid areas is limited. Information delivery mechanisms, such as timing, reliability, language and infrastructural development, are the various constraints that limit access to climate information (Chamboko et al., 2008). Moreover socio-economic factors, such as age, gender, education, ownership of communication assets and farm size influence access to climate information (Oyekale, 2015).

2.3.2 Climate information services dissemination channels

Dissemination channels for CIS highly influence both access and use of climate information services. The various dissemination channels should be readily available and possess user-friendly attributes, such as accuracy, timeliness, language, being trusted and should disseminate usable content (World Bank, 2016). Radio, print media, short mobile messages, television and contact with informed people are various climate information dissemination channels (Kirui et al., 2012). Radio has been reported as the major dissemination channel of climate forecast because it is easily accessible, reaches wider coverage, can use vernacular languages and is of low maintenance cost. Moreover, farmers and pastoralists prefer radio and mobile phones dissemination channels because they view them to be effective and trusted (Hampson et al., 2015).

The medium of forecast transmission can be directly linked to gender disparity in access of weather forecast. For instance, women prefer climate information disseminated through church meetings, *barazas* and community group (Oyekale, 2015). Information disseminated through ICTs is rarely accessible to women since majority of these communication assets are owned by men (McOmber et al., 2013; Hampson et al., 2015). Moreover, older farmers preferred channels that disseminated indigenous knowledge and not modern scientific knowledge (Kirui et al., 2012).

2.3.3 Use of climate information services to inform farmers' decisions

The use of climate services by farmers in decision making against climate risks results in higher agricultural yields (Patt et al., 2017). Based on Climate Information and Services for Africa (CIASA) 2015 report, the utilisation of climate information to influence mitigation decisions was still minimal despite improved research on climate variability and its impacts in Africa. Use of seasonal climate forecast refers to the extent to which this information is incorporated in farmer's decision making against climate-related risks. The limited use of climate information has been linked to various constraints. For instance, lack of access to sufficient and practical information to influence farmers' decisions, lack of trust between producers and users of climate information and lack of capacity to decode and utilise the information in agricultural needs (Onyango et al., 2014). Moreover, users' perception of information fit, the correlation between new knowledge and currently used information and producer-user interactions are interconnected factors that are outlined to influence climate information utilization by farmers (Dalgleish and Coventry, 2005; Lemos et al., 2012). Timing of forecast dissemination, psychological factors and socio-economic factors also influence the use of climate forecast by farmers (Olove et al., 2004).

Farmers in Africa do not employ climate forecast information to modify their managerial decisions against climate risks due to socio-economic factors, namely land availability, labour, access to credit, land tenure, market access and technical information (Ingram et al., 2002; Klopper et al., 2006). High illiteracy levels are also a major constraint towards utilisation of climate forecast advisory services by smallholder farmers. Both men and women demand climate information services, but women face major constraints in the application of climate services in farm decisions due to limited access and control of production resources (Coulibaly et al., 2015).

2.4 Climate information services and adaptation to climate change

Favourable weather is least guaranteed prior to, during and after production seasons in Sub-Saharan Africa. Therefore, to enhance sustainable agricultural production in SSA adaptation to climate change is imperative. Access to climate information services enhances adoption of coping strategies against climate change. Altering crop, livestock, land and water management practices to cope with climate variability are various adaptation strategies (Bryan et al.,2011). Access to climate services has resulted in the adoption of various adaptation strategies, for instance, change in cropping dates and change in crop varieties, use of early maturing varieties, crop diversification, soil and water conservation, fodder planting and use of fertilizers (Eriksen and Rosentrater, 2008; Belay et al., 2017).

2.5 Review of empirical studies on the determinants of access and use of climate information services

Various studies have analysed factors that influence farmer access and utilisation of climate information services in farm decision making against climate change. Oyekale (2015) analysed factors influencing access to forecast on the incidence of pests and diseases and start of rainfall in East and West Africa using the probit model. The author established that access to business income, radio and television ownership, previous exposure to climate shocks and education increased the likelihood of access to the forecast. However, this study used regional data for analysis whereby the sampling unit comprised of eight countries namely; Kenya, Uganda Tanzania, Ethiopia, Burkina Faso, Ghana, Mali, Niger and Senegal. The findings of this study were not country-specific and therefore cannot be used by policy makers to enhance access and use of CIS in Kenya.

Oyekale (2012) analysed factors influencing access to climate forecast sources in the Limpopo river basin of South Africa. The author analysed four climate forecast sources, namely radio, television, extension agents and neighbour. Four separate Probit models were analysed and the results from all sources showed that the likelihood of access to climate forecasts increased with ownership of television, cars, radio, land, previous exposure of hailstorms and floods, and university education while it reduced with farming experience, household size, large farm size and access to fertile land.

Ochieng et al. (2017) analysed enabling conditions for improved use of climate information in arid and semi-arid Baringo County of Kenya. The study used sensitivity analysis to establish the barriers and enablers of use of seasonal climate forecast. The results showed that conflicts and insecurity, culture, lack of information and diversified income sources limited the uptake of seasonal forecast.

Unlike the previous studies that only analysed determinants of either access or use of climate forecast, this study analysed both the determinants of access and use of climate information services. This is because access to climate forecast is the first step towards utilisation it's in farm decision making. Therefore, farmers who utilise this information are a subsample of those with access to climate information.

CHAPTER 3: METHODOLOGY

3.1 Conceptual framework

Access and use of climate information services (CIS) are the first steps toward adaptation to adverse impacts of climate change. Climate information services influence farmer decisions to alter crop management practices and livelihood diversification to reduce farmers' vulnerability to adverse climate anomalies and benefit from favourable conditions.

Farmers largely are dependent on scientific weather forecast since indigenous local indicators have been deemed ineffective and unreliable due to high climate variability. As shown in Figure 1, the Kenya Meteorological Department, Non-governmental Organization (NGOs), community based organisations, donor-funded projects, international research organisations, and regional networks among other stakeholders provide climate information services which entail interpretation of climate parameters to the farmers, their implications and advice on the alternative strategies to mitigate climate risks. This information is transmitted through various dissemination channels which include radio, television, newspapers, extension officers, local authorities, churches, community workshops, farm trials and interaction with informed neighbours or friends.

The various dissemination channels used to transmit CIS should possess user-friendly attributes. For instance, farmers will access and use CIS from channels that are affordable, easily accessible, accurate, reliable, trusted and using understandable language. These dissemination channels should also be consistent, effective and provide timely information to enable farmers choose appropriate coping strategies.

Various factors have been hypothesised to influence both access and use of climate information services (Figure 1). Economic factors such as employment, income and interest rates influence both access and use of CIS.

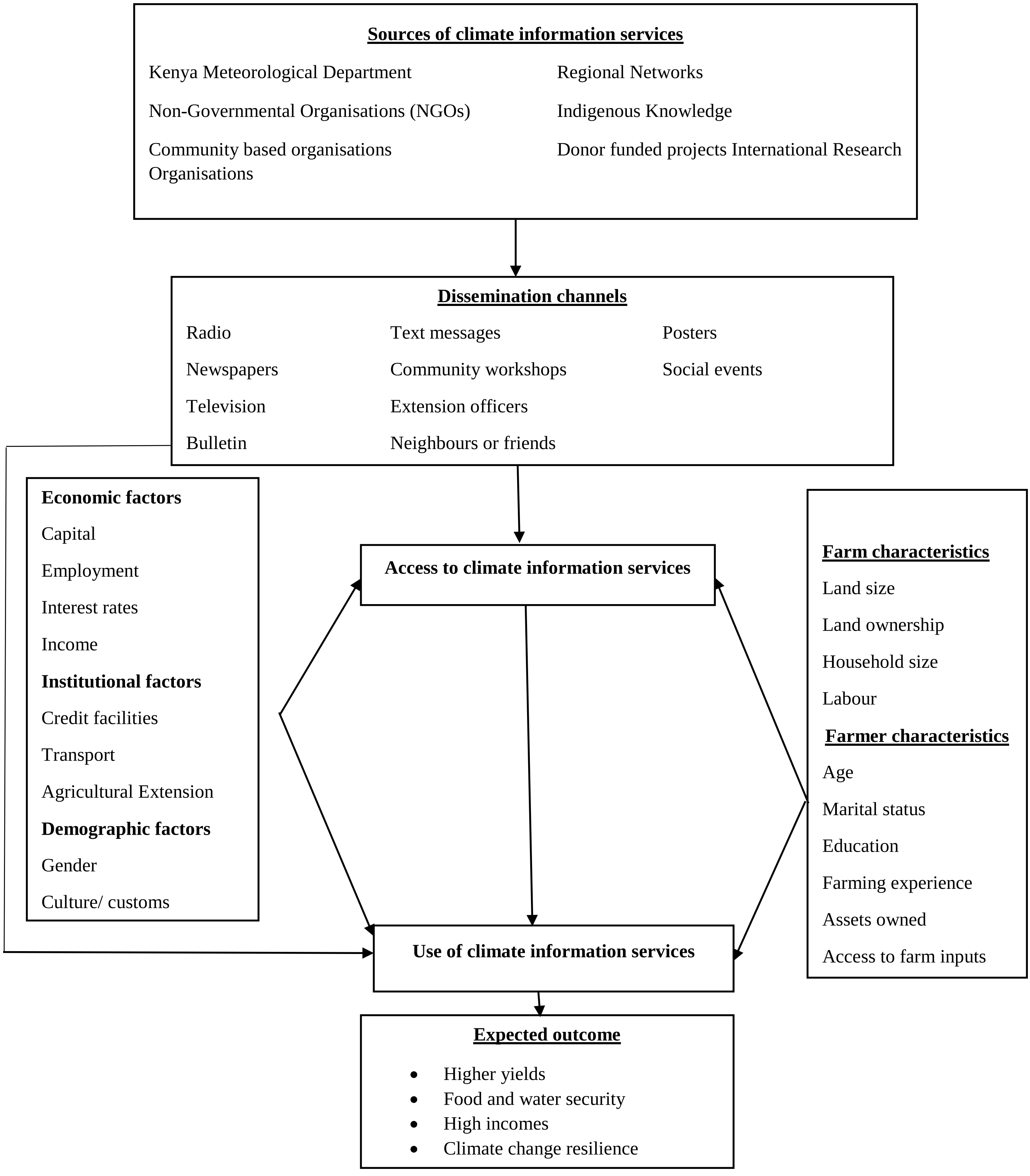

Figure 1: Conceptual framework showing links between various determinants of both access and use of climate information services

Source: Author's conceptualization

For instance, interest rates will influence farmer access to credit to purchase farm inputs. Farmers with higher incomes have a higher adaptive capacity, and therefore, have a higher likelihood of accessing and using CIS. Employed farmers will seek climate information and utilise it to maximise agricultural output for household consumption and income diversification.

Institutional factors, such as extension services, credit facilities and transport, also influence access and use of CIS. Extension agents are trusted channels of climate information services. Therefore, farmers' interaction with extension agents increases the likelihood of access and utilisation of CIS. Demographic factors such as culture influence access and use of climate information services in that some farmers will highly depend on their indigenous local forecast which will reduce their likelihood of access to modern CIS.

As shown in Figure 1, farm characteristics such as land size, land tenure, household size and access to labour also influence access and use of CIS. In addition, farmer characteristics such as age, gender, education, marital status, farming experience and asset ownership influence access and use of CIS. For instance, the age of household head which is correlated to farming experience also determines the access to climate information services. Older farmers prefer indigenous climate information compared to the young farmers who may rely more on scientific climate forecast. Moreover, older farmers have monitored climate change over time and established alternative adaptation options thus reducing their probability of access and utilisation of climate information services.

Education level is expected to increase the likelihood of access and use of climate information services since more educated farmers are aware of climate change and acknowledge the benefits of climate change adaptation. Male and female-headed households have different likelihoods of access to climate information services. The gender disparity in access of climate information services can be attributed to dissemination channel since men own the majority of communication assets (McOmber et al., 2013). Women have limited production resources compared to men and this reduces their likelihood of utilising climate information services.

Timely access to accurate and reliable climate information services and use in farm decisions against climate risks result in various benefits. These CIS will enable farmers to adjust their farm operations hence increase their climate change resilience. Moreover, as shown in Figure 1, the use of CIS will also result in higher agricultural yields, food security and higher household income.

3.2 Study Area

This study was undertaken in Makueni County which lies on the South Eastern part of Kenya. It is part of the Arid and Semi-Arid Lands (ASALS) in Kenya which occupy 83 percent of country's total land mass (Macharia et al., 2012). This County experiences hot and dry climate and an average annual rainfall between 200-700mm (Mutua et al., 2016). The county sits on 8,034.7 Km^2 area bordering Kajiado, Kitui, Taita Taveta and Machakos counties with a population of 468,297 male and 493,442 female totaling to 961,740 (GoK, 2013; GoK, 2015).

According to Makueni County Integrated Development Plan (2013), the county has experienced variable climate change, including insufficient rainfall and drought which have compromised food and water security. The lower region of the county receives a minimum rainfall of 300mm to 400mm thus necessitating the growth of drought-tolerant crops (sorghum, millet) and livestock production as the only viable economic activity.

Agriculture is the major source of livelihood which accounts to 78 percent of household income in the County (GOK, 2013). This is practiced on limited large-scale farming systems averaging 30 ha and small-scale farming systems averaging 3.4 ha which are the majority

(GOK, 2015). The various agricultural practices in the area are limited cash crop farming (coffee and cotton), food crop farming (maize, beans, pigeon peas, sorghum, millet and cowpeas), livestock keeping (sheep, goats, cattle, chicken, beekeeping, donkey, pigs and fish) and fruit trees (mango and citrus). Due to over-dependence on rain-fed agriculture as the main source of livelihood, the county is highly vulnerable to recurrent drought and erratic rainfall (Mutua et al., 2016).

The county is divided into nine sub-counties, namely Makueni, Kathonzweni, Kilungu, Mbooni East and West, Kibwezi, Makindu, Nzaui and Mukaa. This study was conducted in Makueni Sub-county which has three divisions: Wote, Kaiti and Kee. Wote Division is the largest (400.6 KM^2) followed by Kaiti (184 KM^2) and lastly Kee (81.9 KM^2). Each division is divided into sub locations which are the smallest administrative units.

