DETERMINANTS OF SMALLHOLDER MAIZE FARMERS' ADAPTATION STRATEGIES TO CLIMATE CHANGE IN BAHATI SUB-COUNTY, NAKURU COUNTY, KENYA.

BY

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A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF DEGREE OF MASTER OF ARTS IN PROJECT PLANNING AND MANAGEMENT OF THE UNIVERSITY OF NAIROBI

2015

DECLARATION

This research project is my original work and has not been presented in this or any other University/ Institution for the award of degree or diploma.

Sign:……. Date:…….

JOHN W. WAMALWA

L50/70654/2013

Approval

This research project has been submitted for examination with my approval as supervisor of University of Nairobi.

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ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to my supervisor Dr. Waiganjo for the guidance and encouragement without which developing this project would have not been possible.I am also grateful to all the lecturers for the support towards the successful study at the University of Nairobi, Nakuru extramural center also thank my dear wife Lilian for her continuous encouragement during my studies. Lastly, I extend my sincere gratitude to all my friends and colleagues at the University for the moral support during our days in the campus.

DEDICATION

This research project is dedicated to my wife Lilian and my daughter Merleen Nanyama for their continued support and consistent encouragement in my studies and my friends who instilled in me the discipline to study.

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LIST OF ACRONYMS AND ABBREVIATIONS

DfID : Department for International Development

ENSO : El Nino Southern Oscillation

FAO : Food and Agriculture Organization

FAOSTAT : Food and Agricultural Organization Statistics

GHG : Green House Gas

GoK : Government of Kenya

IISD : International Institute for Sustainable Development

IPCC : Intergovernmental Panel on Climate Change

KNBS : Kenya National Bureau of Statistics

MNL : Multinomial Logit

MNP : Multinomial Probit

SEI : Stockholm Environmental Institute

UNEP : United Nations Environmental Program

UNFCCC : United Nations Framework Convention on Climate Change

ABSTRACT

Kenya's agricultural sector contributes significantly to the economy which directly contributes 26 percent of the annual Gross Domestic Product (GDP) and another 25 percent indirectly. The sector accounts for 65 percent of Kenya's total exports and provides over 70 percent of informal employment in the rural areas. As such any climatic changes would impact greatly on the country's agricultural sector a concern for everyone in the country. Therefore, this study aimed at investigating the determinants of small holder maize farmers' adaptation strategies to climate change in Bahati Sub-County, Nakuru County. This study was guided by the following objectives; to establish the extent to which labour supply determine small holder Maize farmers adaptation strategies to climate change in Bahati Sub-County, Nakuru County, to assess the extent to which agricultural extension service determine small holder Maize farmers adaptation strategies to climate change in Bahati Sub-County, Nakuru County, to examine the extent to which socio-economic determine small holder Maize farmers adaptation strategies to climate change in Bahati Sub-County, Nakuru County. Descriptive survey design was used for the study with the target population being the farmers in Bahati Sub-County, Nakuru County. The sample was made up of 225 respondents. Primary as well as secondary data sources were used for the study and analyzed using descriptive statistics. Data was collected using questionnaires as the main study instruments. The analysis of the data was done using the Statistical Package for Social Scientists (SPSS) version 21. Data was presented in form of tables. Descriptive statistics were presented in form of frequencies, percentages, means and standard deviations. Inferential statistics were in form of pearson correlation coefficient to show the relationship between the independent and the dependent variable. the study found out that labour supply and financial capabilities do not have significant relationship with adaptation to climatic change. Agricultural extension services were found to have a weak negative significant relationship with adaptation to climatic change. The researcher concluded that agricultural extension services negatively influenced adaptation to climatic change. It was recommended that the government should organize seminars to train farmers on new ways of farming for them to be able to adapt to climatic changes and that farmers should embrace irrigation methods in their maize farming to ensure production through out the year.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

This study investigates the determinants of small holder Maize farmer's adaptation strategies to climate change in Bahati Sub-County, Nakuru County. Adaptation is an important way in which farmers respond to climate change (Adger et al., 2003; Bradshawn et al. , 2004; Barbier et al. , 2008). The way in which affected farmers will adapt determines the scale of climate change impacts and hence their farming production and livelihoods. Knowledge of adaptation measures and factors affecting farmer households' portfolio of adaptation is important for policy makers' ability to facilitate relevant conditions for households' adaptation. Previous research on determinants of households' adaptation behavior has mainly focused on perceptions of impacts of climate change (Blennow and Persson, 2009), incentives and the ability to adapt (Hoffmann et al., 2009), and environmental factors (Seo and Mendelsohn, 2008).Climate change has been defined by the Intergovernmental Panel on Climate Change, IPCC (2007) as any change in climate over time which arises as a result of both human activity and natural variability. Climate change impacts are already felt by many people and ecosystems in many parts of the world and have the potential to cripple the drive for sustainable growth and development (World Bank, 2008). The evidence of climate change includes increased temperatures, reduced precipitation, frequent droughts and scarcity of water (Adger et al., 2003; IPCC, 2007). The climate is projected to change in the coming decades at unprecedented rates with its attendant adverse consequences.

According to IPCC (2007), Africa is expected to experience the highest levels of warming with some countries, Kenya inclusive, also experiencing decline in rainfall. Climate change introduces numerous uncertainties over the livelihoods of farming communities that depend heavily on the weather and climate (Al-Hassan and Poulton, 2009; Athula and Scarborough, 2011). It impacts on land use and livestock management by altering crop, forage and livestock growth and yield (Mu and McCarl, 2011). Climate change negatively affects the basic elements of food production such as soil, water and biodiversity (FAO, 2009). Smallholder farmers have therefore been modifying their practices to better adapt to the changing climate. The FAO (2009) however opines that traditional coping mechanisms are not sufficient for dealing with medium to long-term impacts of climate change. Hence, innovative or modern strategies are expected to play a critical role in the mitigation of, and adaptation to climate change (IISD, 2005).

Kenya's agricultural sector contributes significantly to the economy which directly contributes 26 percent of the annual Gross Domestic Product (GDP) and another 25 percent indirectly. The sector accounts for 65 percent of Kenya's total exports and provides over 70 percent of informal employment in the rural areas. Therefore, the agricultural sector is not only the driver of Kenya's economy but also the means of livelihood for the majority of Kenyan people (Government of Kenya GoK, 2010). Kenya's agriculture is mainly rain fed and is entirely dependent on the bimodal rainfall in most of the country. The performance of rain fed agriculture varies due to the diverse agro-climatic zones. However, there is a relatively high risk of crop failure due to increased frequency of dry spells and an uneven rainfall distribution (GoK, 2010).The agricultural sector is dominated by primary production of a few commodities namely: cereals (Mixed Farming, wheat and rice), traditional food crops (pulses, roots and tubers, millet and

sorghum), industrial crops (sugar cane, pyrethrum, cotton, tobacco and sisal), export crops (tea, coffee and horticulture) and livestock (milk, meat and eggs) (Kang'ethe, 2004.

Maize is Kenya's most important staple food grown in almost all agro ecological zones and on two out of every three farms (Table 1.1). It accounts for about 40 percent of daily calories and has per capita consumption of 98 kilograms (Betty, 2005). About 90 % of the Kenyan population depends on the crop directly or indirectly in terms of food, employment and income. Maize is a food security crop in the country as well as a commercial enterprise in Rift Valley and some parts of Central, Western and Eastern provinces. In 2011, the area under Maize production was 2,131,887 Ha; realized yields were 37.5 million bags of dry Maize and 4.6 million bags of green Mixed Farming. Total Maize crop was worth 87.8 billion (Multi-Disciplinary Team, 2012).

Table 1.1 Kenya's Maize Production per Province in 2011

Province	Area (Ha)	Dry Maize Yield(90 kg)	Green Maize yield (90 kg)	Total Production(90 kg)
Central	182,248	1,708,726	970,322	2,679,048
Rift valley	650,270	19,196,203	1,775,132	20,971,334
Eastern	540,854	3,457,007	894,377	4,643,134
Western	255,511	5,795,028	405990	6,201,018
Nyanza	319,483	5,864,990	308,684	6,173,674
Coast	179,499	1,482,225	303,442	1,785,660
North Eastern	3,130	8,995	Nil	8,995
Total	2,131,887	35,520,694	4,662,960	42,183,654

Source: Multi Disciplinary Team, 2012

The economic performance of the agricultural sector is usually uncertain due to its biological nature in addition to relying mainly on rain fed agriculture and livestock rearing under natural conditions. This type of production is inherently risky because of variability of rainfall, animal mortality due to livestock diseases and fluctuations in output prices. The environment in most of low income countries is characterized by crop diseases, flooding, illness of household members and crime, often creating uncertainty (Capitanio, 2008).Being a climate sensitive sector, Agriculture is potentially affected by climate change, both positively and negatively. Given much of Kenyan agriculture is currently rain-fed; there are potentially wide ranging effects from the potential changes in precipitation. Moreover, there are a number of complex interactions with other factors, e.g. extreme events (heat, floods, and droughts), soil, pests and diseases, and complex interactions with other key sectors, e.g. water availability for irrigation (SEI, 2009). These conditions put the farming households at a greater level of uncertainty in terms of expected outputs. Recent trends have shown a declining trend in Maize yields in the past few years since 2006 with the worst being 2009 (Figure 1) (Owuor, 2010).Farmers and stakeholders are increasingly blaming climatic variability and climate change to these dwindling yields as the population is becoming more aware of the shocks realized in production. Policy makers should think of strategies to contain this situation as population keeps increasing in proportionately with production figures which will eventually cause direct food insecurity.

People observe that rainfall is unpredictable, water resources have changed, perennial rivers have become seasonal and boreholes are dried up or saline. Rain does not come enough and when it does it is in torrents (Vermuelen et al. 2008). Changes in weather patterns have induced a shift from wheat and potatoes to shorter cycle crops, such as Maize and beans, sweet potatoes and vegetables, and cattle (Walubengo 2007). Fodder is no longer grown, and cattle keepers must

now take their herds to remote pastures which also heightens the risk of conflict. Farmers no longer plant live hedges, due to their slow growth, but do plant trees in the hope that they will attract rain. According to the Kenya Red Cross (Aug 7, 2009, Drought Operation Update) the Sub County was hit hard by the recent drought, which led to high numbers of children dropping out of primary school because of the famine.

