

ANALYSIS OF THE ADAPTABILITY LEVEL OF WHEAT FARMERS TO CLIMATE VARIABILITY – THE CASE OF RONGAI DISTRICT, KENYA

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**A Thesis Submitted to the Graduate School in Partial Fulfillment for the Requirements of
Master of Science in Agricultural and Applied Economics of Egerton University**

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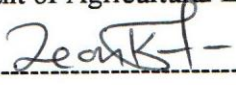
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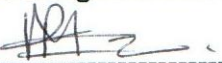
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APPROVAL

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DEDICATION

I dedicate this work to my wife Florence, my son Meewel, my parents Mr. James Rono and Mrs. Ann Rono, brothers and sisters, Edith, Nancy, Emmy, the late Joyce, Ernest and Collins for their sincere support.

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ABSTRACT

The performance of agriculture is influenced by many factors including climate variability. This factor is gradually being recognized as a key element in shaping the form, scale, size and time-frame of agricultural productivity. Climate variability is expected to have significant economic, environmental and social impacts on various sectors of the Kenyan economy. In particular, rural farmers who depend on major crops like maize and wheat for their livelihoods are likely to bear the brunt of adverse impacts. The extent to which these impacts are felt depends on the extent of adaptation in response to climate variability. The key question here is, why are wheat farmers in Rongai district facing continued decline in wheat output despite general evidence that farmers have adapted to climatic variability? The main objective of the study was to analyze the perception and the adaptability level to climate variability among the wheat farmers in Rongai district. The study used multistage sampling procedure to select 150 wheat farmers in Rongai district informed by both primary and secondary data sources. Data was analysed using descriptive statistics and the double hurdle model using STATA version 9.0 computer programs. The results indicated that 62% of the farmers perceived climate variability while 38% had not in the study area. The double-hurdle estimation revealed that adaptation to climate variability is governed by two independent decisions: the decision to adapt and the decision on the extent of adaptation. The estimation results also showed that these two separate decisions are determined by different sets of factors. The primary factors influencing the decision to adapt to climate variability are experience in wheat production, group membership and perception about disease occurrence. On the other hand, the extent of adaptation to climate variability was positively and significantly related to access to credit facilities but negatively related to composition of the household, rainfall change, temperature change and the age of the household head. The study therefore, recommends policy interventions in increasing adaptation through improved access to climate information on seasonal forecasts or early warning and creation of strategies that would improve access to credit facilities among the wheat farmers in Kenya. Through this, adaptation to climate variability would be successful consequently increasing resilience to adverse impacts of climate related disasters in Kenya.

TABLE OF CONTENTS

DECLARATION AND APPROVAL.....	ii
COPYRIGHT.....	iii
DEDICATION	iv
ACKNOWLEDGEMENT.....	v
ABSTRACT.....	vi
TABLE OF CONTENTS	vii
LIST OF TABLES.....	x
LIST OF FIGURES.....	xi
LIST OF ABBREVIATION AND ACRONYMS	xii
CHAPTER ONE	1
INTRODUCTION	1
1.1 Background Information	1
1.1.1 Climate and Agriculture in Kenya.....	5
1.1.2 Wheat Sub Sector in Kenya.....	5
1.2 Statement of the Problem.....	7
1.3 General Objective.....	7
1.4 Specific Objectives.....	8
1.5 Research Questions	8
1.6 Justification of the Study.....	8
1.7 Scope and Limitation	9
1.8 Definition of Terms.....	10
CHAPTER TWO	11
LITERATURE REVIEW	11
2.1 Review of climatic variability and adaptation studies in agriculture.....	11
2.2 Theoretical Framework	14
2.3 Conceptual Framework	15
CHAPTER THREE.....	18