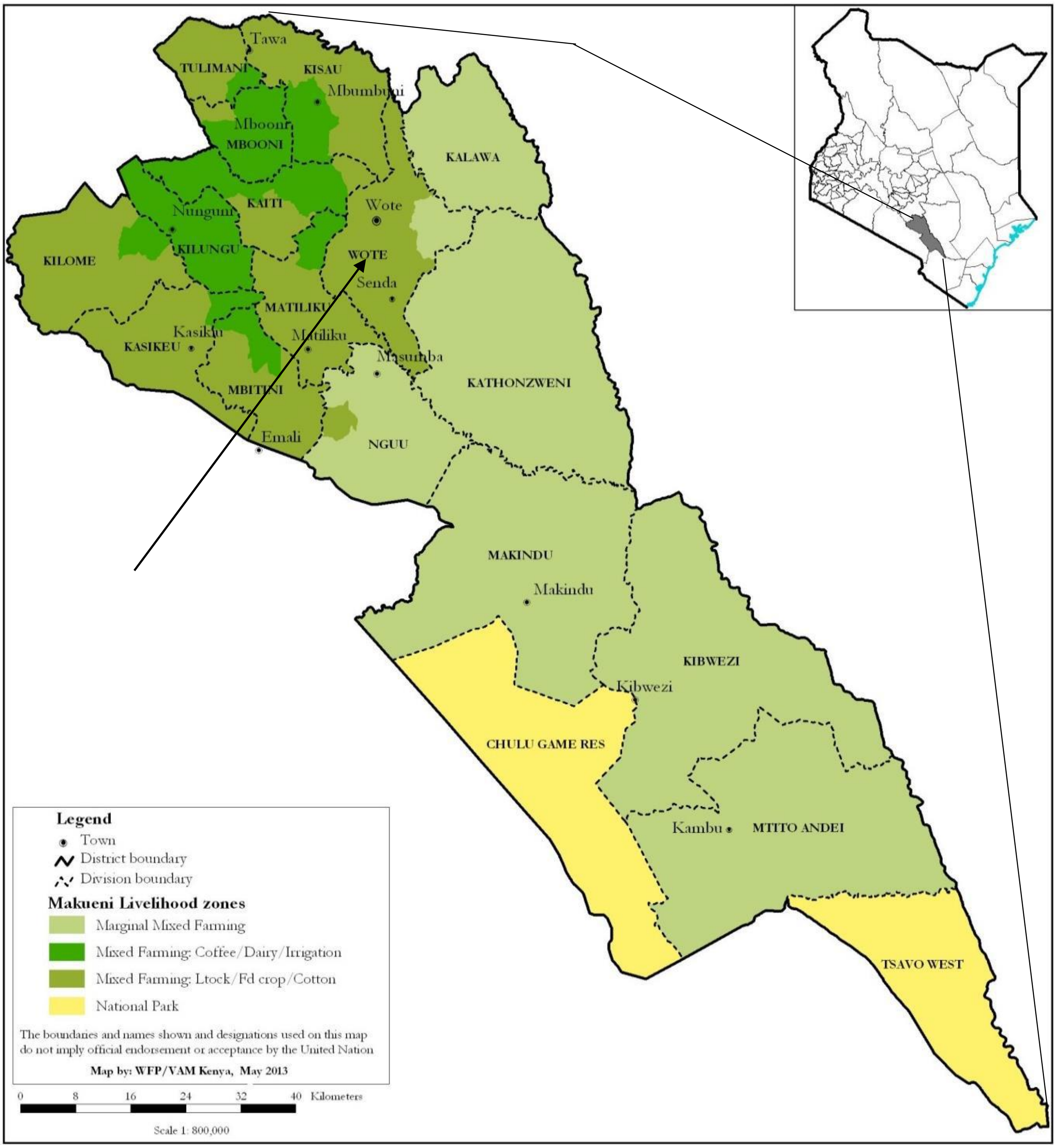

Figure 2: Map of Makueni County

3.3 Empirical framework

This study was anchored on utility maximisation theory in which an individual makes a choice among mutually exclusive alternative choices j and k. In this case j represents farmer's choice to use climate information services in decision making while k represents farmer's choice not to use climate information services. This study assumed that a farmer used climate information services if the derived utility was significantly higher than when he or she made farm decisions without incorporating climate information services. Utility was not observable but farmer's preference was dictated by his or her decision to use CIS or not. The utility function was given by U_{ki} and U_{Ji} and therefore since utility was unobservable farmer's decision revealed what gave the highest utility for ith farmer. The linear random utility model is given as:

$$U_{ji}= \beta i_j Xi_j + e_{ji} \text{ and } U_{ki}= \beta_{ki} X_{ki} + e_{ki} \quad (1)$$

Whereby U^k and U^J were the perceived utilities, X vector represented the explanatory variables that influenced farmers decision, β_j and β_k were the parameters estimated,e_j and e_k were the error terms which were assumed to be independent and identically distributed (Greene, 2002).

If $U_{Ji} > U_{ki}$ (equation 2) then the observable indicator was 1 to denote that a farmer derived higher utility by using climate information services in climate risk management decisions whilst 0 indicated $U^k > U^J$ (equation 3) when the farmer derived high utility without use of climate information services hence equation 3 (Greene, 2002).

$$U_{ji}= \beta_{ji} X_{ji} + e_{ji} > U_{ki} = \beta_{ki} X_{ki} + e_{ki} \quad (2)$$

$$U_{ki} = \beta_{ki} X_{ki} + e_{ki} > U_{ji}= \beta_{ji} X_{ji} + e_{ji} \quad (3)$$

The probability Y= 1 denoted that the farmer used climate information services in their farm decision making against climate risks.

Therefore the equation was given by:

$P(Y=1/X)= P(U_{Ji} > U_{ki})$

$P(\beta i_j Xi_j + e_{ji} - \beta_{ki} X_{ki} + e_{ki} > 0/X)$

$P(\beta i_j Xi_j - \beta_{ki} X_{ki} + e_{ji} - e_{ki} > 0/X)$

$$P(X^{*} X_i + e^{*} > 0/X= F(\beta^{*} X_i) \qquad (4)$$

From the equations above P represented the probability function, $e^{*}= e_{ji} - e_{ki}$ represented the random error term, $\beta^{*} = \beta_j - \beta_k$ represented the unknown parameters estimated and $F(\beta^{*} X_i)$ was the cumulative distribution function of e^{*} evaluated at $\beta^{*} X_i$ (Greene, 2002).

Farmer's decision to use CIS in farm decision making was a two-step process which implied that by choosing to use climate services, individual i was self-selected in the population of those who had access to climate information services. Therefore, this suggested the use of Heckman model with sample selection econometric model to address the sample selection bias (Heckman, 1976; Robert et al., 2004; Walton et al., 2008).

3.3.1 Climate information services accessed by smallholder farmers in Makueni County

This objective analysed the various climate information services accessed by farmers and the various dissemination channels. This was achieved using descriptive statistics in Statistical Packages of Social Science (SPSS) software and the results summarised by use of means and frequencies. These results were presented using tables and graphs to show the CIS accessed by most farmers and the most preferred dissemination channels.

3.3.2 Usefulness of climate information services in farm decision making

The second objective analysed the usefulness of CIS in farm decisions against negative impacts of climate change. Farmers' perception of the usefulness of climate information services in farm decision making against climate risks was collected using a five-point Likert scale. The categories of response were; 1= not useful, 2 = small extent, 3= medium extent, 4= large extent and 5= very large extent. Mean and standard deviation were not appropriate to analyse these categories since they were ordinal and the intervals could not be assumed to be equal (Jamieson, 2004). Therefore, frequencies were used to obtain the most useful climate information services in farm decision making and the results presented in a table.

3.3.3 Determinants of access to climate information services

The outcome of access to CIS was dichotomous whereby farmers either accessed CIS or not. Analytical approaches commonly used in decisions that involve choices with binary outcomes in economics are the probit and logit models. The difference between probit and logit choice model is that probit model assumes the error terms are independent and normally distributed whereas logit models assume that the error term has a standard logistic distribution (Greene, 2002).

3.3.4 Determinants of use of climate information services in farm decision making

Similar to access to climate information services, farmers' decisions are dichotomous whereby they decide whether to utilise CIS or not for climate change adaptation. Farmer's decision to use CIS is a two-step process that involves his or her access to the information, and then the utilisation in farm decisions against climate risks. In a two-stage process, the second stage of utilisation of CIS is a sub-sample of the first (access to CIS). Thus, it is likely that the sub-sample used in the second stage is non-random and necessarily different from the first (which included those who did not access CIS), and this creates a sample selection bias. Therefore, the Heckprobit model which is a modification of the Heckman two-step model was used to correct for selectivity bias (Ven and Van Praag, 1981). In this model, both the dependent variables in the selection and outcome equations are dichotomous. The selection equation analysed the determinants of access to CIS and the outcome equation analysed the determinants of use of CIS. The sub-sample used in the second stage was non-random and necessarily different from the first (which included those who did not access CIS), therefore, to correct for non-exposure bias the Inverse Mills Ratios (IMR) were included in the second stage (outcome equation) as is done in the case of the Heckman model (Heckman, 1979).

Previous studies, such as Deressa et al. (2008), Broeck et al. (2013) and Asrat and Simane (2018), used Heckprobit to analyse the factors that influenced farmers' adaptation to climate change. The benefit of this model is that it can easily be estimated using STATA and also it can be estimated using the maximum likelihood approach without heavy computation challenges (Billari and Borgoni, 2005). To achieve correct results from the Heckprobit model, the explanatory variables in the selection equation should not be identical to those in the outcome equation. In many instances the explanatory variables in selection equation also affect the outcome; hence this model limits that at least one explanatory variable in the selection equation should be excluded in the outcome equation (Sartori, 2003).

Model specification

The Heckman probit model assume that the error terms of the selection and outcome equation are correlated. Empirically, the model can be described as follows:

$Y1$ (ASCIS) = 1 if the farmer had access to seasonal CIS

0 if the farmer had no access to seasonal CIS

$Y2$ (USCIS) = 1 if the farmer used seasonal CIS in farm decision making

0 if the farmer did not use seasonal CIS in farm decision making

$Y2 = \beta X_i + \beta_\lambda \alpha_i + \varepsilon_{1i}$ = Main Equation (5)

Equation 5 is the second stage equation plus the inverse mills ratio as an additional explanatory variable to solve for selectivity bias. $Y2$ (use of CIS), was meaningfully observed if $Y1$ (access of CIS) =1.

$Y_1 = \alpha Z_i + \varepsilon_{2i}$ = Selection Equation (6)

$Y_2 = \beta X_i + \varepsilon_{1i}$ = Latent Equation (7)

Where ε_1 and $\varepsilon_2 \sim N\ [0, 1]$

$Corr\ [\varepsilon_1\ \varepsilon_2] = \rho$

β and α were the vector of coefficients associated with the independent variables, X_i and Z_i represented the exogenous variables (socio-economic characteristics) that determined $Y2$ and $Y1$ respectively, $\boldsymbol{\varepsilon_1}$ and $\boldsymbol{\varepsilon_2}$ were the respective error terms normally distributed with zero mean, unit variance and correlation ρ. When the $\rho \neq 0$ the standard probit model 7 would yield biased estimates. Therefore, to correct for selectivity bias this study considered that

Prob ($Y1 = 1$) = Prob ($\varepsilon_{2i} > -\alpha Z$i) = Prob ($\alpha Z_i$) = Φ (αZ_i),

Whereby, Φ represented the cumulative distribution at αZ_i. Hence

$E[Y2 \mid Y1] = 1] = \beta X_i + \rho\sigma\lambda_i\ (\alpha Z\text{i})$ (8)

Where $\lambda_i = \phi\ (\alpha Z_i)/\Phi\ (\alpha Z_i)$, with ϕ representing the probability density function at αZ_i. λ_i is the inverse mills ratio (IMR) which is the ratio of value of density function of standard normal distribution αZ_i and the probability of being in the sub sample with access to seasonal CIS which is similar to cumulative distribution valued at αZ_i for the households with access and a complement of 1 for households without access. On the other hand $\rho\sigma$ is the regression coefficient on the inverse mill ratio $\beta\lambda$. Therefore to correct for selectivity bias and achieve unbiased efficient estimates IMR was included in the second stage equation (5).

In correspondence with previous studies on access and utilisation of climate information conducted by Ingram et al. (2002); Oyekale (2012); Kirui et al. (2012); Yong (2014) and Ochieng et al. (2017), the independent variables included in the selection equation (Determinants of access to CIS) were; **Farmer characteristics** (Age of household head measured in years, Gender of household head dummy male = 1 Female = 0, Household size continuous, Education of household head in years, major livelihood activity Dummy 1 = farming 0 = other, Household monthly income Kenya Shillings)**,** **Farm characteristics** (Farm size in ha continuous, Frequency of drought exposure continuous)**, Institutional factors**, (Access to extension services dummy 1= farmers with access to extension services and 0= farmers without access, Access to credit dummy 1= Household with access to credit, 0 = Household without access to credit, Group membership dummy 1= belong to agricultural group, 0= doesn't belong to agricultural group)**, Communication assets** (radio ownership dummy 1 = Household that own a radio, 0 = not own a radio, Television ownership dummy 1= Household owned a TV, 0 = no TV). Similar variables were used in the outcome equation with an exception of group membership. Additionally, **Farm characteristics** such as access to organic fertilizers dummy 1 = Household with access to organic fertilizers and 0= Household without access to organic fertilizers, access to improved seed dummy 1= Household with access to improved seed and 0 = without access, access to farm equipment dummy 1= Household with access to farm equipment and 0 = without access were added in the outcome model.

3.4 Justification of explanatory variables of the model

Table 1 shows that the age of the household head which is correlated to farming experience was expected to reduce the likelihood of both access and use of CIS. This is because along the years older farmers have established own methods to manage climate risks (Oyekale, 2015). Moreover, they preferred utilising acquired indigenous knowledge which reduced their demand for accessing CIS (Kirui et al., 2012).

Table 1: Variables included in the Heckprobit model and expected signs

Variable Description	Nature Of Variable	Expected Sign in Access to Cis	Expected Sign in Use of Cis
Age of the farmer	Continuous	-	-
Gender	Dummy variable (Male =1 Female = 0)	+	+
Household size	Continuous	+	+
Farm size	Continuous	+	+
Major source of income	Dummy variable (Farming =1 other = 0)	+	+
Farming experience	Continuous	-	-
Own radio	Dummy variable (Yes=1 No = 0)	+	+
Own television	Dummy variable (Yes=1 No = 0)	+	+
The frequency of drought exposure	Continuous	+	+
Access extension services	Dummy variable (Yes=1 No = 0)	+	+
Access to credit (formal or informal)	Dummy variable (Yes=1 No = 0)	+	+
Access to improved seed	Dummy variable (Yes=1 No = 0)	*	+
Household monthly income	Continuous	+	+
Access to inorganic fertilizer	Dummy variable (Yes=1 No = 0)	*	+
Access to farm equipment	Dummy variable (Yes=1 No = 0)	*	+
Group membership	Dummy variable (Yes=1 No = 0)	+	*

Note: The * in the table shows that (access to improved seed, inorganic fertilizer and farm equipment) variables were not included in the selection equation while (group membership) was not included in outcome equation.

Gender of Respondent: Gender refers to social roles and responsibilities attributed to man and women while sex is the biological characteristics that differentiate a man and a woman.

Men and women are expected to have different likelihoods of access to CIS from different dissemination channels. This depends on asset ownership and their respective day-to-day activities. According to McOmber et al. (2013), women are always on the periphery of accessing climate information because they are often left out in many communication channels. The male-headed households are expected to have a higher likelihood of utilising CIS because they control majority of assets and production resources compared to female farmers (Hassan and Nhemachena, 2008).