1.2 Statement of the Problem

According to IPCC (2007), Africa is expected to experience the highest levels of warming with some countries, Kenya inclusive, also experiencing decline in rainfall. Climate change introduces numerous uncertainties over the livelihoods of farming communities that depend heavily on the weather and climate (Al-Hassan & Poulton, 2009; Athula & Scarborough, 2011). It impacts on land use and livestock management by altering crop, forage and livestock growth and yield (Mu & McCarl, 2011). Climate change negatively affects the basic elements of food production such as soil, water and biodiversity (FAO, 2009). Smallholder farmers have therefore been modifying their practices to better adapt to the changing climate. The FAO (2009) however opines that traditional coping mechanisms are not sufficient for dealing with medium to long-term impacts of climate change. Hence, innovative or modern strategies are expected to play a critical role in the mitigation of, and adaptation to climate change (IISD, 2005).

In Kenya, the main participants in agriculture are small holder farmers owning small tracks of lands. Ensuring food security and nutrition has been a key element in Kenya's agricultural policies and strategies. The small holder farmers are key contributors to food security and as such their adaptation to climatic change is key in enhancing food security. Adaptation helps farmers achieve their food, income and livelihood, security objectives in the face of changing climatic and socio-economic variability, extreme weather conditions such as droughts and

floods. Adaptation to climatic changes by farmers is pegged on many factors. The study focused on effects of labour supply, agricultural extension services, and financial capabilities on adaptation to climatic changes. Most of the farmers in Bahati sub-county are small holder farmers largely depending on maize farming as their main supply of food. Over the years, there has been notable change in the weather patterns that might have had significant influence on the maize farming in this area. As such it is important to establish the coping ability of this farmers to this climatic changes in their endeavor to maintain food security. Little or no research has been done on the determinants of adaptation to climatic changes in Kenya and more so in Bahati sub-county. Therefore the study aimed at establishing the determinants of small holder maize farmers' adaptation to climatic changes in Bahati sub-county.

1.3 Purpose of the study

The purpose of this study was to investigate the determinants of small holder Maize farmer's adaptation strategies to climate change in Bahati Sub-County, Nakuru County.

1.3.1 Objectives of the Study

i. To establish the extent to which labour supply determine small holder Maize farmers' adaptation strategies to climate change in Bahati Sub-County, Nakuru County.
ii. To assess the extent to which availability of agricultural extension service determines small holder Maize farmers' adaptation strategies to climate change in Bahati Sub-County, Nakuru County.
iii. To examine the extent to which financial capability determine small holder Maize farmers adaptation strategies to climate change in Bahati Sub-County, Nakuru County.

1.4 Research Questions

i. To what extent does labour supply determine small holder Maize farmers' adaptation strategies to climate change in Bahati Sub-County, Nakuru County?

ii. To what extent does availability of agricultural extension service determines small holder Maize farmers' adaptation strategies to climate change in Bahati Sub-County, Nakuru County?

iii. To what extent does financial capability determine small holder Maize farmers' adaptation strategies to climate change in Bahati Sub-County, Nakuru County?

1.5 Significance of the Study

The climate is changing and mitigation efforts to reduce the sources or enhance the sinks of greenhouse gases will take time. Adaptation is therefore critical and of concern in developing countries, particularly in Africa where vulnerability is high because ability to adapt is low. The findings of this study will help inform the farmers on the best adaptation strategies to ensure that they achieve their food, income and livelihood security objectives. Secondly the study will help in bringing to the attention of the policy makers on the challenges experienced by Farmers in their efforts to adapt to climatic change. The findings will further help in informing the agricultural extension officers on the need for their services by the farmers in this area. Finally the results of the study will to the existing body of knowledge and form the basis for future research by those who will be interested in this area of research.

1.6 Scope of the study

The study was confined to Bahati Sub-County, Nakuru County where Maize farming is the main economic activity. The area was chosen due to existence of many small holder farmers who mainly rely on maize farming to supplement for their food. The study investigated the effect of labour supply, agricultural extension services and financial capacity of farmers on the adaptation to climatic changes. The study was carried out between the month of March and July.

1.7 Limitation of the study

Bahati Sub-County, Nakuru County being a cosmopolitan county with the majority of Kalenjin and kikuyu tribes, language barrier was experienced due different spoken languages by different tribes as most farmers are aged farmers who dd not understand English and Kiswahili well. This was countered by using the field assistants who understood the local language for easy interpretation. The outright refusal by some households to respond to questions was also experienced and this was countered by use of experienced field assistants who are mainly locals and who were conversant with the house hold behaviors. The problem of time management also came up as many heads of households were working class hence finding them during day time was rather difficulty hence call backs were witnessed.

1.8 Assumptions of the study

The study assumed that the sample size chosen perfectly represented the small holder Maize farmers in Bahati Sub-County, Nakuru County who were the target population and that the respondents gave the right information for the study.

1.9 Definitions of Significant Terms used in the Study

Agriculture Extension Service: The application of scientific research and new knowledge to agriculture practices through farmer education.

Climate change: Any change in climate over time which arises as a result of both human activity and natural variability.

Coping strategies: This concept means the methods used by households to survive when confronted with unanticipated livelihood failure (source). In this the methods adopted by small holders

Strategies: Is a high level plan to achieve one or more goals on the condition of uncertainty.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Increase in the price of Maize from time to time has often impacted adversely on the poor who divert meagre household incomes to Mixed Farming. In 2009, Maize prices were 100 to 130 percent higher than normal levels (USAID, 2009). This has been associated with a number of causes including lack of productivity enhancing Impacts of drought on food technologies, high incidence of pests and diseases, security in Kenya staples including Mixed Farming. Growth in Maize production has been marginal averaging about 2 percent. This is lower than the population growth rate which stands credit (Nyoro et al., 2007). As a result, on-farm yields are low averaging 1.5–2.6 tonnes per hectare compared to on-station yields of about 5–8 tonnes per hectare. In the last one decade, the country has experienced years of heightened food insecurity and dependence on imports and emergency humanitarian assistance. In 2009, Kenya imported 16.8 million bags of Maize(GoK, 2010). Therefore, this chapter presented related theoretical and empirical studies on climate change, agricultural extension services and labour supply and adaptation strategies. The chapter also presented the conceptual framework and the research gaps.

2.2 Theoretical Framework

One important reason for adaptation analyses in the climate change field is to estimate the degree to which modeled impacts of climate change scenarios could be moderated or offset (or ‘‘mitigated’’) by ‘‘adaptation to the impacts’’ (Parry 2002; Mendelsohn et al 2000; Fankhauser 1998). These analyses address Article 2 of the United Nations Framework Convention on

Climate Change (UNFCCC), which commits countries to mitigate green-house emissions in order to avoid ‘‘dangerous’’ anthropogenic changes in climate. Adaptations are considered to assess the degree to which they can moderate or reduce negative impacts of climate change, or realize positive effects, to avoid the danger. These analyses are usually undertaken at broad scales, where equilibrium or statistical models are used to estimate impacts with and without adaptation, in order to address the question: how serious or ‘‘dangerous’’ are specified scenarios of climate change (Dessai et al 2003; Tubiello et al 2000; Winters et al 1998; Parry et al 2001). When analyzed for this purpose, adaptations are conventionally assumed or hypothetical, and their effect on the system of interest is estimated relative to the estimated impacts (e.g. in terms of costs, savings, etc.). For this use, the focus is on the effect of the assumed adaptations. The purpose is to estimate impacts of climate change, and to estimate the difference adaptation could make.

A second purpose of adaptation analysis focuses on specific adaptation options or measures, for a particular system subject to climate change stimuli. These analyses address the articles of UNFCCC that commit countries to ‘‘formulate and implement measures to facilitate adequate adaptation to climate change’’ (Article 4.1). The purpose of these analyses is to assess the relative merit or utility of alternative adaptations, in order to identify the ‘‘best’’ or better ones (e.g. Dolan et al 2001; Klein et al 1999; Fankhauser et al 1999; Niang-Diop and Bosch 2004). The analysis involves selecting a suite of ‘‘possible adaptations’’, chosen by the researcher from hypotheses, observations, modeling, extrapolation, analysis, key informants or deductive reasoning. These possible adaptations are usually considered to be distinct and discrete, in order that they can be subjected to evaluation according to some common principles or criteria. Among the tools used to rank or rate the relative merit of possible adaptations are benefit-cost, cost

effectiveness and multiple-criteria procedures. Common variables employed are benefits, costs, implementability, effectiveness, efficiency, and equity (Fankhauser et al 1999; Feenstra et al 1998; Smith et al 1998; Adger et al 2005a). Such analyses assume that there is, in practice, a process through which adaptations are selected and implemented, and that the relative evaluation analysis fits into this process. The focus of these studies is to rate or rank potential adaptations, but they rarely investigate the processes through which adaptation measures are undertaken, either in light of climatic change specifically (which is very rare) or as part of policy and decision-making processes to which adaptations to climate might relate.

A third school of analysis focuses on the relative adaptive capacity (or vulnerability) of countries, regions or communities, and involves comparative evaluation or rating based on criteria, indices and variables typically selected by the researcher (Van der Veen and Logtmeijer 2005; O'Brien et al 2004a; Kelly and Adger 2000; Adger et al 2004; Brooks et al 2005; Rayner and Malone 2001). Vulnerability is taken as the ''starting point'' rather than the residual or ''end point'' (O'Brien et al 2004b), and it is assumed to be measurable based on attributes or determinants selected a priori. The expected application is that adaptation efforts should be directed to those areas with the greatest exposures or least adaptive capacity. In this third type of research, the analyst selects the factors or determinants of vulnerability or adaptive capacity (sometimes with local inputs), obtains measures on these (usually aggregate surrogates from available secondary data), adopts an aggregation function over the measures (usually summation) and calculates an overall vulnerability value for each system. This research does not aim to identify the processes, determinants or drivers of adaptive capacity and vulnerability as they function in each system - they are taken as given, and used as the basis for the rating or ranking

analysis. Nor does this analysis substantively address the policy and decision-making processes that deal with the conditions that can alter adaptive capacity and vulnerability .