METHODOLOGY	18
3.1 Area of Study	18
3.2 Sampling Procedure and Sample Size.....	20
3.3 Data Collection.....	20
3.4 Data Analysis	21
3.4.1 Analysis of wheat farmers' perceptions to climate variability	21
3.4.2 Analysis of adaptation and extent of adaptation to climate variability among the wheat farmers	21
3.4.3 Empirical Model and Specification.....	24
3.4.4 Factors hypothesized as affecting the extent of adaptation to climate variability	25
CHAPTER FOUR.....	29
RESULTS AND DISCUSSIONS.....	29
4.1 Farmer and farm characteristics	29
4.2 Forms of getting information apart from extension agents	34
4.3 Analysis of wheat farmers' perceptions to climate variability.....	35
4.3.1 Temperature Changes	37
4.3.2 Precipitation and vegetation cover Changes.....	37
4.3.3 Changes in diseases occurrence.....	38
4.3.4 Changes in pest infestation	39
4.4 Analysis of adaptation and extent of adaptation to climate variability among the wheat farmers	39
4.4.1 Adaptation options in response to variability in temperature.....	39
4.4.2 Adaptation options in response to variability in rainfall	40
4.4.3 Adaptation to changes in vegetation cover.....	41
4.4.4 Adaptation to changes in diseases occurrence.....	42
4.4.5 Adaptation to changes in pest infestation	42
4.5 Analysis of factors affecting adaptation and extent of adaptation to climate variability among the wheat farmers	43
4.5.1 Effect of household characteristics on extent of adaptation to climate variability.....	45
4.5.2 Effect of institutional factors on extent of adaptation to climate variability	45
4.5.3 Effect of Climatic and other factors on extent of adaptation to climate variability	46

CHAPTER FIVE 48

CONCLUSIONS AND RECOMMENDATIONS..... 48

5.1 Conclusions 48

5.2 Recommendations 49

REFERENCES..... 50

APPENDIX..... 55

QUESTIONNAIRE 55

LIST OF TABLES

Table 1: Summary of drought and extreme rainfall events and the number of people affected in different parts of Kenya from 1980 - 2008.....	4
Table 2: Wheat Production and Prices 2005 - 2009	6
Table 3: Measurement and description of the double hurdle model variables	28
Table 4: Farmer and farm characteristics and test of equality of means.....	30
Table 5: Gender of household head among adapters and non adapters	31
Table 6: Education level among the Adapters and Non Adapters	32
Table 7: Training and membership to local organizations among the adapters and non adapters	33
Table 8: Forms of getting information among the adapters and non adapters.....	34
Table 9: Main constraints in changing the farming ways among the adapters and non adapters	35
Table 10: Farmers' perception to climate variability in Rongai district.....	36
Table 11: Adapters and non adapters to climate variability in Rongai district.....	39
Table 12: Maximum likelihood estimation of the Double Hurdle Model	44

LIST OF FIGURES

Figure 1: Cumulative rainfall departure for Menengai rainfall station.....	3
Figure 2: Conceptual framework	16
Figure 3: Map of Rongai District.....	19
Figure 4: Temperature trends for Rongai district.	37
Figure 5: Rainfall trend for Rongai District.....	38
Figure 6: Percentage of adaptation options in response to variability in temperature.....	40
Figure 7: Percentage of adaptation options in response to variability in rainfall	41
Figure 8: Percentage of adaptation to changes in vegetation cover.....	41
Figure 9: Adaptation to changes diseases occurrence	42
Figure 10: Adaptation to changes in pest infestation.....	43

LIST OF ABBREVIATION AND ACRONYMS

BW1	Bread Wheat 1
BW2	Bread Wheat 2
CIMMYT	International Wheat and Maize Improvement Centre
GDP	Gross Domestic Product
GoK	Government of Kenya
IPCC	Intergovernmental Panel on Climate Change
KARI	Kenya Agricultural Research Institute
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KMD	Kenya Meteorological Department
MoA	Ministry of Agriculture

CHAPTER ONE

INTRODUCTION

1.1 Background Information

The climate of Africa ranges from humid equatorial regime, through seasonally arid tropical regimes, to Mediterranean-type climates. This climate exhibit different degrees of temporal variability, particularly with regard to rainfall and temperature. Understanding and predicting these inter-annual, inter-decadal and multi-decadal variations in climate has become the major challenge facing most African climate scientist in recent years.