Education: This variable represents primary, secondary and tertiary education levels. This variable is hypothesized to have a positive relationship with access and use of CIS. This is because farmers with formal education are enlightened and in a better position to understand the implications of climate change. According to Rehman et al. (2013) increase in education levels among farmers resulted to increase in access to agricultural information. Moreover, educated farmers also have a higher probability of adopting new technologies hence a higher likelihood of using climate information services (Ochieng et al., 2017)

Household size: Household size has a positive association with adaptation to climate change (Belay et al., 2017). This implies that households with larger numbers are expected to have a higher demand for climate information services. This is because the increase in number of productive household members leads to readily available household labour which increases the likelihood of using CIS (Yong, 2014). Alternatively, increase in household size could also reduce the likelihood of access and use of CIS because additional productive household members seek off-farm employment which reduces overdependence on farm income (Oyekale, 2012).

Farm size: Land is an important factor for coping and adapting to climate change (Hassan and Nhemachena, 2008). Households with large farm sizes are expected to have a higher likelihood of access and use of climate information. This is because farmers with large farms are able to practice crop and livestock diversification and spread climate-related risks (Yong, 2014; Belay et al., 2017).

Major Income activity: households that depend on farming as the sole income activity are expected to have a higher likelihood of accessing and utilising climate information in their farm management decision against climate risks. This is because these farmers have a major concern on the negative impacts of climate change which threaten their major source of livelihood (Kitinya et al., 2012).

Frequency of drought exposure: previous exposure to climate shocks was expected to increase the likelihood of both access and use of CIS. Rational farmers previously exposed to climate-related risks (drought, floods and pest and diseases) have a higher probability of seeking CIS and using them in risk mitigation decisions (Oyekale, 2012).

Ownership of radio/ television/ phone: Access to communication assets was expected to increase household's likelihood of access and utilisation of CIS. This is because majority of CIS providers disseminate the information through these communication channels. For instance, majority of farmers in Kenya depend on radio as the main dissemination channel for climate information (Kitinya et al., 2012).

Access to Credit: access to formal or informal credit is an important factor that determines adoption of various agricultural technologies. Access to credit facilities was expected to increases farmer's likelihood of access and use of CIS. For instance, access to credit facilities will enable farmers to purchase new crop varieties, fertilizers and farm equipment to enable them adapt to climate change. According to Ochieng et al. (2017), unavailability of credit facilities is a major hindrance to the utilisation of seasonal climate forecast

Access to Extension Services: access to extension services was expected to increase farmers' likelihood of access and use of climate information services. This is because extension agents are the most preferred and trusted dissemination channel of climate information (Kirui et al., 2012). Moreover, contact with extension agents grants farmers the privilege to ask questions pertaining to the utilisation of climate information.

Access to improved seed, farm equipment and organic fertilizers: Access to farm inputs was expected to increase the likelihood of utilising CIS. Climate information alone is not enough to influence farmer's decisions but it is dependent on the availability of resources need to respond to the forecast (O'Brien et al., 2000). Fertilizers and improved seed are key inputs in agricultural production hence these variables were hypothesised to increase farmers' probability of utilisation of climate information in their farm decisions. According to Recha et al. (2008), lack of ox-drawn power limited use in climate information services since farmers were not able to cultivate their farms during the communicated dates.

Group Membership: membership in formal or informal networks was expected to increase the likelihood of access to climate information services. Social networks are important in enhancing climate change adaptation since they enhance communication and discussions of new agricultural technologies among farmers (Deressa et al., 2008).

3.5 Research Design

This study employed a cross-sectional survey design whereby information about the sample was collected at a specific point in time. Quantitative data which was collected using questionnaires administered on household heads was used to analyse the determinants of access and use of climate information services among smallholder farmers in Makueni County.

3.6 Data Types and Sources

This study used primary and secondary data for analysis. Primary data was collected through interviews and structured questionnaires to obtain both qualitative and quantitative data on demographic and socio-economic characteristics of the farmers, including age, gender, education, livelihood activity, total farm size, radio and TV ownership, access to improved seed, fertilizers, extension services, farm equipment and group membership.

3.7 Sampling

This study used multistage sampling to arrive at the desired sample. Makueni Sub County was purposively selected due to its high exposure to bad dry spells associated with higher temperatures, low resilience to climate variability, declining food production and scarce water resources. In the second stage, two wards (Muvau ward and Wote ward) were selected from the total of six wards with the help of county agricultural officer. Muvau ward had a total of six sublocations and Wote three sub-locations. In the third stage, two sub-locations were randomly selected from Wote ward and three from Muvau ward. In the fourth stage, a list of all the villages from the respective sublocation was made and 5 villages randomly selected from each sub-locations. Systematic sampling was employed to select ten households from each village to arrive at the desired sample of 250.

Due to varied population statistics of Makueni County, the desired sample of 250 farmers was arrived at based on previous similar studies that achieved successful observed outcomes from a sample size between 200 and 250 respondents. For instance, Ngugi (2002) used a sample of 240 farmers in his study on climate forecast information among agro-pastoralists farmers in Machakos District, Rankoana (2017) used a sample of 250 farmers in her study on use of indigenous knowledge in subsistence farming in Limpopo province of South Africa and Ochieng et al. (2017) used a sample of 221 farmers in his study on 'Enabling conditions for improved use of seasonal climate forecast in Baringo County'.

3.8 Data Capture and Analysis

Data collected from the field was coded and input in SPSS version 16 and STATA software for descriptive analysis to generate means, modes and frequencies which were displayed in tables, pie charts and graphs.

3.9 Diagnostic tests of heckprobit model

Heteroscedasticity

The existence of heteroscedasticity means unequal variance in the regression model. The Breusch-Pagan Test was used to detect the presence of heteroscedasticity (Greene, 2002).

Multicollinearity

This refers to a state when the independent variables are closely correlated to one another which can result in skewed results. This problem can result in high standard errors, change in signs and magnitude of the coefficients in the regression analysis. To test for the presence of Multicollinearity among the independent variables used in the model, Variance Inflation Factors (VIF) was used (Gujarati, 2004).

Endogeneity

In this study, improved seed and organic fertilizers were potential suspects for endogeneity. Hausman test was used to test for endogeneity whereby the potentially endogenous variable was regressed against on all exogenous variables (Greene, 2002). The residuals were then obtained and included in the main estimation equation. This tests the hypothesis that the coefficient estimates for the residuals are significantly different from zero.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Socio-economic characteristics of household

Table 2 shows that the ages of the household heads interviewed ranged between 23 to 90 years with a mean of 53 years and a standard deviation of 14.2. This implies that majority of smallholder farmers interviewed in the study area are old.

Table 2: Socio-economic characteristics of the household sample

Variables	Mean	Standard deviation
Age of household head	53.1	14.2
Gender of household head (% Male)	65.0	
Household size	5.0	1.9
Education (Years)	9.7	4.3
Land allocated to farming (Acres)	3.3	2.8
Monthly farm income (Ksh)	5.122.8	4,852.9
Households total monthly Income	21,481.4	20,615.2
Access to improved seed (% Yes)	74.0	
Access to credit (% Yes)	60.0	
Access to extension services (% Yes)	27.0	
Farming as major income activity(% Yes)	50.0	
Group membership (% Yes)	78.2	
Access to organic fertilizers (%Yes)	82.3	
Own radio (%Yes)	86.8	
Own television (%Yes)	32.6	

Source: Author's Survey 2017

This finding is similar to that of Kavoi et al. (2014) who found that the mean age of smallholder farmers in Makueni county was 53 years with a range between 25 and 93 years. According to the Kenyan constitution (2010), a youth is a person between 15 and 34 years of age. From this study, majority of farmers interviewed were above this age and thus portraying limited involvement of youth in agriculture. This finding is supported by the World Bank

(2013) report that the youth who are the majority of Kenya's population rarely engage in agricultural practices.

The male respondents accounted for 65 percent of the total respondents implying that majority of the households were male-headed. This result is supported by CCAFS findings in a household survey conducted in 2012 in the study area that 66 percent of households were male-headed (Mwangangi et al., 2012). The average years of education was 9 years which portrays that majority of farmers had attained only elementary level education. This complies with the World Bank (2004) report that the primary school's enrolment rate in Kenya was 87 percent and only half of the population enrolled for secondary education. This implies the presence of high illiteracy levels which hinder effective access and use of climate information services disseminated in nonvernacular languages and reading materials such as newspapers, bulletin, internet and flyers (Cherotich et al., 2012).

The average household size was 5 members. This corresponded with the 2009 census in Kenya which reported a mean of 5 members per household (Republic of Kenya, 2013). The size of a household is linked to vulnerability to climate-related shocks whereby, a large number of household members increased their vulnerability to climate shocks (Nkondze et al., 2013).

Table 3 shows that mixed farming was the main livelihood activity in the study area. However, farming was practiced for subsistence needs with only little surplus sold to meet various household needs. High dependence on rain-fed agriculture for livelihood increases the counties vulnerability to climate change. Therefore enhancing drought resilience agricultural practices and livelihood diversification will reduce the County's vulnerability to climate change and increase food security.

Table 3: Major income activities of households

Income activity	Percentage
Salaried employee	17.28
Business	18.98
Casual labourer	13.99
Farming	49.79

Source: Author's Survey (2017)

Results in Table 4 show that majority of households grew maize, beans, cowpeas and pigeon peas for consumption. This portrays high diversification in food production in the study area.

Table 4: Crops grown by household

Crop grown	Frequency	Percentage
Maize	243	100
Beans	221	91
Cowpeas	228	94
Pigeon peas	215	89
Green grams	155	63
Millet	32	13
Sorghum	22	9
Mangoes	90	37
Oranges	97	41

Source: Author's Survey (2017)

This finding is supported by those of Kitinya et al. (2012) and Mwangangi et al. (2012) who established that maize, cowpeas and pigeon peas were the major food crops grown in the area. While majority of farmers grew more than one crop for diversification and intercropping, others grew only one crop mainly maize due to lack of seeds. According to Omoyo et al. (2015), maize is very sensitive to varying rainfall patterns. This crop was grown by all the respondents in the study area. This finding is supported by that of Kristjanson et al. (2014) who reported that households in Makueni County preferred maize crop than other crops. This is because maize is the highest consumed cereal in arid areas of eastern Kenya and it dominates more than half of Africa's smallholder farmer production (FAO, 2015).

Sorghum which is referred to camel crop in the plant kingdom due to its high tolerance to drought among other adverse climatic conditions was only grown by 9 percent of the respondents. It is a traditional crop in the area but its production has been declining over the years. This decline in sorghum production has been attributed to the fact that its labour intensive, low processing capacity, high production costs and lack of ready marked (Mwadalu and Mwangi, 2013).

Mangoes and Oranges fruit trees are also gaining momentum in the region due to favourable conditions and increased local and international demand. Although faced with a myriad of challenges such as pests, diseases and poor handling methods resulting in post-harvest loses mango and orange production have increased annual household income in the study area.

Besides crop farming, households interviewed also kept small herds of livestock, such as cows, goats, sheep, donkey, rabbit and chicken. These were mainly kept as a source of food, wealth, manure and income to enhance household sustainability. The indigenous zebu cattle also provided draft power for the cultivation of crops.

The average monthly household income was Ksh 21,481.4, and this compared favourably with FAO (2015) finding of Ksh 21,058.3in Kenya. Although farming was the main source of livelihood among households, it only contributed 30 percent of total income. This is attributed to increased climate variability which has constrained rain-fed agricultural production.

The average farm size is 3.3 ha with a minimum of 0.25 ha and a maximum of 20 ha. This finding is similar with the County's average farm size of 3.44 ha (Makueni County First County Integrated Plan, 2013). This was higher than the national average farm size of 2.5 ha per household (Nyoro, 2002). This implies that smallholder farmers dominate agricultural production in Makueni County. This was in agreement with the World Bank (2015) report that smallholder farmers contribute three-quarter of the national agricultural production.

Figure 3 shows that 98 percent of the farmers managed individually owned farmland whereby 65.43 percent inherited their land from parents, 20.16 percent bought and 13.58 percent allocated by clan. This result corresponds to Otieno et al. (2015) findings that 93.3 percent of land in Makueni County was individually owned.

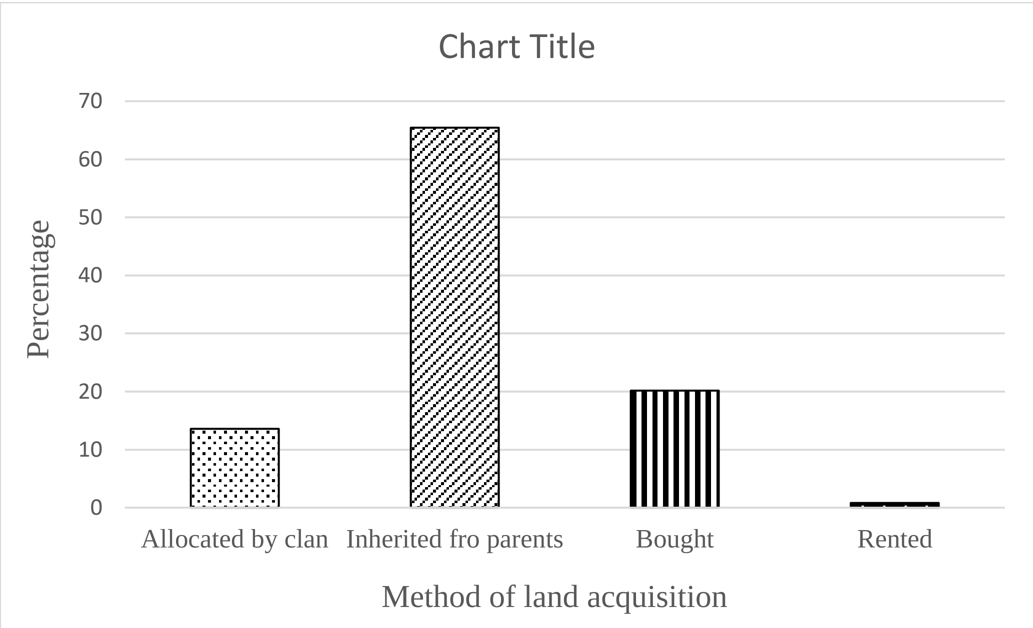

Figure 3: Methods of land acquisition

Source Author's Survey (2017)

The results in table 2 show that 60% of households had access to credit facilities. Access to credit offsets farmer constraints to access production resources. Lack of collateral, inability to pay back and lengthy procedures were the main hindrances to credit access.

Despite extension services being the major change agents towards the transformation of subsistence farming to modern agriculture, only 27.16 percent of the households accessed them (Table 2). Mwangangi et al. (2012) also noted that the lack of extension services was a major hindrance to agricultural development in Makueni County. According to Makueni County Annual report (2017), the current ratio of extension officer to farmer is 1: 1,700 which is very high compared to the recommended ratio 1:690 by the FAO hence compromising effective access and use of appropriate agricultural technologies.

Majority of extension services were offered through home visits and field schools once per year. The government was the major provider of the services followed by NGOs, private organisations and agro based dealers. This finding is supported by Nyoro (2002) who found that the government of Kenya is the monopoly provider of extension services among smallholder farmers. This explains the heightened unavailability of extension services among farmers in the country which is linked to reduced allocation of government funds to agriculture.