The fourth type of analysis focuses on practical adaptation initiatives. Research that focuses on the implementation processes for adaptations is still not common; at least, it is not common under the label of ‘‘adaptation’’ research, and certainly not in the climate change field . There is a vast body of scholarship in the fields of resource management, community development, risk management, planning, food security, livelihood security, and sustainable development that deals with the actual practices and processes of adaptation, although the word ‘‘adaptation’’ may not be explicitly used (Sanderson 2000; Gittell and Vidal 1998; Alwang et al 2001; Haimes 2004). By ‘‘practical application’’, we mean research that investigates the adaptive capacity and adaptive needs in a particular region or community in order to identify means of implementing adaptation initiatives or enhancing adaptive capacity. This enables the identification and development of particular adaptive measures or practices tailored to the needs of that community. The aim is not to score adaptations or measure relative vulnerabilities, nor to quantify impacts or estimate effects of assumed adaptations. Rather, the focus is to document the ways in which the system or community experiences changing conditions and the processes of decision-making in this system (or that influence the system) that may accommodate adaptations or provide means of improving adaptive capacity (Keskitalo 2004; Ford and Smit 2004; Sutherland et al 2005; Va´squez-Leo´ n et al 2003).

It tends not to presume the specific variables that represent exposures, sensitivities, or aspects of adaptive capacity, but seeks to identify these empirically from the community. It focuses on conditions that are important to the community rather than those assumed by the researcher or

for which data are readily available. It employs the experience and knowledge of community members to characterize pertinent conditions, community sensitivities, adaptive strategies, and decision-making process related to adaptive capacity or resilience. It identifies and documents the decision-making processes into which adaptations to climate change can be integrated. It is sometimes called a ‘‘bottom-up’’ approach in contrast to the scenario-based ‘‘top-down’’ approaches. The distinctive motivation here is to identify what can be done in a practical sense, in what way and by whom, in order to moderate the vulnerability to the conditions that are problematic for the community (Pahl-Wostl 2002; Moss et al 2001; Morduch and Sharma 2002).

Increase in the price of Maize from time to time has often impacted adversely on the poor who divert meagre household incomes to Mixed Farming. In 2009, Maize prices were 100 to 130 percent higher than normal levels (USAID, 2009). This has been associated with a number of causes including lack of productivity enhancing Impacts of drought on food technologies, high incidence of pests and diseases, security in Kenya staples including Mixed Farming. Growth in Maize production has been marginal averaging about 2 percent. This is lower than the population growth rate which stands credit (Nyoro et al., 2007). As a result, on-farm yields are low averaging 1.5–2.6 tonnes per hectare compared to on-station yields of about 5–8 tonnes per hectare. In the last one decade, the country has experienced years of heightened food insecurity and dependence on imports and emergency humanitarian assistance. In 2009, Kenya imported 16.8 million bags of Maize(GoK, 2010).

Maize demand in the country has been on the increase outstripping supply. For instance, in 2008 Maize production stood at 2.4 million metric tonnes (26 million bags) against a national

requirement of 3.1 million tonnes (34 million bags). With the country's population projected to be 43.1 million by the year 2020, the demand for Maize is likely to be 5 million metric tonnes.

Poor people in developing countries are most vulnerable to the impacts of climate change owing to their limited capacity to cope with climate shocks and stresses and their reliance on natural resources and the environment (DFID, 2004). Smallholder farmers are disproportionately affected, with over 1.5 billion people worldwide living in smallholder households in rural areas where their livelihoods depend on agricultural activities (World Bank, 2008). There is therefore an urgent need to identify approaches that strengthen the adaptive capacity of smallholders and enhance their ability to respond to climate change.

2.3 Labour Supply and Adaptation Strategies to Climate Change

Labour has been defined as the economic resource that includes all forms of human effort that results in the production of goods and services (Kenya Literature Bureau 2005). Labour can further be categorized into family labour which consists of the father and members of the family with the head of the family acting as the supervisor and hired labour, which is labour employed outside the family. The latter can either be permanent or casual (Beardshaw, et al 2001). Casual labour supplement the family labour and permanent labour when there is a lot of work to be done in the farm, during peak period (Norton, et al 2006). Permanent labour which is hired on monthly basis depends on the nature of the farm enterprise and its productivity depends on the effectiveness of supervision (Mailu & Mwangi 2005). According to Christian Partners development Agency (2008), labour is needed for weeding, fertilizer and manure application, tipping and pruning that are necessary for high yields.

Although small scale farmers in developing countries have low capacity to adapt to climate change effects, they have, however, survived and coped in various ways over time (Mano and

Nhemachena, 2006). A better understanding of how they are doing it is essential for designing incentives to enhance adaptation. Supporting the coping strategies of local farmers through appropriate public policy, investment and collective actions can help increase the adoption of well-crafted adaptation measures (IISD, 2007).

Adaptation to climate change is costly (Mendelson, 2004) and this cost could be revealed through the need for intensive labour use. Thus, if farmers do not have sufficient family labour or the financial capacity to hire labour, they cannot adapt to climate change. Previous analyses of barriers to climate change adaptation show that shortage of farm labour is one of the major constraints to adaptation by farmers (Deressa 2008, Adger 2001).

The characteristics of areas of farming bring out some specific features that characterise rural labour markets as opposed to urban labour markets. Johnson (1991) emphasises the limitations of residing in rural areas by outlining the individuals' occupation/residential choice paradigm: the choice of farming involves a very severe restriction on residential choice, while the choice of a farm residence greatly reduces family's employment opportunities across sectors. Moreover, the geographical dispersion of agriculture as an industry and its rural location away from other industries increases the costs of obtaining information about non-farm jobs and diminishes the probability of household mobility to switch industries (Huffman, 1977).

It is, however, worth noting that agriculture is not the only sector engaged in the rural economy although it often dominates employment, particularly as remoteness increases. As several studies on agriculture and rural labour markets have emphasized, the descriptive statistics are self-explanatory: the agricultural sector, in comparison to industry and service sectors, is characterized by high age of agricultural workers (Bojnec et al., 2003; Bojnec & Dries, 2005;

Van Herck, 2009), as well as low level of education attainment, with a significant proportion of the population having no more than a primary education. These factors are very important as they define the low level of human capital of the agrarian sector, and thus constrain the supply of skilled labour from this sector (Goodwin & Holt, 2002; Huffman, 1977)

The process of economic development is associated with a declining share of agriculture in total employment: there has been a massive movement of people out of agriculture throughout the world, with a decline in both the absolute level and the relative importance of farm employment especially in Europe (Breustedt & Glauben, 2007), and in the United States (Barkley, 1990). The integration of farm and non-farm labour markets, which has been triggered by economic growth and technological change, in terms of improved communication and transportation systems, has allowed a reallocation of labour by farm residents from farm to off-farm work. The expansion of communication systems to rural areas, which led to a better access to knowledge and ideas, and the reduced cost of transportation, have decreased the transaction costs of resource adjustments and have been accompanied by a more efficient allocation of people in the rural labour market. Nonetheless, agriculture remains an important source of income for many rural households, particularly in the poorest and least developed regions (Kancs et al., 2009a). A household will allocate its labor such that the marginal return to labor on- and off-farm equalizes, and the marginal product of labor on the farm equalizes with the wage rate for hired labor (Kamau, 2007).

2.4 Agricultural Extension Services and Adaptation Strategies to Climate Change

In order for the agricultural sector to adapt against climate change, agriculture and extension policies and strategies are essential tools for this to be realized. For instance, UNFCCC (2008) found that farmers who had access to extension contact adopted farming technologies 72%

greater than farmers who had no access to extension contact. Nhemachena (2008) also emphasized that exposure to extension services influences the capacity of farmers to adapt to climate change. Farmer to farmer extension has also been reported by Deressa et al. (2010) to have a positive influence on the adoption of adaptation technologies in response to climate change.

It should also be emphasized that agricultural extension enhances the efficiency of making adoption decisions. According to Adesina and Forson (1995) of the many sources of information available to farmers, agricultural extension is the most important for analyzing the adoption decision. Also, in the specific case of climate change adaptation, access to climate information may increase the likelihood of uptake of adaptation techniques. According to IPCC (2011) climate change and its associated uncertainties implies that extension services need to regularly access new knowledge and extend it in an adequate and timely manner to the farmers. It also entails harnessing the local using the two sources of knowledge (extension and farmers) to improve adaptation practices. The low levels of education of some extension officers adversely affect the quality of extension services (Mmbengwa, 2009).

According to FAO (2003), it has been observed that agricultural extension is involved in public information and education programs that could assist farmers in mitigating the effects of climate change. According to FAO (2003) , such involvements include awareness creation and knowledge brokerage on the issues of climate change; building resilience capacities among vulnerable individuals, communities and regions; encouragement of wide participation of all stakeholders in addressing climate change issues and developing appropriate framework for coping/adapting to climate change effects/impacts. Through extension services, farmers can receive skills and knowledge to produce food. Mmbengwa (2009) asserted that farmers with

access to extension services have better chance of engaging more profitably in agriculture than those that have no access. Benhin (2006) noted further that farmers' level of education and access to extension service are major determinants of speed of adoption of adaptation measures to climate change. Extension service is an important source of information on climate change as well as adaptation options hence farmers who have contact with extension agents are more likely to be aware of climate change and available adaptation options, and subsequently adopt these options (Nhemachena & Hassan, 2007; Gbetibouo, 2009; Deressa et al., 2010).

2.5 Financial Capability and Adaptation Strategies to Climate Change

Smallholder farmers are disproportionately vulnerable to the impacts of climate change as a result of poverty, marginalization and reliance on natural resources. Climate change is likely to lead to crop yields decreasing in most tropical and sub-tropical regions, thereby negatively impacting agricultural sectors and worsening issues of food security in developing countries. Although smallholders have considerable experience in dealing with climate variability, the unprecedented levels of variability associated with long-term climate change are outside the realm of traditional coping strategies (Pettengell, 2010).

Reducing people's vulnerability to climate change is closely linked to the poverty reduction and economic development agendas, since poverty is both a condition and a determinant of vulnerability (Hamill *et al*., 2008). Effective and sustainable adaptation to climate change in the long run is therefore dependent on broad-based economic development in which smallholders are able to move from low return subsistence activities to higher return livelihood activities. Resource limitations and poor infrastructure limit the ability of most rural farmers to take up adaptation measures in response to changes in climatic conditions. With resource limitations, farmers fail to meet transaction costs necessary to acquire adaptation measures and at times

farmers cannot make beneficial use of the available information they might have (Kandlinkar & Risbey 2000).