The UNDP's climate change country profile shows that Kenya's mean annual temperature has increased by 1°C since 1960. This increase has been higher from March to May, and has meant an increase in the number of hot days and hot nights. There has been no statistically significant trend that can be established for the annual precipitation in the country, but an increase in the proportion of rainfall amounts which fall during heavy rainfall events has been noted. These changes in temperature and precipitation levels will result in adverse changes in land and water systems that will subsequently affect agricultural productivity (Kurukulasuriya and Rosenthal 2003). As the threat of climate variability gains momentum, the importance of exploring the relationship between agricultural performance and long term climate effects through variables such as temperature, rainfall and atmospheric carbon dioxide concentration levels, especially in developing countries is growing. Numerous factors influence the performance of agriculture; among these climates variability is gradually being recognized as a key element in shaping the form, size and time-frame of agricultural productivity.

The News Highlight Report of the Food and Agricultural Organization (FAO) (FAO 2001) has observed that in sub-Saharan Africa, long-term climate change would negatively affect agriculture, as well as threaten food security for the world's most vulnerable people. This report has further indicated that climate variability and especially climate extremes, which are more difficult to plan for, might become more frequent, putting additional stress on fragile farming systems. Moreover, climate and agro-ecological zones would shift, forcing farmers to adapt.

Common adaptation methods in agriculture include use of new crop varieties and livestock species that are better suited to drier conditions, irrigation, crop diversification,

adoption of mixed crop and livestock farming systems, and changing planting dates (Bradshaw *et al.* 2004; Kurukulasuriya and Mendelsohn 2006; Nhemachena and Hassan 2007).

Adaptation aims to ensure that people's livelihoods, public and private enterprises, assets, communities, infrastructure and the economy are resilient to the realities of a varying climate. Adaptation should be seen as a process not a one-off activity. A varying climate will require ongoing activities by institutions and individuals to adjust their behavior either in anticipation of predicted impacts or in response to emerging trends and extreme events.

Literature on vulnerability studies are increasing while adaptation measures have not been deeply researched. As a result, most information about adaptation is still embedded in work about the climate change and variability in general. An example of such studies is a study on the economic impact of climate change on Kenyan crop agriculture (Kabubo and Karanja 2006). General information on adaptation to climate variability has also been presented by the Climate Change Screening of Danish Development Cooperation with Kenya (CCSDDCK) and according to the study, farmers have responded to the present climatic variability by adapting. It is crucial to have a greater understanding of the society's adaptive potential to better comprehend the consequences of unabated climate variability (Fankhauser *et al.* 1998).

Figure 1 below is an example of precipitation to give some insight on the climate variability of Rongai district. The data was recorded at Menengai rainfall station. An upward slope indicates a wet period and a downward slope indicates a dry period.