Figure 4 shows intensified use of pesticides in the study area since 87.6 percent of the farmers used them. This is explained by the fact that majority of farmers produce cowpeas, citrus, mangoes among other fruit trees which require the use of pesticides during flowering and fruit development to control pests and diseases and increase yields. This finding corroborates with that of Mwangangi et al. (2012) who reported that 84 percent of the farmers used pesticides in their farms. Contrary to high pesticide use, the use of herbicides was very low in the study area. This is because farmers preferred weeding since it was considered cheaper than buying the herbicides.

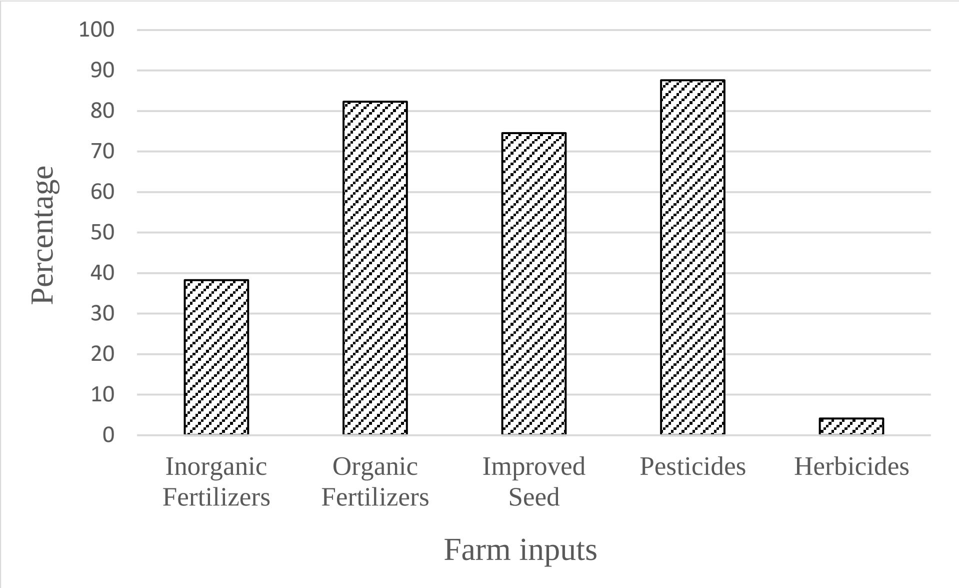

Figure 4: Household's access to farm inputs

Source: Author's Survey (2017)

Among the households interviewed, 74 percent accessed improved seed. This was mainly from relief distribution from both government agencies and non-government organisation (NGOs) and minimal purchases from local agricultural based stores. Although majority of farmers accessed improved seed, the quantities accessed were minimal due to high prices and limited supplies from NGOs (FAO, 2014). Therefore, farmers planted both improved seed and indigenous seeds from their previous harvests.

There was less use of inorganic fertilizers in the area since only 38.27 percent of households accessed them. Majority of farmers attributed less use of inorganic fertilizers to high prices, reduced soil fertility and low rainfall. According to MoALF (2016), high fertilizer prices, farmer's belief that they resulted to poor soils and that crops were more tolerant to drought when planted without them were reasons for their reduced uptake in Makueni County. Unlike inorganic fertilizers, organic fertilizers were used by majority of farmers interviewed because livestock keeping made them easily accessible. Moreover, many regions in Sub-Saharan

Africa are characterised by declining soil fertility and therefore farmers prefer the use of organic manure to replenish organic matter and nutrient content (FAO, 2015).

Further, the results in Table 2 show that 78 percent of the respondent were members of social development groups mainly for social welfare and credit access. Figure 5 shows that among the households in social groups 52 percent were members of Sacco societies. The high percentage of members in Sacco societies can be explained by the fact that members easily access credit based on their savings and are able to earn dividends based on their annual savings.

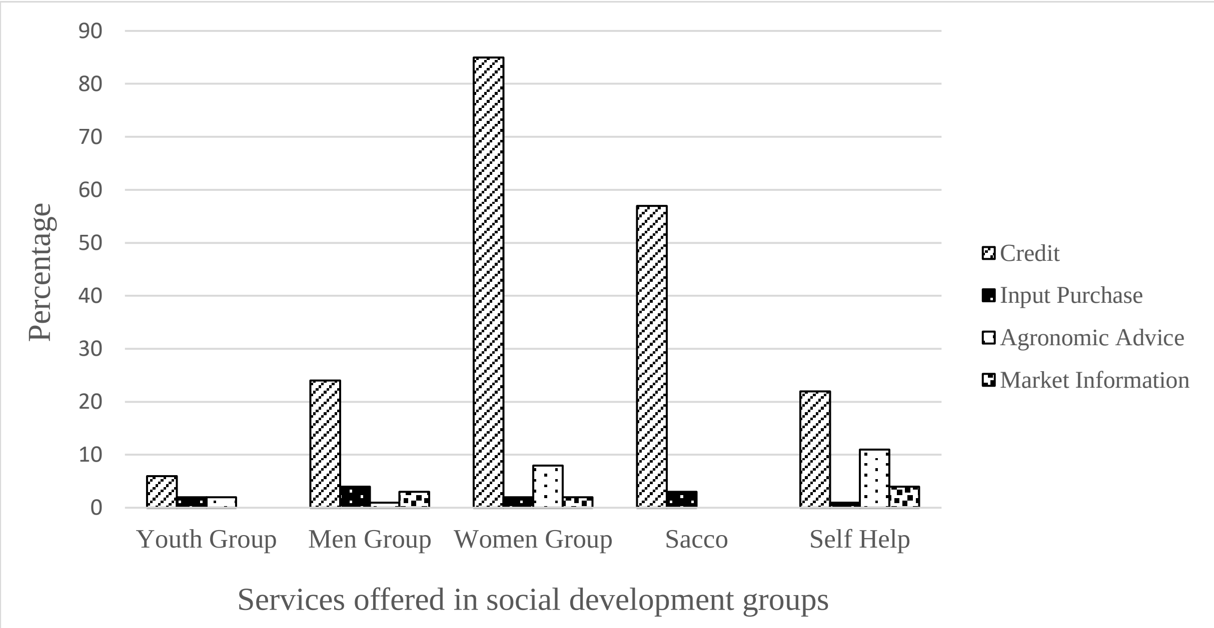

Figure 5: Services offered in social development groups

4.2 Characteristics of climate information services accessed by smallholder farmers

4.2.1 Exposure of climate-related shocks

Majority of smallholder farmers in Makueni County rely on rain-fed agriculture for their daily subsistence and income generation and this increases their vulnerability to climate variability. All the respondents agreed with the statement that climate has changed in the past twenty years. This finding corresponds with that of Kitinya et al. (2012) who found that majority of farmers agreed that the climate has changed over the years.

Table 5 shows various climate shocks experienced by the respondents in the last ten years. More than half of the farmers interviewed acknowledged that they had been exposed to various climate-related shocks in the last ten years. This finding corroborates with that of Mwangangi et al. (2012) who established that 99 percent of smallholder farmers in Makueni county have faced climate-related crisis in the last five years. From the results in Table 5 drought and erratic rainfall were the major climate shocks experienced in the area in the last ten years.

Table 5: Climate shocks experienced by households in last ten years

Climate shocks	**Percentage**
Drought	100
Erratic Rainfall	85
Emergence of new diseases and pests	84
Increased Germination failure	82
Floods	3
Hailstorms	0

Source: Author’s Survey (2017*)*

Frequent drought has also been reported as a major climate shock compromising smallholder crop and livestock farming in arid and semi-arid areas in Sub-Saharan Africa (Mongare and Chege, 2011; Macharia et al., 2012; Otieno et al., 2015; Mutua et al., 2016; Coulibaly et al., 2017). In their study on the evaluation of nature of drought experienced in Makueni County, Mutua et al. (2016) reported that meteorological drought was the major form of drought recorded using standardised precipitation index (SPI). This drought occurs when the degree of precipitation levels is below average over a prolonged period. Among metrological drought is agricultural drought defined as insufficient soil moisture content for crop production and hydrological drought which is below statistical average water levels in lakes, rivers, dams among other water reservoirs (KOPRA, 2010). The frequent drought has resulted in increased crop failure, reduced household herd sizes and recurrent water shortages in the study area (Mongare and Chege, 2011; Mutua et al., 2016).

Table 5 shows that 84 percent of households interviewed reported the emergence of new diseases as an effect of climate change. This corroborates with Yvonne et al. (2016) findings that the increase in diseases was identified as one of the effects of climate change in lower Eastern Kenya. Moreover, 82 percent of households associated increase in germination failure to increased temperatures and variable precipitation levels. Omoyo et al. (2015) reported similar findings that increased evapotranspiration reduced maize seed germination in arid and semi-arid areas of lower eastern Kenya.

Makueni County is classified as an arid and semi-arid area which explains the reported minimum percent of respondents that have been exposed to floods and hailstorm. This observation is supported by Bryan et al. (2011) who concluded that hailstorms and floods are uncommon perils in areas experiencing low and variable precipitation levels. This area did not experience heavy rainfall related perils except the one instance of *el.Nino* rains of 1997 which were reported in the countrywide and rest of the East African region.

4.2.2 Types of climate information services accessed by households

Table 6 shows that more than half of the respondents received climate information. This finding is slightly higher than that of Oyekale (2015) findings in East Africa that 49.4 percent of farmers had access to agronomic advice that accompanied forecast. The various types of climate information and services accessed by households in the study were; seasonal, extreme, daily, weekly, monthly, long-term and indigenous climate information and services.

The seasonal forecast was accessed by majority of farmers followed by a forecast of extreme events and indigenous forecast. These findings are similar to that of Recha et al. (2008) who reported that majority of households in Makueni County were aware of seasonal climate information services. The daily weather forecast was also accessed by more than half of the respondents. Weekly, monthly and long-term forecast were accessed by less than a third of the respondents. These findings correspond with that of Coulibaly et al. (2015) who reported that only a small percent of farmers in Rwanda had access to weekly and monthly forecast.

Table 6: Types of climate information accessed by farmers

Type of forecast	Access to climate information %	Access to climate information with agronomic advice (CIS)%
Seasonal forecast	94.20	77.78
Extreme events forecast	79.46	46.50
Daily climate forecast	60.36	8.23
Weekly forecast	24.54	7.41
Monthly forecast	16.97	8.29
Long-term forecast	28.05	14.81
Indigenous forecast	75.23	20.58

Source: Author's survey

Table 6 shows that 75 percent of households accessed indigenous climate information. This was slightly lower than access to seasonal forecast and forecast of extreme events. This is because access to indigenous forecast has reduced over the years compared to conventional forecast due to increased climate variability which has rendered it ineffective for farmers to predict (Tall et al., 2013). However, some pastoral communities majorly rely on indigenous knowledge due to lack of access to modern climate forecast (Ochieng et al., 2017).

Households that accessed indigenous forecast reported movement of the moon and stars, changes in behaviour and appearance of some insects and birds and flowering of some trees as various local climate indicators. These findings concur with those of Speranze at al. (2010) who established that appearance of rare insects, migration of bees and change in the behaviour of some birds and insects as indicators used to forecast drought in Makueni County. Coulibaly et al. (2015) also reported that change in cloud colours, colours of animal intestines when slaughtered were some of the natural indicators used to predict the weather by smallholder farmers in Tanzania. This shows that local indicators are not similar in various geographical locations because they are influenced by culture and beliefs of the community.

Among the households interviewed, 77.78 percent accessed seasonal forecast accompanied by agronomic advice. This finding was slightly higher than that of Oyekale (2015) who reported that 49 percent of farmers accessed seasonal forecast accompanied with agronomic advice in East Africa. Daily, weekly, monthly and long-term climate information was rarely accompanied with agronomic advice. This corroborates with that of Gichangi et al. (2015) who reported although the daily forecast was accessed by majority of farmers in semi-arid areas of Kenya it was not accompanied with information useful by farmers in decision making. Moreover, lack of agronomic advisory services for long-term forecast was linked to the fact that they were irrelevant at community level since farmers were more concerned with immediate issues and crisis (Srinivasan et al., 2011).

Introduction of new crop varieties, planting early maturing varieties, early land preparation and change of planting dates were the various agronomic advice that accompanied seasonal forecast (Table 7). This finding agrees with that of Recha et al., (2008) who found that change in planting dates and crop variety were the various agronomic advice that accompanied seasonal forecast from KMD. Households changed both maize and beans seed varieties depending on the forecast received but maintained cowpeas, green grams, sorghum and pigeon peas cultivars because they were not aware of available alternatives. Frequent drought was the major climate extreme experienced by households. Planting of drought-tolerant varieties and early maturing varieties were the agronomic advice that accompanied prediction on drought occurrence.

Table 7: Agronomic advice that accompanies seasonal and extreme events forecast

Climate forecast	Agronomic advice received by farmers
Seasonal forecast	• Introduction of new crop varieties • Plant early maturing varieties • Early land preparation • Planting Dates (Early planting/Late planting)
Extreme events forecast	• Plant drought-tolerant varieties • Plant early maturing varieties

Source: Author’s survey (2017)

4.2.3 Dissemination channels of climate information services

Table 8 shows 82.96 percent of households interviewed reported radio as the predominant source of climate information, followed by television at 9.42 percent. This observation is supported by Amwata et al. (2016) findings that smallholder farmers in Makueni county highly relied on radios, television and audiovisuals sources which are classified he as conventional sources of climate information. Various studies on access to climate information services have reported radio as the main channel preferred by farmers (Hampson et al., 2014; Coulibaly et al., 2015; Serra and Mckune, 2016; Coulibaly et al., 2017). Ingram et al. 2002 and Oyekale (2015) linked high access to climate information services through the radio to low cost, trust, use of vernacular language and wide coverage.

Table 8: Climate information dissemination channels

Source of climate information	Percentage accessed
Radio	82.96
Televison	9.42
Newspapers	2.69
Friends and relatives	2.24
Peer farmers	0.90
Cell Phones	0.45
Baraza meetings	0.45
Printed material	0.45
Extension services	0.45

Source: Author's survey (2017)

Radio, television, cell phones, internet and printed media are various examples of sources of climate information which disseminate scientific climate forecast based on weather and climatic models provided by the Kenya Meteorological Department (KMD). Majority of conventional sources such as newspapers, internet and bulletins are not easily accessible to smallholder farmers in rural areas due to high cost, high illiteracy levels and lack of proper network access.

Findings as given in Table 8 show that the percentage of households that accessed climate information through extension services is insignificant since limited number of farmers had access to extension services. Serra and Mckune (2016) reported similar finding that access to climate information services through extension agents and baraza meetings was insignificant from a study conducted in Senegal on climate information services and behavioural change. Although extension agents are important and trusted source that significantly enhance access and use of climate information majority of smallholder farmers in Sub-Saharan African lack proper access of them which hinder their dependence for farm information (Mudombi and Nhamo, 2014; Ochieng et al., 2017). Areas with regular contact with extension agents reported that extension agents were a major source of access to climate information and services after radio (Kirui et al., 2012).