Chinvanno et al. (2008) report that in order to cope with the impacts of climate hazards, rice farmers in the Mekong River Delta in Vietnam have mainly used their own household resources and have concentrated their adaptation actions within their farm boundaries. Faced with limited financial capability, instead of investing in costly defensive efforts such as small scale irrigation, farming households have used alternative adaptation strategies such as adjusting the crop calendar or using alternative crops and seed varieties. Studies on to what extent social capital determines households' choice of these adaptation measures may have distinct policy relevance since available resources such as social capital can be used up given chronic problems of human and financial resource constraints.

Mark et al. (2008) argued that a lack of adaptive capacity due to constraints on resources like access to weather forecasts or better seed varieties may result in further food insecurity. The result of a study conducted by Centre for Environmental Economics and Policy in Africa across African countries showed that lack of access to credit or saving, water, appropriate seeds, security of property rights, market access and lack of adequate information about climate change are some of the major problems encountered by farmers in adapting to the effects of climate change (CEEPA, 2006). Most of the problems or constraints encountered by farmers in adaptation to climate change are associated with poverty (Deressa 2008). Lack of money hinders farmers from getting the necessary resources and technologies which assist in adapting to climate change.

According to FAO (1997), Most African farmers are resource poor and cannot afford to invest on irrigation technology to adapt to climate change in order to sustain their livelihood during harsh climate extremes such as drought which often causes famine. With limited income (poverty), the acquisition of necessary facilities was difficult. They may not only be costly, but may also appear scarce for poor farmers. In addition, the farmers may not also have the necessary facilities for current information like radio and television to obtain weather forecasts. This underscores the problems of under capitalization of farmers (Enete & Achike 2008) and suggests the need to improve the availability of credit to them. Benhin (2006) reports that lack of access to credit or saving and adequate information about climate change are some of the major problems encountered by farmers in adapting to climate change in Africa. Deressa (2008) reported that most of the problems or constraints encountered by farmers in adaptation to climate change are associated with poverty.

2.6 Adaptation to Climate Change in Agriculture

Increasing climate variability and climate change are impacting on agricultural livelihoods since resource-poor farmers are unable to cope with multiple stressors or adapt to climate-related risks. It is reported that about 70 % of the total Maize production in the developing world comes from low income countries (FAOSTAT, 2010). It is estimated that one quarter of the global Maize area is affected by drought in any given year. Some of the losses are blamed on soil fertility, pests and disease (Heisey and Edmeades, 1999). Easterling *et al*. (2007) argued that harvest at current levels of productivity and population growth is likely to fall far short of future demands. Additionally, projections of climate change will further exacerbate the ability to ensure food security and foster economic growth within many Maize producing areas. Easterling *et al.* (2007) further recommends that development of improved germ plasm to meet the needs of future

generations in light of climate change and population growth is of the utmost importance. Thornton *et al*. (2009) on the other hand stated that the use of new varieties alongside improved management options can offset yield losses by up to 40%. IPCC (2007) strongly suggests Maize growing regions of Sub-Saharan Africa will encounter increased growing season temperatures and frequency of droughts.

The two important determinants of the impact of climate change in a given region are the degree of exposure to climate stressors, and the underlying sensitivity of the natural and social systems (FAO, 2011). What is most important in food production are the frequency, magnitude and duration of the extreme climate events such as droughts, floods, hail, storm winds, heat waves as well as long-term climate changes such as rising temperature and changing rainfall regimes. Impacts of climate change on land-based economic activities and associated livelihoods are usually very significant, through direct effects on critical natural resources such as soil and water, and on the growth and economic value of crops and livestock (FAO, 2011). Human activities that end up degrading land make these impacts even worse because degraded lands have much higher sensitivity to climatic hazards than those which enjoy good vegetation cover and soil water infiltration abilities.

The volatile climatic conditions, and in particular drought, pose a major threat to the agricultural sector, Maize security and livelihoods of smallholder farmers in Kenya. Drought has become a frequent phenomenon making it difficult for the affected vulnerable smallholder Maize farmers to cope and recover. At the national level, the country has failed to placed Kenya in the category of countries that depend on imported Maize and humanitarian emergency relief operations. In

this respect, WEMA was launched as a demand driven technological innovation designed to strengthen the resilience and adaptive capacity of Maize farmers to cope with drought.

The partners will develop new African drought-tolerant Maize varieties, incorporating the best technology available internationally. The long-term goal is to make drought tolerant Maize available royalty-free to smallholder farmers in Sub-Saharan Africa most of whom are women – so they can enhance their food security and increase household incomes. Risk of crop failure from drought is one of the primary reasons why smallholder farmers in Africa do not adopt improved farming practices. With the expansion of Maize production in the areas susceptible to drought, it is expected that farmers will get higher, stable, and reliable yields. Commercialization of Maize varieties being developed under WEMA is projected to increase yields in the drought prone areas within the range of 25 percent compared to the current varieties.

The concepts of adaptation, adaptive capacity, vulnerability, resilience, exposure and sensitivity are interrelated and have wide application to global change science . Practical initiatives that tangibly address and improve societal adaptive capacity, thereby reducing vulnerability, are commonly expected to be evident at the community scale (Kates, 2000; Kelly and Adger, 2000; Ford and Smit, 2004). Vulnerability is related both to the differential exposure and sensitivity of communities to stimuli such as climate change and also to the particular adaptive capacities of those communities to deal with the effects or risks associated with the exposures. While exposures, sensitivities and adaptive capacities are evident at community or local levels, they reflect broader forces, drivers or determinants that shape or influence local level vulnerabilities .

Various authors have documented relevant literature on climate change adaptation. argues that "adaptation in the context of human dimensions of global change usually refers to a process,

action or outcome in a system (household, community, group, sector, region, country) in order for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity". On the other hand, Brooks (2003), describes adaptation as ''adjustments in a system's behavior and characteristics that enhance its ability to cope with external stress''. Smit et al. (2000), in the climate change context, refer to adaptations as ''adjustments in ecological-socio-economic systems in response to actual or expected climatic stimuli, their effects or impacts.'' Pielke (1998), also in the climate context, defines adaptations as the ''adjustments in individual groups and institutional behavior in order to reduce society's vulnerability to climate.'' An argument is also raised that, based on their timing, adaptations can be anticipatory or reactive, and depending on their degree of spontaneity they can be autonomous or planned (Fankhauser et al 1999; Smit et al 2000).

Besides understanding rural communities coping strategies, long term changes and sudden shocks need to be viewed critically in terms of how they adapt to these changes. argued that "the extent to which people and institutes are able to successfully respond to a new set of circumstances that they have not experienced before, such as a changed climate, will depend upon their adaptive capacity". Adaptive capacity of households to climate changes usually revolves around livelihood assets, as they are the means on which livelihoods are built. DFID (1999) identifies five types of livelihood assets namely: natural capital, social-political capital, human capital, physical capital and financial capital. Integrating these assets, knowledge on them facilitates understanding of how livelihoods work (IISD, 2003), and in the context of this study how Maize farmers in the study area respond to climatic variability and adapt to change. In general, the stronger, more resilient and more varied the asset base, the greater is people's

adaptive capacity and the level of security and sustainability of their future livelihoods (IISD 2003.

Shiferaw et al (2005), on the other hand, argued that research investments to enhance crop tolerance to drought stress, improving water productivity, and integrated management of land and water resources (e.g. watershed management) have the potential to reduce vulnerability to climatic shocks whilst also improving productivity. This was illustrated in the SAT of India study which evaluated the effects of integrated watershed management in Kothapally village which has contributed to improved resilience of agricultural incomes despite the high incidence of drought. Whilst drought-induced shocks reduced the average share of crop income (as % of total household income) in the non-project villages from 44 to 12 percent, this share remained unchanged at about 36% in the adjoining watershed project village of Kothapally. For agricultural communities and agricultural stakeholders in SSA to adjust to climate change and the predicted increases in climate variability, their ability to cope better with the constraints and opportunities of current climate variability must first be enhanced. If this does not happen, the challenge of adapting to greater climate variability will prove daunting for most and impossible for many .

Fraser et al (2003) proposed a theoretical framework for assessing whether societies or nations are well placed to adapt to climate change, building on the two concepts of social resilience and environmental sensitivity and suggest how that might be applied in a subsistence agriculture context. Community management of natural resources can enhance adaptability in two ways: "by building networks that are important for coping with extreme events and by retaining the resilience of the underpinning resources and ecological systems" (Tompkins and Adger 2004).

The development of strategies to adapt to variability in the current climate may also build resilience to changes in a future climate (Slingo et al 2005). It is important that those affected by risk of future events are involved in adaptive measures and that those measures are compatible with existing decision-making processes (Smit and Pilifosova 2001). Smit and Pilifosova (2001) also suggest that the determinants of adaptive capacity include not only the economic resources and technology to deal with change, but also information and skills, institutions, infrastructure and equity. This concurs with Dilley (2000) who concludes that communication of information could contribute to improved management of climate variability due to ENSO events in Africa.

2.7 Implications of Climate Change to Food Production

Extreme events have long been recognized as being a key aspect of climate change and its impacts of global food production (IPCC 2001a). Wide researches have demonstrated that agricultural systems are vulnerable to variability in climate. Vulnerability can be viewed as a function of the sensitivity of agriculture to changes in climate, the adaptive capacity of the system, and the degree of exposure to climate hazards (IPCC 2001b). Whereas it may be common for producers elsewhere in many parts of the world to have the physical, agricultural, economic and social resources to adapt to the impacts of climate variability on food production systems, it is not the case with many African farmers. This is because over 80 percent of the cereals are rain-fed (Cooper 2004). It has also been found that in many parts of Africa, climate is already a key driver of food security (Gregory et al 2005; Verdin et al 2005).

Future climate projections have revealed increasing temperatures over the coming years. For example, Huntingford et al (2005) suggests that changes in mean monthly precipitation in parts of the African region may be small, but there is a high chance of occurrence of extreme values overall in both rainfall (wet/dry years) and temperature. These changes which are likely to be

more robust than changes in mean rainfall could have serious repercussions on crop production (Coppola and Giorgi 2005). Dore (2005) also found that there is increasing variance in recent observations of precipitation across the tropics, suggesting the emergent importance of extremes in many regions. It is changes on the spatial scale of cropping systems (i.e. the field) that are likely to have the greatest impact on crop production.