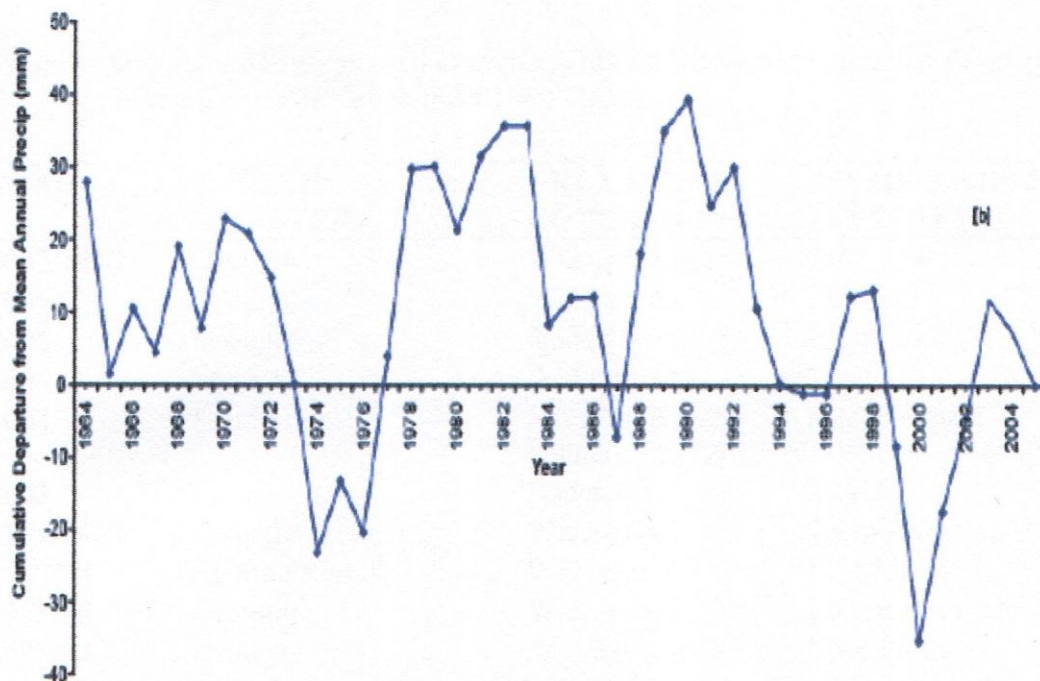


Figure 1: Cumulative rainfall trend for Menengai rainfall station
.Source: Kenya Meteorological Department 2004

The other indicators that can be used to give insight into climate variability are the occurrences of floods and prolonged droughts in Kenya, which in most cases are related to El Nino – Southern Oscillation (ENSO) events. Such events have occurred with increased severity and frequency in recent years, with a greater influence from climate variability events, Kenya Meteorological Department (KMD) (2007). Some of these indicators are shown in table 1 below

Table 1: Summary of drought and extreme rainfall events and the number of people affected in different parts of Kenya from 1980 - 2008

YEAR	TYPE OF DISASTER	AREA OF COVERED	NO. OF PEOPLE AFFECTED
2007/2008	Drought	Widespread	9,000,000
2006	Drought	Widespread	723000
2005	Drought	Widespread	1.2 million
2004	Drought	Widespread	3 million
2004	Land Slides	Nyeri/Othaya Kihuri	5 people dead
2003	Flood	Budalang'i	28,000
1999/2000	Drought	Widespread	4.4 million
1997/98	El Nino floods	Widespread	1.5 Million
1995/96	Drought	Widespread	1.41 million
1991/92	Drought	Arid/Semi Arid zones	1.5 million
1985	Floods	Nyanza/Western	10,000
1983/84	Drought	Widespread	200,000
1982	Floods	Nyanza	4,000
1980	Drought	Widespread	40,000
1977	Drought	Widespread	20,000
1975	Drought	Widespread	16,000
1971	Drought	Widespread	150,000

Source: Kenya Meteorological Department, 2008.

The country witnessed serious droughts at least 13 times in the past 50 years. Major floods that periodically afflict the Lake Victoria region, the lower Tana River basin and coastal areas have also occurred at least six times over the same period. Table 1 shows a summary of extreme rainfall events (drought and flood periods) and numbers of people affected in various parts of the country in the recent times. Since the late 1970s, the country witnessed 103 weather-related disasters, of which more than half had occurred after the year 2000. It is important to note that the drought frequency and number of people affected increased sharply from 1992 (Table 1), and from the beginning of 2009, localized floods have been observed to occur in 22 districts of the arid and semi-arid areas, causing the death of human and animals alike, damage to infrastructure as well as the destruction of large crop fields. Prior to this period, only the Kano plains and Budalangi area in western Kenya, and the lower Tana River basin were classified as flood-prone spots (KMD 2008).