4.3 Usefulness of climate information and advisory services in farm decision making

Table 9 shows the various responses collected from households using a five-point Likert scale on the usefulness of climate information services in farm decision making.

Table 9: Usefulness of climate information services in farm decision making

Climate information services	% Respondent				
	Not useful	Small extend	Medium extend	Large extend	Very large extend
Seasonal CIS	27.13	21.81	16.49	26.06	8.51
Extreme CIS	16.07	38.39	29.46	9.82	6.25
Daily CIS	50.00	35.00	15.00		
Monthly CIS	64.71	29.41	5.88		
Long term CIS	63.16	26.32	10.53		
Indigenous CIS	34.00	38.00	28.00		

Source: Author's survey

Although 77 percent of household accessed seasonal climate information services (Table 6), 51 percent ranked it useful in farm decision making (Table 9). This was based on the reliability and accuracy of the forecast. The seasonal forecast is most useful to farmers compared to other CIS because of seasonality in rural agricultural production among households. The households in the study area have two production season whereby the first one occurs during the long rains (March to May) and the second during the short rains

(November to December). Farmer’s attitude towards the usefulness of seasonal forecast influences their intention to utilise it in their farm management strategies.

4.3.1 Household use of climate information services

Among the households that accessed seasonal climate information services, 40 percent utilised it for farm management decisions against climate change (Table 10). Among the farmers who never utilised CIS 41 percent reported that they did not trust the information. This finding is supported by that of Ziervogel et al. (2005) who established that household use of climate information was dependent on the trust placed on the forecast.

Table 10: Constraints to the use of climate information services

	Percentage % Yes
Used seasonal CIS in farm decision making	40
Barriers to use of CIS	
Not Reliable	40
Didn’t Trust	41
Difficult to understand	11

Source: Author’s survey 2017

Additionally, 40 percent of the farmers who never utilised CIS reported that the information was unreliable. This finding correspond to that of Coulibally et al. (2015) who established that farmers relied on climate information which was more reliable and relevant for their farm decision making. Moreover, Mudombi and Nhamo (2014) acknowledged that climate information should be reliable, trusted and understandable for farmers to utilise it in climate change adaptation.

Timing of land preparation, planting dates, where to plant, type of crop grown, use of manure and change in crop variety were the main changes effected after climate forecast (Table 11).

Table 11: Farm decisions influenced by climate information services

Changes in farm decision making	% Change Influenced by seasonal CIS	% Change influenced by Extreme CIS
Change in timing of land preparation	89.77	51.14
Changes in timing of planting	89.77	48.86
Change in the area allocated to crops	52.27	37.93
Change in decision on where to plant	44.32	43.68
Change in type of crop grown	73.86	45.98
Shift in crop variety	61.36	38.37
The timing of fertilizer application	29.55	14.94
Influence use of manure	46.59	18.60
Timing of weeding	27.27	31.03
Timing of harvesting	28.74	31.76
Timing of crop sales	11.36	19.77
Timing of cattle grazing	10.34	18.39
Decision on where to graze	18.39	24.71
Decision on where to vaccinate	17.05	19.54
Timing of cattle sales	10.47	11.63
Decision on livelihood to start	6.82	10.47
Decision on involvement in off-farm business	14.94	14.94
Decision on the type of livestock kept	4.65	13.95

Source: Author’s Survey (2017)

These findings concur with those of Recha et al. (2008) who established that change in cultivar, application of fertilizers, area planted and planting dates were farm management strategies that reflected the use of seasonal forecast in Kenya. Serra and Mckune (2016) reported similar finding in Senegal that change in furrow orientation during lands preparation, proportion of land allocated for crops and change in crop variety were major farm management changes influenced by climate information services.

4.4 Determinants of access to climate information services

The study used a two-stage probit model with sample selection (Heckprobit model) to control for non-exposure to selectivity bias since farmers who used CIS were non-randomly selected from those who accessed the information. The first stage of the Heckprobit model (selection equation) identified determinants of access to seasonal climate information services.

The multicollinearity test showed that no independent variables were correlated therefore all the variables were included in the model for estimation. The Hausman test showed that there was no endogeneity.

The results indicated the presence of sample selection problem (dependence of the error terms from the outcome and selection models) with rho significantly different from zero (Wald $\chi 2=4{\cdot}44$, with $P=0{\cdot}035$) hence justifying the use of Heckprobit model. Moreover, the likelihood function of the Heckprobit model was significant at 1 percent (Wald $\chi 2=58{\cdot}89$, with $P<0{\cdot}00$), showing its strong explanatory power.

The results of the selection equation showed that age of household head reduced the likelihood of access while household size, television ownership, income, farming and group membership increased the likelihood of access to climate information services. The results in Table 12 show that an increase in the age of household head reduced the likelihood of access to seasonal CIS by 0.85 percent. This implied that older farmers had a less likelihood of accessing climate information services.

This is because older farmers have established climate change adaptation and risk spreading skills which reduce their demand for CIS (Ingram et al., 2002). Moreover, Kirui et al. (2012) established that older farmers preferred indigenous knowledge over modern climate information services.

Table 12: Marginal effects of access to seasonal climate information services

Dependent variable	Access to seasonal CIS		
Independent variable	dy/dx	Std. Err.	P>z
Age of household head	-0.0085	0.00229	0.000***
Gender of household head	-0.0600	0.05593	0.284
Household size	0.0284	0.01517	0.061*
Education of household head	-0.0122	0.00757	0.107
Total farm land	0.0227	0.00803	0.005***
Frequency of draught	-0.0418	0.05394	0.439
Extension services	-0.0550	0.0692	0.427
Credit facilities	0.0716	0.05924	0.227
Main income activity	0.1936	0.06558	0.003***
Monthly income	0.0724	0.02424	0.003***
Ownership of radio	0.0824	0.09564	0.389
Ownership of television	0.0984	0.04932	0.046**
Access to improved seed	0.1248	0.07323	0.88
Group membership	0.1315	0.04971	0.008***

Source: Author’s Survey 2017

Notes: The coefficient of total income was zero which implied high variance in the variable, therefore natural log was taken and used for analysis in the model.

Number of observations 231, Censored observations 52, Uncensored observations 179, Wald chi2 (16) 58.89. Prob>chi 2 0.0000 LR test of indep. eqns. (rho = 0): chi2 (1) = 4.44 Prob > chi2 = 0.035. ***, ** and * represent 1%, 5% and 10% significance levels respectively

The results from this study showed that an increase in household size by one member increased the likelihood of access to seasonal CIS by 2.8 percent. This implied that households with more members had a higher chance of accessing CIS from different sources. Moreover, Deressa et al. (2008) established that households with more members were more likely to adapt to climate change hence a higher demand for climate information services.

A unit increase in farm size increased the likelihood of accessing climate information services by 2.3 percent. This is because households with large farm size are able to diversify crops options and spread risks associated with unpredictable climate hence high demand for CIS. This finding concurs with that of Rehman et al. (2013) who established that an increase in farm size resulted in increased access to agricultural information. Moreover, farmers with large farms have a higher demand for climate information due to the enormity of expected loss attributed to climate change (Oyekale, 2015).

Farmers who engaged in farming as the major livelihood activity had a higher likelihood of access to climate information services. This is because compared to other farmers who have alternative income sources and practiced farming as a mere tradition, farmers who engaged in farming as the major income activity are compelled to seek information and technologies to maximise farm production (Mulinya, 2017). Additionally, households that depend on farming as the main sources of income are more vulnerable to variable climate change hence their need to keep up with climate information services to enhance sustainable agricultural production.

The results also showed that a unit increase in household monthly income increased the likelihood of access to climate information services by 7.2 percent. This is because high income increased household’s adaptive capacity which enhanced their demand for CIS.

This finding is similar to that of Oyekale (2015) who reported that households with higher incomes had a higher probability of accessing climate information in East Africa. Furthermore, increase in household income has a positive relationship with willingness to pay for climate information services (Ouédraogo et al., 2018).

The results show that television ownership increased the likelihood of access to CIS. According to Antwi-Agyei et al. (2013) ownership of communication gadgets such as television enhance access to climate information. Furthermore, television was the main dissemination channels of CIS in the study area after radio.

Group membership increased household’s likelihood of access to CIS. This is because these groups promote farmers’ social capital which enhances networking and information flow. Roncoli et al. (2009) reported similar finding in Burkina Faso that farmers who participated in farmer workshops accessed climate information and understood better probabilistic climate forecast compared to the farmer who did not attend.

4.5 Determinants of use of climate information services

The outcome equation of Heckprobit model analysed the determinants of use of seasonal climate information services. The results showed that age, gender and previous exposure to climate shocks reduced the likelihood of utilising CIS while household income, farming, access to improved seed and radio ownership increased it. Gender plays a significant role in shaping the usability of climate information for adaptation. The results in Table 13 showed that women-headed households had a higher likelihood of utilising seasonal climate information services than male-headed households. This is attributed to the fact that women contribute the highest percentage of rural agriculture compared to men in Africa (FAO, 2015). This finding concurs with those of McOmber et al. (2013) and Shongwe (2014) who reported that women are the main agents in climate change adaptation.

An increase in household head age by one year reduced the likelihood of utilising climate information services by 0.6 percent. This is because older farmers in the study area had less likelihood of accessing climate information services.

Table 13: Marginal effects of utilisation of seasonal climate information services

Dependent variable	Use of seasonal CIS		
Independent variable	dy/dx	Std. Err.	P>z
Age of household head	-0.0060	0.0029	0.037**
Gender of household head	-0.1618	0.0806	0.045**
Household Size	-0.0202	0.0188	0.283
Education	0.0004	0.0106	0.968
Total farm land	-0.0056	0.0086	0.517
Frequency of draught	-0.1461	0.0697	0.036**
Extension services	0.1038	0.0824	0.208
Credit facilities	0.0212	0.0725	0.769
Main income activity	0.2516	0.0796	0.002***
Monthly income	0.2361	0.0367	0***
Ownership of radio	0.2204	0.0711	0.002***
Ownership of television	0.0385	0.0650	0.553
Access to organic fertilizers	0.1307	0.0801	0.103

Access to improved seed	0.1330	0.0723	0.066*
Access to farm equipment	0.1995	0.2738	0.466

Source: Author's Survey 2017

This showed that older farmers were risk averse compared to young farmers who were flexible to use climate information services in farm decision making.

This finding is similar to that of Mulinya (2017) who found that older farmers had less incentive to climate change issues. Moreover, this can be explained by the fact that older farmers have lower energy compared to young farmers who are able to adapt to labour intensive climate-smart agricultural practices (Shongwe, 2014).

A unit increase in household monthly income increased the likelihood of utilising climate information services in risk management decisions by 24 percent. Farmer's response to planting drought-tolerant varieties in expectation of below normal rainfall requires finances to purchase the improved seed. This finding corroborates with those of Ingram et al. (2002) and Ziervogel (2004) who found that lack of finances hindered farmers from using CIS in farm decision making. Moreover, Hansen et al. (2011) linked chronic poverty in Sub-Saharan African to resource limitation that significantly reduced the use of seasonal forecast in farm decision making.

The results also showed that Radio ownership increased the likelihood of utilising seasonal climate information services. This relates to the fact that radio was the most preferred dissemination channel of climate information services in the study area. These findings are similar to that of Oyekale (2012) who reported that radio ownership increased the likelihood utilisation of climate forecast in Limpopo river basin. Moreover, Hampson et al. (2014) established that majority of the farmers used climate information disseminated through radio which was the most trusted and preferred channel.

Frequent exposure to drought reduced household's likelihood of utilising seasonal climate information services in farm decision making by 15 percent. This finding agrees to that of Ziervogel and Calder (2003) who found that farmers who were exposed to previous climate shocks were reluctant to use climate information in farm decision due to reduced or lack of confidence in them. The limited use of CIS could be linked to the fact frequent exposure to climate shocks forced farmers to seek alternative livelihood options that were not vulnerable to climate change (Ogara, 2016).

Access to improved seed increased household's likelihood of utilising climate information services. This finding is supported by that of Patt et al. (2005) who found that access to climate information services was less valuable in farm management decisions without access to farm inputs. Farmer's ability to utilise climate information services in farm decision making is dependent on their access to required farm inputs to maximise benefits of climate information services (O'Brien et al., 2000). Additionally, Recha et al. (2008) and Kitinya et al. (2012) established that lack of improved seeds and seedling were main constraints to efficient crop production.

The results also showed that the households that relied on farming as the main livelihood activity had a higher likelihood of utilising climate information services. This finding agrees with that of Frisvold (2013) who found that an increase in the share of household income derived from agriculture resulted in higher utilisation of climate data.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study established that the average age of smallholder farmers in Makueni County was 53 years. The respondents had acquired primary level education and mixed farming was the main source of livelihood. The main crops grown were maize, beans, pigeon peas, cowpeas, sorghum, green grams, mango and citrus fruit trees. Majority of cereals were grown for household consumption while fruit trees were for commercial purposes. Limited fertilizer use was reported in the study area. This was linked to high fertilizer prices, low rainfall and declining soil fertility. The results also showed that majority of households accessed improved seed in limited quantities due to high prices.

All the respondents acknowledged that the climate has changed in the past 20 years. The various climate shocks reported were frequent drought, more erratic rainfall, the emergence of new diseases and pests and increased germination failure. Drought and erratic rainfall were the main climate shocks that increased food insecurity and water stress in the area.

Majority of households interviewed accessed climate information. Seasonal climate information, the forecast of extreme events, indigenous climate information and daily climate information were the common types of climate information accessed. Radio was the main source of climate information followed by television. Among the households that accessed seasonal climate information, more than half acknowledge that it was accompanied by agronomic advice. Seasonal climate information services were recorded as most useful in farm decision making compared to other climate information services. Among the households that accessed seasonal climate information services, less than half used it in their farms for climate change adaptation. Lack of trust and unreliability of climate information services were the main barriers to their utilisation in farm decisions against climate risks.

Moreover, the results showed older farmers were less likely to access and utilise climate information services. Both men and women headed households accessed climate information services, but female-headed households had a higher likelihood of accessing and utilising it in farm management decisions. Group membership and ownership of radio increased household's likelihood of access to climate information services. Television ownership and access to improved seed increased the likelihood of utilising CIS. Moreover, the results showed that the households frequently exposed to drought had a lower likelihood of utilising climate information services.

5.2 Recommendations

A limited number of households utilised climate information services in farm management decisions. Lack of trust and unreliability of CIS were reported as the main constraints. Therefore, provision of accurate, timely and usable information should be the priority of the Kenya Meteorological Department and other providers of climate information services. Moreover, the providers of climate information services should acknowledge the usefulness of the indigenous forecast and combine it with scientific forecasts to enhance trust in the information.

Household's access to improved seed enhanced the utilisation of CIS. Therefore, resources should be provided to ensure access of improved seed at low cost by all farmers to enhance climate change adaptation. Moreover, female-headed households were more likely to utilise climate information services compared to men-headed households. Therefore, this study suggests that policies should promote women access to production resources to enhance utilisation of CIS. In addition, the providers of CIS should enhance dissemination of the information through channels targeting women.