At the basic level, the argument is, whether smallholder farmers in Africa will continue to farm. It has been identified that, already rural livelihoods at household level are highly diverse, with farming accounting for a lower proportion of disposable income and food security for farming households than 20 years ago. For example, Bryceson (2000) concludes that "diversification out of agriculture has become the norm among African rural populations." There is evidence that households moving out of poverty are those moving either completely or partially out of farming (Ellis and Bahiigwa 2002; Bryceson 2000). It is likely that many households will respond to the challenge of climate change by seeking further to diversify into non-farm livelihood activities either in situ or by moving (or sending more family members) to urban centres.

For these households, farming may remain as (or revert to) a semi-subsistence activity while cash is generated elsewhere. This would be simply a continuation of a well-established trend towards pluriactive, multi-locational families and the transfer of resources through urban–rural remittances (Manvell 2005). However, given the acute population and development related challenges faced by most African nations, many households was forced to remain in the farming sector for livelihood and security for some time to come as the population in Africa undergoes a three-fold increase this century (Commission for Africa 2005).

This will lead to considerable demand for expansion of area under small-farm cultivation for staple crops. Farming for profit, particularly production for international markets, may therefore become more concentrated on fewer farms, as is already happening in the fresh vegetable export market from eastern and southern Africa. Companies with the capital to invest in controlling their production environment through irrigation, netting and crop protection in order to meet stringent quality and bio-safety requirements of European supermarkets are increasing their market share at the expense of smallholders (Dolan and Humphreys 2000; Gregory et al. 2005). This should lead to further irrigation development, and contribute to a recommended doubling of irrigated land by 2015 (Commission for Africa 2005).

It has been observed that in the semi-arid and arid environments where rainfall variability impacts most strongly on livelihoods, farmers have developed coping strategies to buffer against the uncertainties induced by yearly variation in water supply among socio- economic drivers which impact on their lives. In addition, farmers often over-estimate the frequency of negative impacts of climate variability and under-estimate the positive opportunities. A range of factors (population pressure, declining soil fertility, weed invasion, decreasing labour supply, disease, lack of markets or access to markets for high value produce, lack of off-farm employment, etc.) are resulting in agriculture becoming a less viable foundation for rural livelihoods (Jayne et al 2003).

Depending on subjective assessment of risks and vulnerability, farm households make certain adjustments in their choice of strategies, and production and consumption decisions. Such coping strategies, according to Cooper et al (2008), can be broadly grouped into three categories: (a) ex-ante risk- management options such as choice of risk-tolerant varieties, investment in water

management, and diversification of both farming and other associated livelihood enterprises prior to the onset of the season, (b) in-season adjustment of crop and resource management options in response to specific climatic shocks as they evolve, and (c) ex-post risk management options that minimize livelihood impacts of adverse climatic shocks (for example, distress sale of assets, borrowing, cut expenditures on non-essential items). Depending on the household capabilities to manage stress, these mechanisms may vary from household to household and from one geographical location to another. This study aims at establishing coping dimensions and variability among the households in the study area. On the other hand, lists that cropping practices that are often used to mitigate the effects of variable rainfall include: planting mixtures of crops and cultivars adapted to different conditions as formal or informal intercrops; use of crop landraces that are more resistant to climate stresses; use of crop trash as a mulch; planting of starvation-reserve crops and; a variety of low-cost water-saving measures.

2.8 Level of Exposure and Proneness to Climate Shocks

Almost all human societies and their respective activities are sensitive to climate change in one way or another. This is because in large measure where people live and how they generate a livelihood and wealth is influenced by the ambient climate. Since climate is inherently variable for quite natural reasons, human societies have always and everywhere had to develop coping strategies in the face of unwelcome variations in climate or weather extremes. Some of these coping strategies are more technologically dependent, better resourced, or more robust or resilient than others.

Vulnerability as a measure of the degree to which an entity may be hurt or influenced by an object or event has widely been understood. Typically, it has been used in relation to food security assessments, poverty mapping, natural hazard exposure, and climate impact studies

(Liverman 1990; Downing 1991; Comfort et al 1999; UNEP 2000). Within the context of climate studies, conceptualization of vulnerability has mostly focused on marginality, susceptibility, adaptability, fragility, and risk (Dow 1992; Liverman 1994), where the most vulnerable are considered to be those who are most exposed to perturbations, who possess a limited capacity for adaptation, and who are least resilient to recovery (Bohle et al 1994).

In terms of agriculture, Reilly and Schimmelpfennig (1999) differentiate among yield vulnerability, farmer or sector vulnerability, regional economic vulnerability, and hunger vulnerability. They see vulnerability of farmers to climate conditions as a measure influenced by the capacity to take anticipatory actions – such as planting drought resistant seeds, cultivating the least flood-prone areas, changing the crop mix, or seeking off-farm income – as well as to recover from losses or damages. Vulnerability has been assessed at many different levels, including household, community, region, and nation – although most studies emphasize either the micro-level (household) or the macro-level (nation). The micro-level studies typically focus on household vulnerability to either natural events such as droughts or floods, or deterioration in the macroeconomic environment (Webb and Reardon 1992; Teklu 1992; Glewwe and Hall 1998; Dershem and Gzirishvili 1998; and Moser 1998).

Vulnerability is determined by the likely responses of the resources on which individuals depend and their availability, and most crucially, by the entitlements to call on these resources. Wide attribution on this fact has been documented by researchers, for example (Sen 1999; Hewitt 1997; Watts and Bohle 1993; Ribot et al 1996; Adger 1999) among others. Vulnerability is therefore a socially constructed phenomenon influenced by institutional and economic dynamics. The vulnerability of a system to climate change is determined by its exposure, by its physical

setting and sensitivity, and by its ability and opportunity to adapt to change. Vulnerability to climate change, as with vulnerability to hazards, is not strictly synonymous with poverty. It has been argued that both vulnerability and adaptation processes to climate change are likely to reinforce unequal economic structures (Kates 2000).

Although these studies tend to suggest broader perspective of societies vulnerability, specific focus on sensitivity of households' most basic foods to climate change have not been clearly articulated. Because food is the most basic requirement, emphasis on variability of smallholders' staple foods is very important, as is the direction of this study.The linkages between climate change, farm household, agricultural production shock including adaptation and mitigation to such risk can be summarized in conceptual framework in figure 2.1.

Farm household interacts with climate through crop and livestock farming for food production and consumption. To increase yield, forest lands are converted to crop lands (extensification) and chemical inputs are intensively used (intensification). As soil is an effective carbon sink, when forest lands are converted to farming fewer carbon is sequestered in the soil and more carbon is released in to the atmosphere to form carbon dioxide. Other agricultural activities such as biomass burning, fertilizer and pesticide production, irrigation, and farm machinery are accountable for further GHG emission.

The thermal infrared radiation emitted by the Earth's surface is absorbed by greenhouse gases within the Earth's system leading to an increased infrared opacity of the atmosphere and radiative forcing. The heat and evaporation trapped in this process causes temperature to rise and precipitation pattern to change. Since farming depends essentially on temperature and rainfall, higher temperature and erratic rainfall pattern pose shocks and risks to agriculture. In the short-

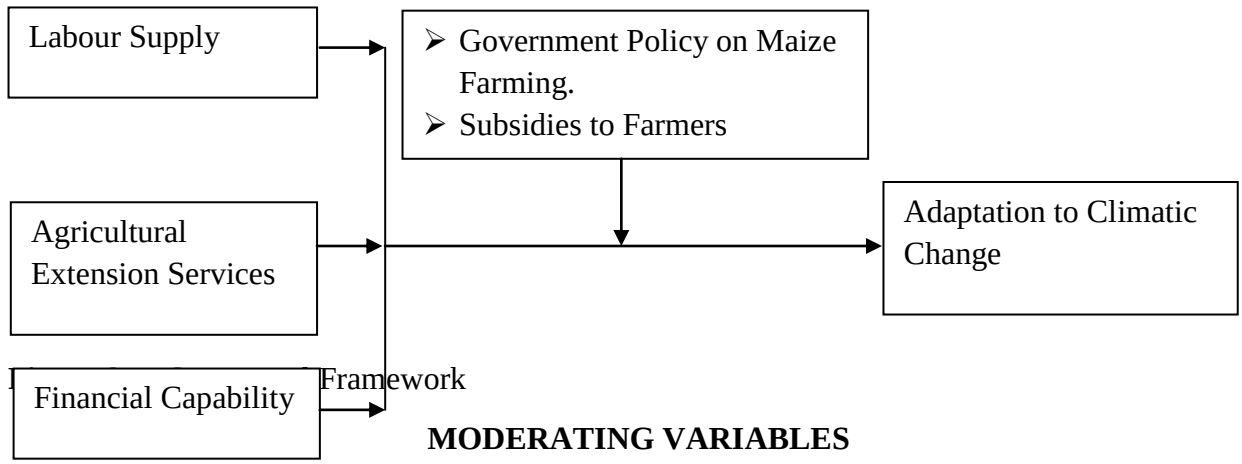
run, prolonged period of drought, erratic rainfall pattern (e.g. late rain onset, early rain termination, sporadic rainfall distribution) and flooding are direct consequence of temperature and precipitation fluctuation while greater incidents of pests and diseases of crop and livestock can be accounted for indirectly. In the long-run, continuous variability and severity of weather distresses eventually leads to environmental degradation such as land degradation, biodiversity loss and unsustainable forestry which damage natural resources essential for agriculture and livelihoods. Although climate fluctuation may increase rainfalls and reduce temperature in some dry areas but the shifting of mean values and widening variation of climatic pattern requires fundamental adjustments of farm planning and cultivation pattern for farm households (Tongruksawattana, 2013).

Having suffered from unexpected agricultural production shocks, farm households may adapt to changing climatic conditions by using available skills, resource, and opportunities to address, manage, and overcome adverse conditions brought about by such shocks to maintain livelihoods. The exposure of agricultural production shocks creates initial impact on household's food production and consumption. Farm households have a number of options to adjust to actual or expected production shock effects in order to moderate harm and minimize residual impact These include: 1.Adjustment of farming practices and technology including replanting, application of external inputs and machinery, treatment of diseases and pests, use of improved varieties which are tolerant to drought, disease and pest, Early or relay planting, conservation agricultural practices, crop diversification and crop intensification (Kristjanson et al. 2012). 2. Sell assets such as livestock, lands and other assets and use savings. 3. Borrow and 4.Reduce consumption, (Tongruksawattana, 2013).