1.1.1 Climate and Agriculture in Kenya

Climate, vegetation and land use potential have been used to assess land suitability for different uses. The major elements of climate that affect herbage growth are the intensity and duration of rainfall, the relationship between annual rainfall and potential evapotranspiration and the year-to-year variation in rainfall. Kenya is divided into seven agro-climate zones using a moisture index based on annual rainfall expressed as a percentage of potential evaporation. Areas with an index greater than 50% have high potential for cropping and are designated zone I, II and III. These zones account for 12% of Kenya's land area. The semi-humid to arid regions (zones IV, V, VI and VII) have indexes of less than 50% and a mean annual rainfall of less than 1100 mm. (Sombroek *et al.* 1982)

These zones are generally referred to as the Kenyan range-lands and account for about 80% of the land area. The seven agro-climate zones are each subdivided according to mean annual temperature to identify areas suitable for growing each of Kenya's major food and cash crops. Most of the high potential areas are located above an altitude of 1200m above the sea level and have mean temperatures of below 18°C. These areas are mainly suitable for livestock farming (mostly cattle and sheep), cash crops (coffee, tea and pyrethrum) and key food crops (maize, beans and wheat). The medium potential zones favor farming systems similar to the high potential areas, but temperatures are higher and productivity lower. In these zones barley, cotton, cassava, coconut and cashew nuts are also cultivated. Ninety percent of the arid and semi-arid areas lies below 1260m and mean annual temperatures range from 22°C to 40°C. These areas are less suited for arable agriculture but support sorghum, millet, livestock and wildlife.

1.1.2 Wheat Sub Sector in Kenya

Wheat is the second most important cereal in Kenya after maize in terms of production and consumption. Wheat production declined in the 2009 season to register 1.3 million bags though the area under the crop increased by 1 per cent to reach the highest record of 131,594 ha in the year under review. More specifically, production has been on the decline since 2005 dropping from 4.1 million bags in 2005 to as low as 2.4 million bags in 2009 as shown in Table 2 (Ministry of Agriculture, 2009). The trend can be attributed to various factors among them being erratic climatic conditions, unpredictable producer prices, pests and high input prices, (Ministry of Agriculture 2009). In contrast to production, wheat consumption in Kenya has been on a general increase. Due to the rising demand for wheat, caused by high population growth and

increased urbanization, consumption has increased faster than production. The current domestic wheat requirements are about 1,072,000 bags of 90 kilograms. Kenya has therefore relied on imports to meet domestic needs in wheat. Wheat import volumes have been on the rise since 2008 when imports were recorded at 538,500 tons; the lowest in the series. Thus at 781,700 tons, 2009 represents an increase of 45 per cent compared with 2008 as shown in Table 2 below.

Table 2: Wheat Production and Prices 2005 - 2009

Year	2005	2006	2007	2008	2009*
Area (ha)	159,477	150,488	104,176	130,273	131,594
Production					
90 kgs bags	4,063,294	3,978,454	3,936,105	3,737,241	2,436,678
Tons	365,696	358,061	354,249	336,688	219,301
Unit price per bag (Kshs)	1,639	1,714	3,000	2,600	3,571
Average Yield (bags/ha)	25.00	26.00	28.00	11.32	18.5
Consumption (90 bags)	893,120	903,120	892,000	853,000	1,072,000
Import (tons.)	621,839	650,400	564,300	538,500	781,700
Total Value Production (billion Kshs)	6.66	6.82	10.03	11.20	8.70

Source: Directorate of Crops, 2009

Increased wheat imports into Kenya and declining production levels poses two challenges. First, increased wheat imports dampen domestic prices, which is a disincentive to domestic production. As a result, farmers will tend to shift to enterprises that are more lucrative. This can perpetuate dependence on wheat imports, the source of which may be unpredictable. Secondly, decreased production levels can lead to collapse of the manufacturing industry for wheat products, resulting in substantial loss of employment and livelihood for many Kenyans. These challenges make it necessary to review the wheat industry in Kenya in order to identify the constraints faced, and propose policy options that can help in the development of the industry.