Younger farmers had a higher likelihood of accessing and using climate information services. Therefore, the providers of CIS should target younger farmers in formulation and dissemination of the CIS to enhance climate change adaptation. Television (TV) and Radio ownership also increased the likelihood of access and use of climate information services. Therefore, the providers of climate information services should enhance timely and frequent dissemination of detailed climate information through channels that target famers who do not own radio and TV to ensure majority of farmers' access and utilise it.

5.3 Suggestions for further research

Although the study established that television and radio ownership enhanced access and use of CIS, information on the timing of when CIS are communicated through TV and radio was not captured. Moreover, the number of times the household head used the television or radio was not captured. Therefore, this calls for a study to establish how the timing of CIS broadcasting and the number of times of television and radio viewing affect household's access and use of the information.

The findings also showed that female headed households had a higher likelihood of utilising CIS therefore research should be done to establish the various dissemination channels preferred by women.

References

Ali, A., and Erenstein, O. (2017). Climate Risk Management Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. Climate Risk Management, *16*, 183–194. https://doi.org/10.1016/j.crm.2016.12.001

Amissah-Arthur, A. (2003). Targeting Climate Forecasts For Agricultural Applications In Sub-Saharan Africa : Situating Farmers, Climatic Change 58: 73–92

Amwata, D.A., Nyariki, D.M. and Musimba, N.R. K. (2016) Factors Influencing Pastoral and Agropastoral Household Vulnerability to Food Insecurity in The Drylands of Kenya: A Case Study of Kajiado and Makueni Counties. Journal of International Development, J. Int. Dev. 28, 771–787.

Asrat, P. and Simane, B. (2018). Farmers' perception of climate change and adaptation strategies in the Dabus watershed, North-West Ethiopia. Ecological Processes, 7:7 https://doi.org/10.1186/s13717-018-0118-8

Belay, A., Recha, J.W., Woldeamanuel, T. and Morton, J. F. (2017) Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. Agric & Food Security. 6:24 DOI 10.1186/s40066-017-0100-1

Bernard, M., Adwera, O. A., Kungu, K. J., Charles, T. and Wakhungu, P. J. W. (2012). Case Study on Climate Compatible Development (CCD) in Agriculture for Food Security in Kenya Prepared by Technical Guidance and Support : African Centre for Technology Studies (ACTS) Project : Advancing Climate Compatible Development for Food Security, (November).

Billari, F.C. and Borgoni, R. (2005) Assessing the use of sample selection models in the estimation of fertility postponement effects. Statistical Methods & Applications 14:

389–402 DOI: 10.1007/s10260-005-0122-x

Bobadoye, A.O., Ogara, W.O., Ouma, G.O. and Onono, J.O. (2016). Assessing Climate Change Adaptation Strategies among Rural Maasai pastoralist in Kenya. American Journal of Rural Development, Vol. 4, No. 6, 120-128.

Brooks, K., Zorya, S., Gautam, A. and Goyal, A. (2013). Agriculture as a sector of Opportunity for Young people in Africa. Policy research working Paper Report number WPS 6473

Bryan, E., Deressa, T. T., Gbetibouo, G. A. and Ringler, C. (2009). Adaptation to climate change in Ethiopia and South Africa : options and constraints. Environmental Science & Policy 1 2 413–426 https://doi.org/10.1016/j.envsci.2008.11.002

Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S. and Herrero, M. (2011). Adapting agriculture to climate change in Kenya : Household strategies and determinants.

Chamboko, T., Mtambanemgwe, F., Chikowo, R., Mapfumo, P. and Mekutia, M. 2008. Climate change and variability information access and adaptation: The case of smallholder farming communities in Zimbabwe. pp. 110-115.

Chang'a, L. B., Yanda, P. Z. and 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 Vol. 3(4), pp. 66-72.

Coulibaly Y. J., G. Kundhlande, N. Amosi, Tall A., Kaur H. and Hansen J. (2015). What climate services do farmers and pastoralists need in Tanzania? Baseline study for the GFCS Adaptation Program in Africa. CCAFS Working Paper no. 110. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at www.ccafs.cgiar.org

Coulibaly, J.Y., Birachi. E.A., Kagabo, D.M. and Mutua, M. (2017). Climate services for Agriculture in Rwanda: Baseline survey report. CCAFS Working Paper no. 202. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available online at www.ccafs.cgiar.org

Coulibaly, J.Y., Kundhlande G., Tall A., Kaur H. and Hansen, J. (2015). What Climate Services Do Farmers and Pastoralists Need in Malawi? Baseline Study for the GFCS Adaptation Program in Africa. CCAFS Working Paper no. 112. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at www.ccafs.cgiar.org

Deressa, T. T., Hassan, R. M. and Ringler, C. (2011). Climate Change and Agriculture Paper: Perception Of and Adaptation to Climate Change by Farmers in the Nile Basin of Ethiopia. Journal of Agricultural Science, 149, 23–31, DOI: 10.1017/S0021859610000687

Deressa, T., Hassan, R.M., Alemu, T., Yesuf, M. and Ringler, C. (2008). Analysing the Determinants of Farmers' Choice of Adaptation Methods and Perceptions of Climate Change in the Nile Basin of Ethiopia. IFPRI Discussion Paper 00798.

Desanker, P. V. and Justice, C. O. (2001). Africa and global climate change : critical issues and suggestions for further research and integrated assessment modeling, Climate Research Vol. 17: 93–103, 2001

Dinku. T., Asefa. K., Hilemariam. K., Grimes, D. and Connor, S. (2011). Improving availability, access and use of climate information. WMO Bulletin, 60 (2).

Dore, M. H. I. (2005). Climate change and changes in global precipitation patterns : What do we know ? *31*, 1167–1181. https://doi.org/10.1016/j.envint.2005.03.004

Eriksen, S. and Rosentrater, L. (2008). Climate Change in Eastern and Southern Africa Impacts, Vulnerability and Adaptation Climate Change in Eastern and Southern Africa Impacts, Vulnerability and Adaptation.

Food and Agriculture Organization of the United Nations (FAO). (2011).The role of women in agriculture. Food and Agriculture Organization of the United Nations: Rome, Italy. ESA Working Paper No. 11-02

Food and Agriculture Organization of the United Nations (FAO). (2014). Seed Security Assessment in the South-Eastern livelihood Zones of Kenya. Food and Agriculture Organization of the United Nations: Rome, Italy.

Food and Agriculture Organization of the United Nations (FAO). (2015).The economic lives of smallholder farmers. Food and Agriculture Organization of the United Nations: Rome, Italy.

Frisvold, G. B. and Murugesan, A. (2013). Use of Weather Information for Agricultural Decision Making. Weather Climate and Society, volume 5, DOI: 10.1175/WCAS-D-12-00022.1.

Gessei, M. M. (2012). Towards improving smallholder agriculture: Role of climate information services in Ethiopia.

Gichangi, E.M., Gatheru, M., Njiru, E.N., Mungube, E.O., Wambua, J.M. and Wamuongo, J.W. (2015).Assessment of climate variability and change in semi-arid eastern Kenya. Climatic Change, 130, 287–297, DOI 10.1007/s10584-015-1341-2.

Graham, R., Ticehurst, H., Leathes, B., Visman, E., Bayley, S., Kane, C. and Rosalind, G. (2015). Scoping, Options Analysis and Design of a “ Climate Information and Services Programme ” for Africa (CIASA): Final report May 2015.

Greene, W. H. (2002). *ECONOMETRIC ANALYSIS Senior Media Project Manager : Victoria Anderson Production Editor : Michael Reynolds*.

Gujarati, D. N. (2004). *Basic econometrics*. Tata McGraw-Hill Education.

Hammer, G. L., Hansen, J. W., Phillips, J. G., Mjelde, J. W., Hill, H., Love, A., and Potgieter, A. (2001). Advances in application of climate prediction in agriculture, Agricultural Systems 70, 515–553

Hampson, K.J., Chapota, R., Emmanuel, J., Tall, A., Huggins-Rao, S., Leclair, M., Perkins, K., Kaur, H. and Hansen, J. (2014). Delivering climate services for farmers and pastoralists through interactive radio: scoping report for the GFCS Adaptation Programme in Africa. CCAFS Working Paper no. 111. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at www.ccafs.cgiar.org

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

Hansen, J. W., Marx, S. and Weber, E. (2004).The Role of Climate Perceptions, Expectations, and Forecasts in Farmer Decision Making. International Research Institute for Climate Prediction (IRI).

Hansen, J.W., Masons, S.J., Sun, L. and Tall, A. (2011). Review of Seasonal Climate Forecasting for Agriculture in Sub-Saharan Africa. Expl Agric, volume 47 (2), pp. 205–240, DOI: 10.1017/S0014479710000876

Hassan, R., and Nhemachena, C. (2008). Determinants of African farmers' strategies for adapting to climate change: Multinomial choice analysis. *African Journal of Agricultural and Resource Economics*, *2*(1), 83-104.

Heckman, J.J. ‘Sample Selection Bias as a Specification Error’, *Econometrica (*1979*), 47(1),* 153-162.

Herrero, M., Ringler, C., Van de Steeg, J., Thornton. P., Zhu, T., Bryan, E., Omolo, A., Koo, J. and Notenbaert, A. (2010). Climate variability and climate change and their impacts on Kenya’s agricultural sector. Nairobi, Kenya. ILRI.

Howden, S. M., Soussana, J., Tubiello, F. N., Chhetri N., Dunlop, M. and Meinke, H. (2007) Adapting agriculture to climate change PNAS vol. 104 _ no. 50 _ 19691–19696

http://dx.doi.org/10.1787/9789264235199-en

Ingram, K.T., Roncoli, M.C. and Kirshen, P.H. (2002). Opportunities and constraints for farmers of West Africa to use seasonal precipitation forecasts with Burkina Faso as a case study. Agricultural Systems, 74, 331–349.

Jones, J.W., Hansen, J. W., Royce, F. S. and Messina, C.D. (2000). Potential benefits of climate forecasting to agriculture Agriculture. Ecosystems and Environment, 82, 169–184.

Kadi M., Njau L.N., Mwikya J. and 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

Kagunyu, A., Wandibba, S. and Wanjohi, J. G. (2016). The use of indigenous climate forecasting methods by the pastoralists of Northern Kenya. Pastoralism, 6(1), 7.

Kiem, A.S. and Austin, A. S. (2013). Drought and the future of rural communities: Opportunities and challenges for climate change adaptation in regional Victoria, Australia. Global Environmental Change, 23, 1307-1316.

Kirui, V.C., Waiganjo, M. and Cheplogoi, S. (2014). Evaluating Access and Use of

Dissemination Pathways for Delivering Climate Information and Services to Women Farmers in Semi-Arid Kenya. International Journal of Advanced Research, Volume 2, Issue 9, 44-53

Kitinya, K.T., Onwonga, R.N., Onyango, C. and Mbuvi, J.P. (2012). Climate Change and Variability: Farmers' Perception, Experience and Adaptation Strategies in Makueni County Kenya. Asian Economic and Social Society, Volume 2, No. 3. ISSN (P): 2304-1455, ISSN (E): 2224-4433.

Klopper1, E., Vogel, C.H. and Landman, A.W. (2006). Seasonal Climate Forecasts – Potential Agricultural-Risk Management Tools? Climatic Change, 76, 73–90, DOI: 10.1007/s10584-005-9019-9.

Kothari, C. R. (2004). *Research Methodology: Methods & Techniques*. *New Age International (P) Ltd*. https://doi.org/10.1017/CBO9781107415324.004

Liang, S. (2017). Incorporating Indigenous Knowledge in the Local Government ' s Early Warning System : A Case Study from Baringo County, Kenya Incorporating Indigenous Knowledge in the Local Government ' s Early Warning System : A Case Study from Baringo County, Kenya.

Luseno, W. K., Mcpeak, J. G., Barrett, C. B., and Little, P. D. (2003). Assessing the Value of Climate Forecast Information for Pastoralists : Evidence from Southern Ethiopia and Northern Kenya, *31*(9), 1477–1494. https://doi.org/10.1016/S0305-750X(03)00113-X

Macharia, P.N., Thuranira, E.G., Ng'ang'a, L.W., Lugadiru, J. and Wakori, S. (2012). Perceptions and Adaptation to Climate Change and Variability by Immigrant Farmers in Semi-Arid Regions of Kenya. African Crop Science Journal, Vol. 20, Issue Supplement s2, pp. 287 – 296.

Marshall, N. A., Gordon, I. J. and Ash, A. J. (2011). The reluctance of resource-users to adopt seasonal climate forecasts to enhance resilience to climate variability on the rangelands. *Climatic Change*, *107*(3-4), 511-529.

McCrea. R., Dalgleish L. and Coventry, W. (2005). Encouraging use of seasonal climate forecasts by farmers, International Journal of Climatology Int. J. Climatol. 25: 1127–1137 (2005). DOI: 10.1002/joc.11641137, 1127–1137. https://doi.org/10.1002/joc.1164

McOmber, C., Panikowski, A., McKune, S., Bartels, W. and Russo, S. (2013). Investigating Climate Information Services through a Gendered Lens. CCAFS Working Paper no. 42, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at www.ccafs.cgiar.org

Mongare, N. and Chege, W. (2011). Livelihoods under climate variability and change: An analysis of the adaptive capacity of rural poor to water scarcity in Kenya's drylands. Journal of Environmental Science and Technology, 4(4), 403-410.

Mudombi. S. and Nhamo, G. (2014). Access to Weather Forecasting and Early Warning Information by Communal Farmers in Seke and Murewa Districts, Zimbabwe. J Hum Ecol, 48(3): 357-366.

Mulinya, C. (2017). Factors Affecting Small Scale Farmers Coping Strategies To Climate Change In Kakamega County In Kenya. IOSR Journal of Humanities and Social Science (IOSR-JHSS), Volume 22, Issue 2, Ver. II, PP 100-109 e-ISSN: 2279-0837, p-ISSN: 2279-0845. www.iosrjournals.org

Mutimba, S., Mayieko, S., Olum, P., and Wanyatma, K. (2010). Vulnerability and Adaptation Preparedness in Kenya.

Mutua, L. N., Omuterema, S. and Gweyi, J. O. (2016). Evaluation of the Nature of Drought

Experienced in Makueni County, Kenya.

Mutua, L.N., Omuterema, S. and Gweyi, J.O. (2016). Evaluation of the Nature of Drought Experienced in Makueni County, Kenya. Research on Humanities and Social Sciences, Vol.6, No.16.

Mutunga, E.J., Charles, N.K. and Patricia, M. (2017). Smallholder Farmers' Perceptions and Adaptations to Climate Change and Variability in Kitui County, Kenya. Earth Sci Clim Change, 8:3 DOI: 10.4172/2157-7617.1000389.

Mwadalu, R. and Mwangi, M. (2013). The potential role of sorghum in enhancing food security in semi-arid eastern Kenya : A review, 5786–5799.