At the same time, farm households may undertake mitigation strategies to reduce the sources or enhancing the sinks of greenhouse gases. Possible climate change mitigation strategies which aim to increase the uptake and storage of carbon in plants, trees and soils (carbon sequestration) in the earth systems such as; Agricultural conservation, sustainable intensification and agroforestry. In addition to agricultural production shocks and risks, farm households simultaneously face shocks and risks from other sources. Fluctuations in input, output and food prices, reduction in household business and employment income represent economic shocks/risks. Health shocks/risks include family sickness and death of household member. Lastly, social shocks/risks encompass theft, discrimination, conflict and violence. Hence household income and food security is a result of overall intra-household adaptation to shocks and management of risks, (Tongruksawattana, 2013).

2.9 Conceptual Framework

A conceptual framework is a conceptualization of the relationship between the variables in the study and shows the relationship graphically or diagrammatically. It is a hypothesized model identifying the concepts under study and their relationships (Mugenda & Mugenda, 1999). The possible relationships between independent variables and the dependent variable are as shown if figure 2.1. Independent variables included labour supply, agricultural extension services and financial capability while adaptation to climatic change was the dependent variable.


Labour Supply
Government Policy on Maize Farming.
Subsidies to Farmers
Agricultural Extension Services
Adaptation to Climatic Change
Financial Capability
MODERATING VARIABLES
INDEPENDENT VARIABLES
DEPENDENT VARIABLE

I Framework

2.10 Research Gaps

According to IPCC (2007), Africa is expected to experience the highest levels of warming with some countries, Kenya inclusive, also experiencing decline in rainfall. Climate change introduces numerous uncertainties over the livelihoods of farming communities that depend heavily on the weather and climate (Al-Hassan and Poulton, 2009; Athula and Scarborough, 2011). It impacts on land use and livestock management by altering crop, forage and livestock growth and yield (Mu and McCarl, 2011). Climate change negatively affects the basic elements of food production such as soil, water and biodiversity (FAO, 2009). Smallholder farmers have therefore been modifying their practices to better adapt to the changing climate. The FAO (2009) however opines that traditional coping mechanisms are not sufficient for dealing with medium to long-term impacts of climate change. Hence, innovative or modern strategies are expected to play a critical role in the mitigation of, and adaptation to climate change (IISD, 2005).

Agriculture is the mainstay of Kenya's economy. It accounts for approximately 27 percent of Kenya's Gross Domestic Product (GDP) and is the main source of livelihoods for about 80 percent of the population in rural areas (MoA, 2009). Over the years, the Kenya Government has strived to achieve national, household and individual food security. This is evidenced by several development strategies and policies that have been prepared and launched to steer the development of the agricultural sector in the country. They include the 'Strategy for Revitalizing Agriculture (SRA) (2004-2014)'. Kenya's current development goals and ambitions are articulated in the Vision 2030. to drive the economy to a projected 10 percent economic growth annually over the next two decades through promotion of an innovative, commercially oriented and modern agriculture (GoK, 2007). Ensuring food security and nutrition has been a key element in Kenya's agricultural policies and strategies.

Adaptation helps farmers achieve their food, income and livelihood, security objectives in the face of changing climatic and socio-economic variability, extreme weather conditions such as droughts and floods. Farmers can reduce potential damage by making tactical responses to these changes, however the researcher noted that there is lack of empirical work on agricultural extension services, financial capability and labour supply determinants as far as small holder maize farmers adaptation strategies to climate change is concerned especially in Bahati Sub-County, Nakuru County.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research design and methodology that was used in the research. It provides the rationale that was used by the researcher in choosing the design. The target population, sample size and sample selection, data collection procedures and data analysis.

3.2 Research Design

The study adopted a descriptive research design. Descriptive research design is used to obtain information concerning the current status of the phenomenon to describe what exists with respect to variables or conditions in a situation hence allowing observation of life experiences. Therefore it allowed for obtaining information on determinants of small holder farmers adaptation strategies to climate change in Bahati Sub-County, Nakuru County.

3.3 Target Population

According to Mugenda and Mugenda (2003) population is the entire group of individuals, events or objects that have a common observable characteristics. It is that aggregated of all that conforms to a given specification. The target population of this study included small holder maize farmers from Bahati Sub County, Nakuru County

3.4 Sample Size and Sampling Selection

Frankel and Wallen (2000), define sample as any part of population of individuals on whom information was obtained in a research study. They define sampling as the process of selecting the individuals who participated in the research study. The sample size was drawn from the

target population of the study. Krejcie and Morgan (1970) proposed a table of calculating the sample size from target population. The sample was selected using random sampling. From the various Locations in the sub-county, the researcher randomly selected 45 farmers from each Location to come up with a total of 225 farmers. The locations were Kabatini, Dundori, Kiamaina, Lanet and Bahati.

3.5 Data Collection Instruments

Frankel and Wallen (2000) define a research instrument as the device the researcher uses to collect data. Both primary and secondary sources of data were used. Primary data was collected mainly by administration of questionnaires to the farmers. The researcher used the help of research assistant to help in collecting data. Farmers who were not able to read and write were assisted to fill the questionnaire by the research assistants who had been trained how to do so prior to data collection. Secondary data was obtained from agricultural office documents and reports.

3.6 Validity of the Research Instrument

Validity refers to the extent to which the research tool/ instrument is accurate, correct and true. Saunders et al (2002) argues that research is only valid if it actually studies what it sets out to study and only if the findings are verifiable. To increase the validity of the data collection tool, a pre-test of the questionnaire was conducted with farmers from neighbouring sub – county. To ensure validity the researcher gave a draft of the instruments to the supervisor so as to check the validity of the instruments. Also a pilot study was carried out in the nearby sub-county this is Rongai Sub-County which has similar climate changes.

3.7 Reliability of the Research Instrument

To strengthen the reliability of the tool, the study used internal consistency techniques. This involved correlating a score in one item with scores obtained from other items in the instrument. The Cronbach's Coefficient Alpha was computed on the items to establish their correlation. Obtaining a high coefficient implies high correlation among the items and thus internal consistency (and to a large extent validity) of the tool. This study ensured the reliability of instruments through carrying out a pilot study in Rongai Sub-County. Cronbach alpha coefficient values greater than 0.7 were considered an indication of high reliability (Vogt, 1999). The results for the pilot study were as shown in table 3.1 below.

Table 3.1: Cronbach Alpha Coefficient Values

Valuable	Number of items	Alpha (α) values
Labour Supply	7	0.72
Agricultural Extensions Services	7	0.76
Financial Capability	7	0.81
Adaptation to climatic change	7	0.71

All the valuables recorded cronbach alpha coefficient values greater than 0.7 hence the instrument was reliable.

3.8 Operation Definition of Variables

The researcher used measurement scales to investigate the various variables in the study.

Table 3.2: Operation Definition of Variables

Research Objectives	Independent Variable	Indicators	Measurement	Measurement scale	Data collection	Data analysis tools
To establish the extent to which labour supply determine small holder Maize farmers adaptation strategies to climate change in Bahati Sub-County, Nakuru County.	Labour Supply	Human Labour	Farm size, number of hours, Skills	Nominal	Questionnaires	Descriptive statistics
To assess the extent to which availability of agricultural extension service determines small holder Maize farmers adaptation strategies to climate change in Bahati Sub-County, Nakuru County.	Education level, resource centre available,	Skills acquired in farming	Farmers activities, skills gained	Nominal	Interview guide Questionnaires	Descriptive statistics
To examine the extent to which socio-economic factors determine small holder Maize farmers adaptation strategies to climate change in Bahati Sub-County, Nakuru County.	Household size, Gender of the head of the family, Family income	Amount of money earned from farming, farm products (Kgs), maize, beans, vegetables, milk meat, trays of eggs	Access to credit loan	Nominal	Questionnaires	Descriptive statistics

Research Objectives	**Dependent Variable**	**Indicators**	**Measurement**	**Measurement scale**	**Data collection**	**Data analysis tools**
Determinants of smallholder maize farmers' adaptation strategies to climate change	Adaptation strategies to climate change	Strategies to climate change Methods of coping	Farmers activities, Skills gained, usage of new methods	Nominal	Questionnaires Interview guides	Descriptive statistics

3.9 Data Analysis Technique

Cohen and Manion (1994) say that once all the data has been collected, editing should be done to identify and eliminate errors made by the respondents. Data analysis is the breakdown of large components of research data into simpler, easily synthesized and understood parts. After collection of the raw data, it was sorted out and edited to identify black spaces or unfilled items and those that have been wrongly responded. Descriptive statistics such as frequencies and percentages was used to analyze the data using a Statistical Package for Social Scientists (SPSS), version 12. Inferential statistics in the form of Pearson product moment correlation coefficient was used to show the relationship between variables.

3.10 Ethical Consideration

Before going to the field the researcher requested a research permit from Nacosti and the University of Nairobi. After obtaining all the required documents, the researcher travelled to Bahati Sub-County to collect the data. The respondents were reminded not to disclose their names and was assured of confidentiality of their responses.

CHAPTER FOUR

DATA ANALYSIS,PRESENTATION AND INTERPRETATION

4.1 Introduction

This chapter presents the findings from the analysis of the data collected. The findings were in form of both descriptive and inferential statistics. The findings were accompanied by detailed discussions on the various aspects under analysis. Essentially, the presentations of findings were in tandem with the research objectives and the study variables. The researcher presented the findings and discussions relative to the background information of the respondents.

4.2 Response Rate

The study sample comprised of 225 respondents. The researcher distributed 225 questionnaires of which 205 of them were properly filled and returned. This represented a response rate of 91% which is classified as very good according to Babbie (1990).

4.3 Background Information

The researcher had sought to establish the background information for the respondents in regard to age, level of education, years in farming and the size of their farms. The findings for the analysis were as represented in the following sections.

4.4 Age of the respondents

As regards the ages of the respondents, the findings are as presented in the Table 4.1.

Table 4.1: Age of the respondents

		Frequency	percentage
Valid	25-30 Yrs	24	11.7
	31-40 Yrs	146	71.2
	Above 40 Yrs	35	17.1
	Total	205	100.0

The findings indicated that the majority of the respondents were aged between 31-40 years making up 71.2% of the respondents. 17.1% of the respondents were above 40 years while 11.7% were aged between 25-30 years.

4.5 Level of Education

Further the researcher sought to establish the level of education of the respondents. The results from the analysis are as shown in the Table 4.2.

Table 4.2: Level of Education

		Frequency	percent
Valid	Degree	4	2.0
	Diploma	28	13.7
	Secondary	118	57.6
	Primary	55	26.8
	Total	205	100.0

The table indicates that only 15.7% of the respondents had acquired post secondary education. The remaining 84.4% had only acquired basic primary and secondary education.