Mwangangi, M., Mutie, M. and Mango, J. (2012). Summary of Baseline Household Survey Results: Makueni, Kenya. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at www.ccafs.cgiar.org.

Nganga, J. K. (2006). Climate change impacts, vulnerability and adaptation assessment in East Africa.

Nkondze, M. S., Masuku, M. B., & Manyatsi, A. (2013). Factors affecting household's vulnerability to climate change in swaziland: a case of Mpolonjeni Area Development Programme (ADP). Journal of Agricultural Science, 5(10), 108.

O'Brien, K., Sygna, L., Næss, L.O., Kingamkono, R. and Hochobeb, B. (2000). Is Information Enough? User Responses to Seasonal Climate Forecasts in Southern Africa. Center for International Climate and Environmental Research, (3).

Ochieng, R., Recha, C. and Bebe, B.O. (2017). Enabling Conditions for Improved Use of Seasonal Climate Forecast in Arid and Semi-Arid Baringo County—Kenya. Open

Access Library Journal, Volume 4, e3826ISSN Online: 2333-9721 ISSN Print: 2333-9705.

OECD (2015), Environment at a Glance 2015: OECD Indicators, OECD Publishing, Paris.

Omoyo, N.N., Wakhungu, J. and Oteng'i, S. (2015). Effects of climate variability on maize yield in the arid and semi-arid lands of lower eastern Kenya. Agriculture & Food Security, 4:8 DOI 10.1186/s40066-015-0028-2.

Onyango, E., Ochieng, S., Awiti, A., Onyango, E., Ochieng, S., & Awiti, A. O. (2014). Weather and climate information needs of small-scale farming and fishing communities in western Kenya for enhanced adaptive potential to climate change Weather and climate information needs of small-scale farming and fishing communities in western Kenya, (January), 187–193.

Orlove, B. S., Broad, K., and Petty, A. M. (2004). Factors that influence the use of climate forecasts: evidence from the 1997/98 El Nino event in Peru. *Bulletin of the American Meteorological Society*, *85*(11), 1735-1743.

Otieno, O.G.; Junga, J.O.; Badamana, M. S.; Amimo, J.o. (2015). Indigenous Knowledge Used in Breeding and Management of Capra hircus Populations in Kajiado and Makueni Counties, Kenya. Open Journal of Genetics, 5, 111-135.

Ouédraogo, M., Barry, S., Zougmoré, R. B., Partey, S. T., Somé, L., & Baki, G. (2018). Farmers' Willingness to Pay for Climate Information Services: Evidence from Cowpea and Sesame Producers in Northern Burkina Faso. Sustainability, 10(3), 611.

Oyekale, A.S. (2012). Factors influencing access to climate forecasts in the Limpopo River Basin of South Africa. Journal of Food, Agriculture & Environment, Vol.10 (3&4), 1058-1062.

Oyekale, A.S. (2015). Factors Explaining Farm Households ' Access to and Utilization of Extreme Climate Forecasts in Sub-Saharan Africa (SSA). Environmental Economics, 6 (1), 91–103

Patt, A., Suarez, P., Gwata, C. and Clark, W.C. (2005). Effects of Seasonal Climate Forecasts and Participatory Workshops among Subsistence Farmers in Zimbabwe. Proceedings of the National Academy of Sciences of the United States of America, Vol. 102, No. 35 pp. 12623-12628.

Rech, C.W., Shisanya, C.A., Makokha, G.L. and Kinuthia, R.N. (2008). Perception and use of Climate Forecast Information among Smallholder Farmers in Semi-Arid Kenya. Asian Journal of applied sciences, 1(2): 123-135.

Rehman, F., Muhammad, S., Ashraf, I., and Ruby, T. (2013). Effect of Farmers' socioeconomic Characteristics on Access to Agricultural Information: Empirical Evidence from Pakistan. *Young (Up to 35), 52*, 21-67.

Republic of Kenya, Makueni County. (2013). First County Integrated Development Plan 2013-2017, August

Republic Of Kenya, Makueni County. (2016). Wealth Creation and Socio-Economic Transformation Annual Development Plan 2017/2018.

Roncoli, C. (2006). Ethnographic and Participatory Approaches to Research on Farmers ' Responses to Climate Predictions. Climate Research, 33, 81–99.

Roncoli, C., Jost, C., Kirshen, P., Sanon, M., Ingram, K.T., Woodin, M., Somé, L., Ouattara, F., Sanfo, B.J, Sia, C., Yaka, P. and Hoogenboom, G. (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, DOI 10.1007/s10584-

008-9445-6.

Roudier, P., Sultan, B., Quirion, P., Baron, C., Alhassane, A., and Traor, S. B. (2012). An ex-ante evaluation of the use of seasonal climate forecasts for millet growers in SW Niger, *771*(March 2011), 759–771. https://doi.org/10.1002/joc.2308

Salami, A., Kamara, A.B. and Zuzana, B. Smallholder Agriculture in East Africa: (2010). Trends, Constraints and Opportunities, Working Papers Series N° 105 African Development Bank, Tunis, Tunisia.

Serra, R. and McKune, S. (2016). Climate information services and behavioural change: The case of Senegal. Sahel Research Group Working Paper No. 010.

Shongwe, P. (2014). Factors Influencing the Choice of Climate Change Adaptation Strategies by Households: A Case of Mpolonjeni Area Development Programme (ADP) in Swaziland. Journal of Agricultural Studies, Vol. 2, No. 1.

Singh, C., P. Urquhart and E. Kituyi. (2016). From pilots to systems: Barriers And Enablers To Scaling Up The Use Of Climate Information Services In Smallholder Farming Communities. CARIAA Working Paper no. 3. International Development Research Centre, Ottawa, Canada and UK Aid, London, United Kingdom. Available online at www.idrc.ca/cariaa. ISSN: 2292-

Speranza, C. I., Kiteme, B., Ambenje, P., Wiesmann, U., and Makali, S. (2010). Indigenous knowledge related to climate variability and change: insights from droughts in semi-arid areas of former Makueni District, Kenya. Climatic Change, 100(2), 295-315.

Srinivasan, G., Rafisura, K. M., and Subbiah, A. R. (2011). Climate information requirements for community-level risk management and adaptation, *47*(Box 1), 5–12. https://doi.org/10.3354/cr00962

Tall, A., Hansen, J., Jay, A., Campbell, B., Kinyangi, J., Aggarwal, P.K. and Zougmore, R. (2014).Scaling up climate services for farmers: Mission Possible. Learning from good practice in Africa and South Asia. CCAFS Report No. 13. Copenhagen: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available online at www.ccafs.cgiar.org

Thornton, P. K., Jones, P. G., Owiyo, T. M., Kruska, R. L., Herrero, M., and Kristjanson, P. (2006). Mapping climate vulnerability and poverty in Africa. Report to the Department for International Development.

Uddin, M. N., Bokelmann, W., and Entsminger, J. S. (2014). Factors affecting farmers' adaptation strategies to environmental degradation and climate change effects: A farm level study in Bangladesh. Climate, 2(4), 223-241.

Van De Ven, W.P.M.M. and Van Praag, M.S. (1981). The Demand for Deductibles in Private Health Insurance: A Probit Model with Sample Selection. Journal of Econometrics, 17, 229-252.

Van den Broeck, G., Perez Grovas, R.R., Maertens, M., Deckers, J., Verhulst, N. and Govaerts, B. (2013). Adoption of conservation agriculture in the Mexican Bajío. Outlook on Agriculture, 42 (3), 171-178.

Vermeulen, S. J., Aggarwal, P. K., Ainslie, A., Angelone, C., Campbell, B. M., Challinor, A. J. and Wollenberg, E. (2011). Options for support to agriculture and food security under climate change. *Environmental Science and Policy*, 1–9. https://doi.org/10.1016/j.envsci.2011.09.003

Vogel1, C. and O'Brien, K. (2006). Who can eat information? Examining the effectiveness of seasonal climate forecasts and regional climate-risk management strategies. Climate research, Vol. 33, 111–122.

Walton, C.J, Lambert, M.D, Roberts, R.K, Larson, A.j, English, C.B., Larkin, L.S., Martin, W.S., Marra C.M., Paxton, W.K. and Reevs, M.J. (2008). Adoption and Abandonment of Soil Sampling in Cotton Production. Journal of Agricultural Resource Economics 33(3): 428-448.

Wilkinson, E., Budimir, M., Ahmed, A. K., and Ouma, G. (2015). Climate information and services in BRACED countries, (1), 1–20.

Wood, S. A., A. S. Jina, M. Jain, P. Kristjanson, and R. S. Defries. 2014. "Smallholder farmers cropping decisions related to climate variability across multiple regions." Global Environment Change, Vol. 25

World Bank. (2004). "Strengthening the Foundation of Education and Training in Kenya: Opportunities and Challenges in Primary and General Secondary Education", Report No.28064-KE. The World Bank: Washington, DC, USA.

World Bank. (2016). Climate Information Services Providers in Kenya. Report Number 103186-KE; World Bank: Washington, DC, USA.

Yong, D.N. (2014). Factors Affecting the Choice of Adaptation Measures to Climate Change: The Case of Famers in the Sudano-Sahelian Area of Cameroon. Tanzanian Economic Review, Vol. 4 Nos. 1 & 2, 56–72.

Yvonne, M., Richard, O., Solomon, S., and George, K. (2016). Farmer Perception and Adaptation Strategies on Climate Change in Lower Eastern Kenya: A Case of Finger Millet (Eleusine coracana (L.) Gaertn) Production. *Journal of Agricultural Science, 8*(12), 33.

Ziervogel, G. (2004). Targeting seasonal climate forecasts for integration into household level decisions: the case of smallholder farmers in Lesotho. The Geographical Journal, Vol. 170, No. 1, pp. 6-21.

Ziervogel, G. and Calder, R. (2003). Climate variability and rural livelihoods: assessing the impact of seasonal climate forecasts in Lesotho. Area, 35.4, 403–417

Ziervogel, G., and Opere, A. (2010). Integrating meteorological and indigenous knowledge-based seasonal climate forecasts for the agricultural sector: lessons from participatory action research in sub-Saharan Africa. *CCAA learning paper, 1*.

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. *Agricultural Systems*, *83*(1), 1-26.

IPCC, 2007: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 976pp. 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. *Agricultural Systems*, *83*(1), 1-26. Gichangi, E.M., Gatheru, M., Njiru, E.N., Mungube, E.O., Wambua, J.M. and Wamuongo, J.W. (2015).Assessment of climate variability and change in semi-arid eastern Kenya. Climatic Change, 130, 287–297, DOI 10.1007/s10584-015-1341-2.

Appendices

Appendix I, Household Questionnaire

UNIVERSITY OF NAIROBI

DETERMINANTS OF ACCESS AND USE OF CLIMATE INFORMATION SERVICES

HOUSEHOLD SURVEY QUESTIONNAIRE

Respondent

This survey intends to interview the head of household, spouse of the older family member above 18 years of age responsible for household farm decision making.

The purpose of this study is to get insights on determinants of access and use of climate information services for academic purposes and gather information that will be used to guide policies targeting climate change in Kenya. Your response will be greatly appreciated and I assure you that the information shared will be strictly confidential.

For further information kindly contact Emily Muema via email, emilymuema89@gmail.com or 0718010449. This interview will require approximately 30 to 45 minutes. I kindly request we start the interview

Questionnaire number…………………… Date of interview (dd-mm-yyyy) ……………

Name of interviewer…………………….

SECTION 1: HOUSEHOLD INFORMATION

1:1 Division ……………………. 1:2 Sublocation ………………………………

1:3 Village……………………..

Name of respondent……………………… 1:4 Phone number…………………..

1:5 Please fill in the table below the first name of all household members starting with the HH, spouse and other members using the codes below. *'A household is defined as a group of people currently eating from the same pot under the same roof or same compound for households with more than one structure for a period of at least four months a year'.*

1.5.1 Household number……………………………………

HH member code	1.5.2 Sex 1=male 2=female	1.5.3 Relation to Head SEE CODES	1.5.4 Age in years	1.5.5 Years of formal education completed	1.5.6 Major income activity SEE CODES	1.5.7 Marital Status SEE CODES
Respondent						
Household Head						
		Codes: 1=Head 2=Spouse 3=Son/daughter 4=House help 5=other			**Codes** 1=salaried employee 2=Business person 3= casual labourer 4=farming 5=other	**Codes** 1=Married, 2=Single, 3= separated 4= Divorced 5=Widow/Widower

SECTION 2: FARM ENTERPRISE

2.1 Land ownership; please fill in the table below

Total land size owned by the hhold in (acres)………………………

2.1.1 Method of Land acquisition	**Land size in acres**	**2.1.2 Tenure system** **1. Private with title deed 2. Private without title deed 3. Communal 4. Other……………**
1. Allocated by clan		
2. Inherited from parents		
3. Bought		
4. Rented		
5. Gifted		
6. Other………..		
7. Total		

2.13 What is the terrain of your farm? (1= Flat, 2= Hilly, 3=Steep slope 4= Other (Specify)………………………..

2.2 What are the various livestock that you keep? Please indicate in the table below.

Livestock	**Numbers**	**2.2.1 Motive:** 1= Subsistence 2=Commercial 3=Both Commercial and Subsistence 4= Wealth 5=Other... (Specify)………….	**2.2.2** Years of Livestock Keeping
1. Cattle			
2. Sheep			
3. Goats			
4. Donkeys			
5. Chicken			
Others (specify)……			

2.3 What are the various crops that you grow? Please indicate in the table below.

2.3.1Crop grown	**2.3.2** Do you grow this crop (1=Yes 0=No)	**2.3.**3Land size grown (acres)	**2.3.**4Yield in the last **YEAR** (Kg)	**2.3.5 Motive: (**1-Subsistence 2=Commercial 3=(Both subsistence and commercial) 4= Other...	**2.3.6** Years of Growing this crop
1. Maize					
2. Beans					
3. Cowpeas					
4. Pigeon peas					
5. Millet					
6. Sorghum					
7. green grams					
8. Vegetables					
9.Other specify………..					

2.37 How many years do you have of farming experience? ....

2.4 Do you have access to these inputs and equipment required in farming?

	2.4.1 Do you have access to these farm inputs? 1=Yes or 2=No	**2.4.2 If not what are the various reasons. 1= lack of finances, 2=Poor input markets, 3= other**	**Cost per annum**
1. Inorganic fertilizers			
2. Organic Fertilizers			
3. Improved seeds			
4. Pesticides			
5. Herbicides			
6. Farm equipment eg hand hoes, pangas, ploughs etc			
7. other specify			

SECTION 3: Awareness and Perception of Climate Change

3.1 To what extent do you agree with the statements below on climate change over the past 20 years?

	Do you agree with the following statements: 1=Yes 2=No
The number of rainy days has reduced	
Increased dry spells	
Frequent drought	
Frequent Floods	
New diseases for crops have emerged	
The rate of germination failure has increased	

3.2 Have you been exposed to various climate shocks and to what extent has it affected your crops and livestock in the last 10 years?