4.6 Years of Farming

The researcher sought to find out the period for which the respondents had been in farming. The findings from the analysis are as shown in Table 4.3.

Table 4.3: Years of Farming

		Frequency	percent
Valid	1-5 Yrs	20	9.8
	6-10 Yrs	17	8.3
	11-15 Yrs	9	4.4
	Above 15 Yrs	159	77.6
	Total	205	100.0

The table indicated that 77.6% of the respondents had been in farming for over 15 years. This shows that these respondents had a lot of experience in the trends of farming in this region. 22.4% of the respondents had been in farming for less than 15 years.

4.7 Size of Respondents Maize Farms

The findings from the analysis indicated that a majority of the respondents had between a quarter of a hectare and one hectare. As such these were small scale farmers.

4.8 Descriptive Statistics

The researcher sought to establish the means and standard deviations of the responses to give the descriptive statistics of the variables. The results were presented with respect of every study variable and are discussed in the section as below.

4.8.1 Labour Supply

The researcher in this case sought to establish the views of the respondents as regards the aspects of labour supply in their farming activities. The researcher established the means and standard deviation of the responses to extract important deductions from the responses. The findings for the analysis were as presented in the table 4.4.

Table 4.4: Labour Supply

	N	Min	Max	Mean	Std. Dev
1. I entirely utilize family labour in our farming activities	205	5	5	5.00	.000
2. I lack skilled labour in conducting our farming activities	205	1	5	4.91	.539
3. Availability of sufficient labour has enabled me to adopt to new farming mechanisms	205	1	2	1.03	.182
4. I lack the financial capacity to employ hired labour in the farms	205	1	5	4.86	.710
5. I prefer non farming employment rather than farm employment	205	5	5	5.00	.000
6. With increased exposure to urban centers, more energetic young labourers have vacated farming	205	4	5	4.99	.099
7. Agriculture remains a major source of income in this area	205	5	5	5.00	.000
Valid N (listwise)	205				

The table indicates that the respondents strongly disagreed that availability of sufficient labour had enabled them adopt to new farming mechanisms with a mean of approximately 1 (strongly disagree). However, the respondents strongly agreed with all the other aspects of labour supply recording means of approximately 5 (strongly agree). The respondents showed greater agreement in their responses recording standard deviations of less than 1. This indicated greater cohesions in their opinions as regard this aspects of labour supply.

4.8.2 Agricultural Extension Services

The researcher further sought to establish the views of the respondents as regards to the aspects of agricultural extension services. The researcher computed the means and standard deviations of the various aspects to enable him draw some inferences. The findings for the analysis are presented in Table 4.5

Table 4.5: Agricultural extension services

	N	Min	Max	Mean	Std. Dev
1. I frequently get agricultural extension services in my farming	205	1	5	1.27	.703
2. Through extension services, I get up to date information on climatic changes	205	1	5	1.23	.543
3. Through extension services, I have been able to improve our farming methods	205	1	5	4.78	.615
4. I find the agricultural extension officers more knowledgeable in farming activities	205	4	5	4.90	.297
5. I have improved the profitability of my firm due to information received from extension services	205	1	5	4.79	.588
6. Through extension services, am able to cushion myself from harsh weather conditions	205	1	5	1.29	.707
7. There is the existence of farmer extension services	205	5	5	5.00	.000
Valid N (listwise)	205				

From the table, it is observed that the respondents strongly disagreed with the assertions that they frequently get agricultural extension services in their farming, that through extension services, they get up to date information on climatic change and that through extension services, they are able to cushion ourselves from harsh weather conditions. These items registered means of approximately 1 (Strongly disagree). Respondents strongly agreed with all the other aspects registering means of approximately 5. There was greater cohesion in responses with all the aspects registering standard deviations of less than 1. The assertion that there was existence of

farmer extension services indicated greater agreement in the way the respondents answered the statement. This statement had zero standard deviation.

4.8.3 Financial Capability

The researcher in this case established respondents' views in regard to financial capability in their farming activities. The researcher computed the means and standard deviations of the responses and used them in drawing various deductions. The findings for the analysis were as presented in Table 4.6

Table 4.6: Financial Capability

	N	Min	Max	Mean	Std. Dev
1. Most of the farmers in this area practice subsistence farming due to financial constraints	205	5	5	5.00	.000
2. Farmers are able to increase their acreage due to financial empowerment	205	1	5	4.78	.803
3. Farmers have access to credit facilities that enhances their farming efficiency	205	1	2	1.05	.216
4. Due to insufficient funds, farmers are unable to utilize useful information in farming	205	5	5	5.00	.000
5. Farmers just limit themselves to their household resources instead of expensive sophisticated farming methods	205	5	5	5.00	.000
6. Lack of money hinders farmers from getting the necessary resources reguires to improve their farming	205	5	5	5.00	.000
7. Due to unimproved farming methods, farmers are unable to realize sufficient profits in their farms	205	5	5	5.00	.000
Valid N (listwise)	205				

The results in table 4.6 shows that the respondents strongly disagreed that farmers have access to credit facilities that enhances their farming efficiency. This aspect recorded a mean of approximately 1 (Strongly Disagree). The respondents strongly agreed with all the other aspects

of financial capability recording means of approximately 5 (Strongly Agree). Five of the responses showed greater cohesions in the way the respondents responded to the aspects with no standard deviation recorded. The remaining 2 aspects indicated a significant level of cohesion in responses having standard deviations less than 1.

4.8.4 Adaptation to Climatic Change

The researcher sought to establish how the farmers had adopted to climatic changes within this locality. The researcher determined the means and standard deviation for the responses in regard to this aspect. The findings for the responses were as presented in Table 4.7.

Table 4.7: adaptation to climatic change

	N	Min	Max	Mean	Std. Dev
1. There has been greater diversification out of agriculture by most farmers in this area	205	5	5	5.00	.000
2. In most of the families, cash is generated elsewhere while agricultural is semi-subsistence	205	4	5	4.99	.099
3. Most of the farmers have adopted the use of irrigation systems in their farming	205	1	1	1.00	.000
4. There has been an increase of green house farming in this area	205	1	2	1.01	.099
5. Most of the families depend on emergence relief operations to supplement their food supply	205	1	1	1.00	.000
6. There has been development of drought tolerant maize variety that is planted by farmers in the area	205	2	5	4.96	.361
7. Farmers have adapted to climatic change by changing the planting periods	205	5	5	5.00	.000
Valid N (listwise)	205				

The results in table 4.7 indicated that the respondents strongly disagreed that most of the farmers had adopted the use of irrigation system in their farming, that there had been an increase of green house farming in the area and that most of the families depended on emergence relief food

operations to supplement their food supply. These aspects registered means of approximately 1 (Strongly disagree). Further the respondents strongly agreed with all the other aspects of adaptation to climatic change recording means of approximately 5 (Strongly Agree). All responses registered standard deviations less than 1 while some had zero standard deviation. This was an indication that the respondents had greater cohesion in their responses.

4.9 Inferential Statistics

The researcher sought to establish the relationship between the independent variables and the dependent variables. All the responses were on a Likert scale (1-Strongly disagree, 2-Disagree, 3-Not Sure 4-Agree and 5-Strongly agree) with Likert scale data items. As such the responses could be transformed into a composite score of their means. This was then used to compare the independent and the dependent variables to establish the degree of associations between the variables. The results from the analysis are as illustrated in table 4.8

Table 4.8: inferential statistics

		Labour Supply	Agricultural Extension Services	Financial Capability	Adaptation To Climate Change
Labour Supply	Pearson Correlation	1	-.130	.477**	-.027
	Sig. (2-tailed)		.063	.000	.702
	N	205	205	205	205
Agricultural ExtensionServices	Pearson Correlation	-.130	1	-.108	-.243**
	Sig. (2-tailed)	.063		.123	.000
	N	205	205	205	205
Financial Capability	Pearson Correlation	.477**	-.108	1	-.025
	Sig. (2-tailed)	.000	.123		.718
	N	205	205	205	205

Adaptation To Climate Change	Pearson Correlation	-.027	-.243**	-.025	1
	Sig. (2-tailed)	.702	.000	.718	
	N	205	205	205	205

**. Correlation is significant at the 0.01 level (2-tailed).

The table indicates a negative insignificant relationship (r = -.027, p<.702) between labour supply and adaptation to climatic change. This means that the adaptation to climatic change is not significantly affected by labour supply. As such, labour supply has little or no role in as far as the adaptation to climatic change is concerned. Further the findingsindicated that there existed negative significant relationship (r = -.243, p < 0.01) between agricultural extension services and adaptation to climatic change. As such, this was an indirect relationship indicating that extension services negatively influenced adaptation to climatic change.

Additionally, the findings indicated a negative insignificant relationship (r = -.025, p < 0.718) between financial capability and adaptation to climate change. This showed that financial capability does not significantly influence adaptation to climatic change for the farmers in this area.

CHAPTER FIVE

SUMMARYOF FINDINGS, CONCLUSIONS, RECOMMENDATIONS AND SUGGESTIONS

5.1 Introduction

This chapter presents a summary of the major findings from the study based on the research objectives, conclusion from the finding and recommendations derived from the conclusions. The study set out to establish the effect of labour supply, agricultural extension services and financial capability on adaptation to climatic change of small scale maize farmers. The researcher drew a summary of findings and drew pertinent conclusions based on the objectives and gave some recommendations based on the study findings. Finally, the researcher suggested areas for further studies with regard to the findings of this study.

5.2 Summary of Findings

The study had the independent variables comprising labour supply, agricultural extension services, and financial capability. The dependent variable was adaptation to climate change. The researcher drew summaries based on the study findings and presented them as per each objective finding.

5.2.1 Effect of Labour Supply on the Adaptation to Climatic Change

Descriptive statistics indicated that the respondents strongly disagreed that availability of sufficient labour had enabled them adapt to new farming mechanisms. However, respondents strongly agreed with all the other aspects of labour supply. They strongly agreed that they entirely utilize family labour in their farming activities and that they lacked skilled labour in conducting their farming activities. They further agreed that they lacked financial capacity to employ hired labour and that most people prefer non-farming employment rather than farm

employment. With increased exposure to urban centres, respondents agreed that most of the energetic young labourers have vacated farming and they also agreed that agriculture remains a major source of income in that area.

Inferential statistics indicated that labour supply does not significantly influence adaptation to climatic changes. These findings were inconsistent with earlier findings from other scholars who indicated labour supply as a major factor in determining adaptation to climatic change. Mendelson (2004) observed that adaptation to climate change is costly and this cost could be revealed through the need for intensive labour use. Thus, if farmers do not have sufficient family labour or the financial capacity to hire labour, they cannot adapt to climate change. Previous analyses of barriers to climate change adaptation show that shortage of farm labour is one of the major constraints to adaptation by farmers (Deressa 2008, Adger 2001).

5.2.2 Effect of Agricultural Extension Services on Adaptation to Climatic Change

Descriptive statistics indicated that the respondents strongly disagreed that they frequently get agricultural extension services in their farming, that through extension services, they get upto date information on climatic changes and that through extension services, they are able to cushion themselves from harsh weather conditions. On the other hand, respondents agreed that through extension services, they have been able to improve their farming methods, and that they find the agricultural extensions officers more knowledgeable in farming activities. They further agreed that they have improved the profitability of their firms due to information received from extension services, and that there were farmer extensions services within their locality. Inferential statistics indicated that agricultural extension services had weak negative but significant relationship with adaptation to climatic change. This implies that agricultural

extension services have not enhanced adaptation to climatic change in this region but inhibited adaptation.

5.2.3 Effect of Financial Capability on Adaptation to Climatic Change

Respondents were in agreement with the assertions that most of the farmers in that area practiced subsistence farming due to financial constrains, that the farmers are able to increase their acreage due to financial empowerment and that due to insufficient funds, farmers were unable to utilize useful information in farming. Further the respondents agreed that farmers just limited themselves to their household resources instead of expensive sophisticated farming methods, that lack of money hinders farmers from getting necessary resources required to improve their farming, and that due to unimproved farming methods, farmers are unable to realize sufficient profits in their farms. Inferential statistics indicated that financial capability does not have significant relationship with adaptation to climatic change. As such, adaptation to climatic changes does not at all depend on the financial capability of farmers in this region.

5.2.4 Adaptation to Climatic Change

Descriptive statistics indicated that respondents disagreed that most of the farmers had adopted the use of irrigation systems in their farming, that there have been an increase of green house farming and that most of the families depended on emergence relief operations to supplement their food supply. They however strongly agreed that there has been greater diversification out of agriculture by most farmers in this area, that in most of the families, cash is generated elsewhere while agriculture is semi-subsistence. The further agreed that there has been development of drought tolerant maize variety that is planted by farmers in the area and that farmers have adopted to climatic change by changing the planting periods.

5.3 Conclusions

From the summary of findings the researcher made pertinent conclusions as regards the sublect under study. The researcher concluded that labour supply was not an important contributor to adaptation to climatic change. The results indicated an insignificant relationship between labour supply and adaptation to climatic change. This meant that adaptation to climatic change was not in any way affected by labour supply. The researcher further concluded that agricultural extension services have a negative influence on adaptation to climatic change. The findings indicated a weak negative significant relationship between agricultural extension services and adaptation to climatic change. This could be interpreted to mean that, the information they receive does not lead to positive results and therefore does not help them in adapting to climating change. These findings contradict the findings of Adesina and Forson (1995) who argued that, of the many sources of information available to farmers, agricultural extension is the most important for analyzing the adoption decision. Also, in the specific case of climate change adaptation, access to climate information may increase the likelihood of uptake of adaptation techniques.

The researcher further concluded that financial capability also does not influence adaptation to climatic change. The findings indicated an insignificant negative relationship between financial capability and adaptation to climatic change. This contravenes observations from other studies who placed the financial capability as a key determinant of adaptation to climatic change. Reducing people's vulnerability to climate change is closely linked to the poverty reduction and economic development agendas, since poverty is both a condition and a determinant of vulnerability (Hamill *et al*., 2008). Effective and sustainable adaptation to climate change in the long run is therefore dependent on broad-based economic development in which smallholders are able to move from low return subsistence activities to higher return livelihood activities. This

study portrayed financial capability being not a determinant of adaptation to climatic change in this locality.

5.4 Recommendations

The researcher recommended that the government should organize seminars to train farmers on better farming methods that they can adopt in their farming; this would enhance their production capacity and lead to better adaptation to climatic change. Further, farmers should seek for alternative means of enhancing their farming so as to improve on their adaption to climatic apart from only changing the planting periods. Farmers should try to adapt irrigation systems so that they grow their maize through the whole period (in season and out of season). This will increase their production and finally enhance their food security.

5.5 Suggestion for Further Studies

The researcher suggested that this study be replicated in other regions in Kenya for verification and generalization of this research findings throught the country. He further suggested that future scholars should focus on other factors contributing to adaptation to climatic changes by farmers. Finally the researcher suggested that studies should be carried to find out how each of this study variables singly contribute to adaptation to climatic changes.

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APPENDICES

Appendix 1: Letter of Introduction

Good day! My name is John Walubengo Wamalwa a Masters student at the University of Nairobi. I am carrying out a study on climate change and survival techniques of farmers in Maize production in this area. Through random sampling, your household has been selected for the study. Kindly spare your time for this noble exercise. I assure you that whatever we discuss was treated with utmost confidence.

Thank you.

Appendix 1I: Research Questionnaire

This questionnaire is aimed at collecting data to facilitate the study titled: Determinants of smallholder maize farmers' adaptation strategies to climate change in Bahati Sub-County, Nakuru County, Kenya. The questionnaire forms an integral part of the study and the respondents are kindly requested to complete and give any additional information they feel is necessary for the study. The researcher will uphold utmost integrity and ethics by ensuring that the data collected was absolutely for academic purpose and was treated with strict confidentiality.

Section A: Background Information

1. Age

Between 25 – 30yrs ☐ Between 31 – 40yrs ☐

Above 41 yrs ☐

2. Highest level of education attained

Master ☐ Degree ☐

Diploma ☐ Secondary ☐

Primary ☐

3. Number of years as a farmer in Bahati Sub-County, Nakuru County

1 – 5yrs ☐ 6 – 10yrs ☐

11 – 15yrs ☐ Above 16yrs ☐

4. How big is your Maize farm

¼ - 1 Hac ☐ 2 – 5 Hac ☐

6 – 10 Hac ☐ Above 10 Hac ☐

6. What is the percentage of Maize production surplus

25% ☐ 50% ☐ 75% ☐ 100% ☐

SECTION B:

This section contains statements provided on a likert scale as regards to the various variables under study. Kindly use the scale provided to indicate your level of agreement with the statements.

Labour Supply and Adaptation Strategies to Climate Change

Use the following scale to indicate the level to which you agree with the following statements as regards labour supply and adaptation strategies to climatic change.

1-Strongly Disagree (SD) 2-Disagree (D) 3-Not Sure(U) 4-Agree (A) 5 Strongly Agree (SA)

Statement		**1**	**2**	**3**	**4**	**5**
1	We entirely utilize family labour in our farming activities					
2	We lack skilled labour in conducting our farming activities					
3	Availability of sufficient labour have enabled us adopt to new farming mechanisms					
4	We lack the financial capacity to employ hired labour in our farms					
5	Most people prefer non farming employment rather than farm employment					
6	With increased exposure to urban centers, more energetic young labourers have vacated farming					
7	Agriculture remains a major source of income in this area					

Agricultural Extension Services and Adaptation Strategies to Climate Change

Use the following scale to indicate the level to which you agree with the following statements as regards presence of agricultural extension services and adaptation strategies to climatic change.

1-Strongly Disagree (SD) 2-Disagree (D) 3-Not Sure(U) 4-Agree (A) 5 Strongly Agree (SA)

Statement		**1**	**2**	**3**	**4**	**5**
1	We frequently get agricultural extension services in our farming					
2	Through extension services, we get up to-date information on climatic changes					
3	Through extension services, we have been able to improve our farming methods					
4	We find the agricultural extension officers more knowledgeable in farming activities					
5	We have improved the profitability of our firms due to information received from extension services					
6	Through extension services, we are able to cushion ourselves from harsh weather conditions					
7	There is the existence of farmer to farmer extension services					

Financial Capability and Adaptation Strategies to Climate Change

Use the following scale to indicate the level to which you agree with the following statements as regards financial capability and adaptation strategies to climatic change.

1-Strongly Disagree (SD) 2-Disagree (D) 3-Not Sure(U) 4-Agree (A) 5 Strongly Agree (SA)

Statement		**1**	**2**	**3**	**4**	**5**
1	Most of the farmers in this area practice subsistence farming due to financial constraints					
2	Farmers are able to increase their acreage due to financial empowerment					
3	Farmers have access to credit facilities that enhances their farming efficiency					
4	Due to insufficient funds, farmers are unable to utilize useful information in farming					
5	Farmers just limit themselves to their household resources instead of expensive sophisticated farming methods					
6	Lack of money hinders farmers from getting the necessary resources requires to improve their farming					
7	Due to unimproved farming methods, farmers are unable to realize sufficient profits in their farms					

Adaptation to climatic change

Use the following scale to indicate the level to which you agree with the following statements as regards adaptation strategies to climatic change.

1-Strongly Disagree (SD) 2-Disagree (D) 3-Not Sure (U) 4-Agree (A) 5 Strongly Agree (SA)

Statement		1	2	3	4	5
1	There has been greater diversification out of agriculture by most farmers in this area.					
2	In most of the families, cash is generated elsewhere while agriculture is semi-subsistence					
3	Most of the farmers have adopted the use of irrigation systems in their farming					
4	There has been an increase of green house farming in this area					
5	Most of the families depend on emergence relief operations to supplement their food supply					
6	There has been development of drought tolerant maize variety that is planted by farmers in the area.					
7	Farmers have adapted to climatic change by changing the planting periods					

Appendix III

Table 2: Krejcie and Morgan (1970)

N	n		N	n
10	10		180	123
15	14		190	127
20	19		200	132
25	24		210	136
30	28		220	140
35	32		230	144
40	36		240	148
45	40		250	152
50	44		260	155
55	48		270	159
60	52		280	162
65	56		290	165
70	59		300	169
75	63		320	175
80	66		340	181
85	70		360	186
90	73		380	181

95	76		400	196
100	80		420	201
110	86		440	205
120	92		460	210
130	97		480	214
140	103		500	217
150	108		**550**	**225**
160	113		600	234
170	118		650	242