	3.2.1 Have you been exposed to these climate shocks? 1=yes 0=No	**3.2.2** If yes what was the frequency/ how many times in the past 10 yrs.	**3.2.3** If yes, how many times was your **CROP** affected by the shock over the last 10yrs	**3.2.4** If yes, what was the number of **LIVESTOCK** affected by the shock over the last 10 years
Flood				
Drought				
Erratic				

Hailstorm				
Other (specify)				

3.3 If 'yes' above how do you cope and prevent these shocks from affecting your livestock and crops? Please use the codes below to fill in the table.

	3.3.1 How do you prevent these shocks from affecting your **CROPS**? **CODES** **1**=Nothing is done, **2=**Planting trees, **3**=Irrigation, **4=**Drought-tolerant varieties, **5=**Change crop type, **6=**Diversification, **7=**Soil conservation techniques, **8=**Change cropping dates, **9=**Change land area, **10=** Guard fields when crops mature, **11=**Other (specify*)*	**3.3.2** How do you cope with the effects of these shocks from affecting **LIVESTOCK CODES** **1**=Do nothing, **2=**Buy food, **3=**Sell livestock, **4=**Sell household assets, **5=** Reduce meals, **6=**Off-farm labor, **7=**Small business, **8=**Forest product (charcoal, firewood) sales, **9=**Loan, **10=** Family solidarity, **11=** Involve children to assist, **12=** Seek help from neighbours **13=**migrating **14=**Other (specify*)*
Flood		
Drought		
unpredictable rainfall		
Hailstorm		
Other (specify)		

SECTION 4: AWARENESS, ACCESS AND USE OF CLIMATE INFORMATION SERVICES

4.1 Have you heard of climate weather forecast? 1= Yes { }, 2= No { }

4.1.2 If yes what is the source of access? …………… (1=television, 2=extension officers, 3=newspapers, 4=cell phone, 5=radio, 6=friends/relatives, 7=peer farmers, 8=internet, 9=Baraza meetings, 10=printed materials, 11=village leaders, 12=social events, 13=religious organizations, 14=other (specify)

	4.1.3 Have you heard about the following weather forecasts? 1=yes 0=no	**4.1.4 If yes, under which format are you receiving the information? Codes:** 1=phone calling, 2=radio call-in, 3=radio broadcast 4=sms, 6=face to face individual, 7=face to face group, 8=audio-visual, 9=newspaper, 10=poster, 11=fliers, 12=online, 13=graphs, 14=other (specify)	**4.1.5 If yes which is your preferred source of access? Codes: :** 1=television, 2=extension officers, 3=newspapers, 4=cell phone, 5=radio, 6=friends/relatives, 7=peer farmers, 8=internet, 9=Baraza meetings, 10=printed materials, 11=village leaders, 12=social events, 13=religious organizations, 14=other (specify)
Seasonal forecast on the onset of rains			
Forecast of extreme weather (very heavy rains, landslides, floods, strong winds)			
Daily weather forecast (for today or next 2-3 days on rainfall, Temp…)			
Weekly weather forecasts (next 7days (rainfall, Temp, clouds,…)			
Monthly weather forecast (rainfall, temp,…)			
Long-term climate forecast (a long-term trend in climate variability)			
Indigenous forecast (including indigenous knowledge, empirical observations)			

4.2 Is the climate information received accompanied by agronomic advice? Please indicate in the table below using the codes provided.

	4.2.1 Is the climate information received accompanied with agronomic advice 1=yes 0=no	**4.2.2 If yes, tell us which advice? Use CODES below**	4.2.**3 If yes, how will you rate the usefulness of the service to inform your farm decisions and livelihood?** 1=not useful 2=small extent 3=medium extent 4=large extent 5=very large extent
Seasonal forecast on the onset of rains			
Forecast of extreme weather (very heavy rains, landslides, floods, strong winds)			
Daily weather forecast (for today or next 2-3 days on rainfall, Temp…)			
Weekly weather forecasts (next 7days (rainfall, Temp, clouds,…)			
Monthly weather forecast (rainfall, temp,…)			
Long-term climate forecast (a long-term trend in climate variability)			
Indigenous forecast (including indigenous knowledge, empirical observations)			

Code for agronomic advice: 1=Introduce new crops/varieties, 2=Plant early maturing varieties, 3=Start improved irrigation, 4=Improved drainage, 5=Introduce crop cover, 6=Introduce mulching, 7=Terraces, 8=Mechanized farming, 9=Early land preparation, 10=Early planting, 11=Late planting, 12=Use of chemical fertilizers, 13=Use of manure, 14=Use of pesticides/herbicides, 15=Agroforestry 16=Plant drought-resistant varieties 17=livestock off take 18=Herd splitting and migration 19=Mass vaccination/deworming 20=Breed improvement 20=Activate disease surveillance 21=Rangeland reseeding 22=Activate flood evacuation plans

23=Engage in alternative livelihood 24=Other (specify).

4.3 If you have access to climate information services, do you trust them 1= Yes 2= No …….

4.3.1 If yes, to what extent do you trust in the information received on the following?

	1=not at all 2=small extent 3=medium extent 4=large extent 5=very large extent
Seasonal forecast on the onset of rains	
Forecast of extreme weather (very heavy rains,	

landslides, floods, strong winds)	
Daily weather forecast (for today or next 2-3 days on rainfall, Temp…)	
Weekly weather forecasts (next 7days (rainfall, Temp, clouds,…)	
Monthly weather forecast (rainfall, temp,…)	
Long-term climate forecast (a long-term trend in climate variability)	
Indigenous forecast (including indigenous knowledge, empirical observations)	

4.3.2 If you do not trust the CIS, tell us why? ……….

(1=not accurate, 2=not familiar with the forecast, 3=complicated to understand, 4= other (specify)…………)

4.3.3 If you receive the information, do you use them to inform your farm decisions**?**

1= Yes { } 2= No { }………….

4.3.4: If no why don't you use the information, tell us why**? ....**

(1=does not understand technical terms used to communicate the forecast, 2=does not understand the language used 3=not accompanied with advice 4=did not trust the information5=-other (specify)………)

4.4 If you use climate information services in farm decision making what the various changes in farm management and livelihood have you made? Please fill in the table below

	4.4.1 Forecast of an extreme event (e.g: heavy rains, storm, dry spell, strong winds, other) 1=yes 0=No	**4.4.2 Forecast of the start of the rains (onset) 1=yes 0=No**	**4.4.3 Forecast of the weather for today and/or next 2-3 days 1=yes 0=No**	**4.4.4 Weekly weather forecast 1=yes 0=No**	**4.4.5 Forecast of the rains for the following month 1=yes 0=No**	**4.4.6 Long-term climate forecast 1=yes 0=No**	**4.4.7 Indigenous climate forecast 1=yes 0=No**
The timing of land preparation							
Timing of planting							
Area allocation across crops							
Where to plant							
Type of crop variety to grow							
Shift in crop type/variety							
The timing of fertilizer							

application							
Use of manure							
Timing of weeding							
Timing of harvesting							
The timing of crop sales							
Types of livestock to keep							
Timing for grazing							
where to graze							
where to vaccinate cattle							
The timing of cattle sales							
Type of livelihood enterprise to start							
The timing for starting a new business							
Involvement off-farm activities							
Other (specify)							

SECTION FIVE INSTITUTIONAL AND INCOME INFORMATION

5.1 Are you a member of any development group? Fill in the table below

Development group	**5.1.1 Member to a group (1=yes, 0=no)**	**5.1.2=formal 2=informal**	***5.1.3 If yes,* duration of membership (years)**	**5.1.4 Which services are offered by the group (1=credit services, 2=marketing information, 3= marketing of produce 4=Climate information, 5= input purchase, 6=Agronomic advice 7=other, specify……………….…….)**	**5.1.5 Have you frequently participated in groups activities? 1= 1, 0 No.**
Youth group					
Women group					
Men group					
Religious group					

SACCO/credit groups					
Environmental group					
Another group [specify]					

5.2 Have you been provided with extension services in the last 12 months? **1**= Yes **0**= No

5.3 Which organisations provided the extension services... **1**=Government of Kenya, **2**=NGOs, **3**=Private Organisations, **4**= Agro dealer, **5**= other

5.4 What was the channel used to provide extension services? **1**= Phone call, **2**= field schools, **3**= home visits, **4**= other

5.5 What were the terms for the provision of extension services? **1**= Free, **2**= Paid, **3**= Other

5.6 What was the frequency of the visits? **1**=after every **3** Season, **2**= once per month, months, **3**= twice a year, **4**= once per year.

5.7 Do you have access to credit facilities? **1**= Yes **0**= No

5.8 If yes what was the source of credit received? **1**= cooperative bank, **2**= Agricultural finance cooperative **3**= SACCO, **4**=Development group, **5**=Money lender/shylock, **6**=relative/ friend/ neighbour, **7**= community based organisation, **8**= mobile money **9**= other specify

5.9 What was the main purpose of the credit applied? **1**= buy household food **2**= buy farm inputs, **3**= buy livestock, **4**= buy farmland, **5**= other

5.10 What were the various reasons that barred you from access to credit? Note if **5.6** is **0**= no. **1**= Lack of collateral, **2**= high-interest rates, 3=lengthy procedures, 4=no need, 5=unable to pay back, 6= other

5.11 Do you have access to markets? Please indicate in the table below

	Do you have access to markets 1= Yes, 0= No	**Average Distance in Kilometres**	**What type of roads. 1= tarmac, 2= murram, 3= Earth**	**What is the means of transport 1= Public means, 2= Private car, 3= Motorbike, 4= bicycle, 5= walking, 6= other**
1. Market for inputs				
2. The market for crop produce				
3. The market for livestock and livestock products				

5.12 What is the average monthly household income? Please indicate in the table below

Income source	**5.12.1** Amount earned (Ksh)	**5.12.2** Who controls the income from this source? (1= HH head 2= spouse 3= other specify)
Farming activities		
Off-farm activities (farm activities on other holders' farm etc)		
Non-farm activities (e.g owned business, handicraft, carpenter, charcoal etc)		
Remittances and gifts		
Formal employment		
Other income sources, specify…………….		

SECTION SIX: HOUSEHOLD WEALTH INDEX

6.1 **Assets owned by the household**

Which of the following assets does the household own? Fill the table below:

	Asset type	**Number owned**	**Purchasing price (Ksh)**	**Estimated value of the assets (Ksh)**
1	Farm implements- hand hoes, panga, ploughs, etc			
2	Carts and Wheelbarrows			
3	Spray Pumps, irrigation pumps, irrigation pipes			
4	Water tank, borehole			
5	Mobile phones, radios and TV			
6	Bicycle, motorcycle and vehicle			
7	Residential house			
8	Buildings for rent			
9	Livestock owned (TLU)			
10	Land size owned			
11	Shares and Stocks			

12	Radio			
13	Television			
14	Car			
15	Phone			
16	others			

Appendix II, Analysis of Correlation Matrix

	Age	Genderhh	HHolds~e	Educat~n	Taotal~d	draght~q	Qn_5_2~v	Qn_5_7~s	mainin~y	lnincome	Radioo~p	Tvowne~p	Qn2_4~rt	Qn2_4_~d
Age	1.0000													
Genderhh	-0.0188	1.0000												
HHoldsize	-0.0868	0.0253	1.0000											
Education	-0.3733	0.2041	0.0787	1.0000										
Taotalfarm~d	0.3391	0.0484	0.0803	0.0050	1.0000									
draghtfreq	0.0379	-0.0539	0.0029	0.0072	-0.0396	1.0000								
Qn_5_2_acc~v	0.0816	-0.0777	-0.0223	0.0674	0.1520	0.0249	1.0000							
Qn_5_7_cre~s	-0.0438	-0.0172	0.1505	0.1295	0.0943	0.0750	-0.0691	1.0000						
mainincime~y	0.3134	-0.2222	-0.1756	-0.3769	0.1051	-0.1407	0.0455	-0.1439	1.0000					
lnincome	-0.2474	0.0397	0.2078	0.3350	-0.0251	0.0143	0.2122	0.1410	-0.4039	1.0000				
Radioownes~p	-0.0110	0.0154	0.0170	0.0493	0.1038	0.1030	0.0656	-0.0136	-0.0864	0.1866	1.0000			
Tvownership	0.0156	0.0735	0.0985	0.0305	0.0168	-0.0173	0.0238	-0.0377	-0.1096	0.0360	0.0894	1.0000		
Qn2_4_1bAc~t	-0.1869	-0.1713	0.0208	-0.1203	-0.1838	-0.1410	-0.1010	-0.0554	-0.0132	0.1514	0.0135	-0.0029	1.0000	
Qn2_4_1cim~d	-0.0987	0.0307	0.0928	0.1948	0.0304	-0.0064	-0.0361	0.2639	-0.0848	0.0426	0.0273	-0.0370	-0.2393	1.0000
Qn2_4_1ffa~t	0.0634	0.0465	-0.0638	0.0598	0.0086	-0.0025	-0.0396	-0.0128	-0.0657	-0.0004	-0.0711	-0.0435	-0.0301	-0.0359
Agricultur~p	0.1385	-0.0343	-0.0342	-0.0405	0.0182	-0.0532	0.0942	0.0718	0.0631	-0.0431	0.0698	-0.0249	-0.1043	0.0746

	Qn2_4~nt	Agricu~p
Qn2_4_1ffa~t	1.0000	
Agricultur~p	0.0749	1.0000

Appendix III, Endogeneity Results

Qn_4_3_4_useinformationi~c	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Qn2_4_1cimprovedseed	.4394177	.2153462	2.04	0.043	.0149463	.863889
Age	.0038984	.0054349	0.72	0.474	-.0068144	.0146113
Genderhh	.1171534	.1440374	0.81	0.417	-.1667604	.4010673
HHoldsize	-.023371	.0156255	-1.50	0.136	-.0541706	.0074287
Education	.0192888	.0173123	1.11	0.266	-.0148357	.0534133
maritalstatus	.0981542	.0896029	1.10	0.275	-.0784631	.2747716
Taotalfarmland	.0114445	.0110228	1.04	0.300	-.0102826	.0331715
draghtfreq	.1461317	.1347898	1.08	0.280	-.1195541	.4118174
Qn_5_2_accessextensionserv	.257445	.1345806	1.91	0.057	-.0078283	.5227184
Qn_5_7_creditaccess	-.0432291	.0608969	-0.71	0.479	-.1632636	.0768054
mainincimeactvity	.152737	.0688255	2.22	0.028	.0170744	.2883996
lnincome	.0761556	.0705453	1.08	0.282	-.062897	.2152082
Radioowneship	.0617065	.088575	0.70	0.487	-.1128848	.2362977
Tvownership	.0399303	.0541589	0.74	0.462	-.0668229	.1466835
Qn2_4_1bAccessorganicfert	1.87653	1.05292	1.78	0.076	-.198893	3.951953
Qn2_4_1ffarmequipment	.264364	.218325	1.21	0.227	-.1659788	.6947068
resid	-1.735928	1.055839	-1.64	0.102	-3.817103	.3452473
_cons	-3.848867	1.48292	-2.60	0.010	-6.771867	-.9258668