Wheat is grown largely for commercial purposes on a large scale. Kenya is self-sufficient in the hard variety of wheat, but is a net importer of the softer variety. Wheat growing areas in Kenya include the scenic Rift Valley regions of Uasin Gishu, Narok, Marakwet, Elgeyo, Londiani, Molo, Rongai, Njoro and Timau areas. These areas have altitudes ranging between 1200m and 1,500m above sea level, with annual rainfall varying between 800 mm and 2,000 mm, with up to 2,500 mm on higher grounds. The areas under wheat production in Kenya increased from 144,000 hectares in 2002 to 150,000 hectares in 2003. Wheat varieties grown in

Kenya include the high-yielding and drought-resistant Njoro BW1 and Njoro BW2. Njoro BW1 is grown in dry parts such as Lower Narok, Machakos and Laikipia, with a harvest of up to 20 bags an acre. Njoro BW2 performs well in acidic soils, like parts of Uasin Gishu and Rongai districts. Njoro BW2 produces 35 bags of wheat per acre. Other varieties are the duma and chozi, mainly grown in dry areas, which yield about 19 bags an acre, and Kenya heroe and Kenya yombi, which can produce up to 32 bags an acre. Most of these varieties are results of research by the Kenya Agricultural Research Institute (KARI). The major diseases that affect the wheat crop include Anthracnose, Browning Root Rot, Copper Deficiency and Bacterial Blight. Insects that attack the wheat crop include the Army Cutworm, Barley Thrips, and Grasshoppers among others.

1.2 Statement of the Problem

Variable climate events have had devastating effects on the wheat sector in Kenya in the past as evidenced by the erratic decline in production ranging from 379,034 tons in 2003 to approximately 336,688 tons in 2008, leaving the crop dependent groups with a limited source of livelihood. According to studies done in Kenya on effects of climate change, farmers have responded to the present climatic variability by changing their crop management practices (e.g choice of fields, planting dates, crop varieties etc), livestock management practices (e.g feeding and animal health practices), land use and land management. Whereas this may be true, wheat farmers in Rongai district continue to experience declining wheat output due to many factors among them, climate variability. Despite various literatures indicating that farmers have adapted to climate variability in various ways, it is not clear how wheat farmers in Rongai district have adapted to climate variability.

This study seeks to investigate actual adaptation behavior of farmers based on the analysis of farmer decisions in the face of variable climate conditions in order to improve the adaptive capacity of the wheat farmers in Rongai district.

1.3 General Objective

The general objective of this study is to analyze the perception and the adaptability level to climate variability among the wheat farmers in Rongai district in order to improve the adaptive capacity of wheat of farmers.

1.4 Specific Objectives

1. To determine the wheat farmers' perception about climate variability.
2. To assess wheat farmers' adaptation strategies to climate variability.
3. To estimate the extent of adaptation to climate variability among the wheat farmers at farm level.

1.5 Research Questions

1. What is the perception of wheat farmers' about climate variability?
2. What are the adaptation strategies to climate variability among the wheat farmers?
3. What is the extent of adaptation to climate variability among the wheat farmers at farm level?

1.6 Justification of the Study

Recent empirical studies indicate that farmers have already adapted to the existing climatic conditions that they face by choosing crop varieties, livestock breeds or irrigation systems ideal for their prevailing conditions (Niggol, et al. 2008). By studying adaptation to climate variability, researchers can help farmers and policy makers identify efficient adaptation measure that will maximize output within the wheat sector.

Existing adaptation studies suggest that farmers should take different adaptation measures depending on their initial climate conditions. However, these studies focused on the possibility of farmers to adapt to climate variability but did not provide the level or extent of adaptation specific to a certain zone and crop. This information is crucial to the farmers and policy makers who are interested in making investment adjustments to match possible climatic variability. Local adaptation measures are necessary because continental scale adaptation measures may not be appropriate due to the existence of diverse agro-economic conditions across the continent. Adaptation can greatly reduce vulnerability to climate change by making rural communities better able to adjust to climate variability, moderating potential damages and helping them cope with adverse consequences (IPCC 2001). A better understanding of farmers perception on climate variability, ongoing adaptation measures and the decision making process is important to inform policies aimed at promoting successful adaptation in the wheat sector. Adaptation will require the involvement of multiple stakeholders, including policy makers, extension agents, NGO's researchers, communities and farmers. Macro-level analysis focuses on strategic national

decisions and policies on local to regional scales taking into account long term changes in climatic, market and other conditions over long periods (Bradshaw *et al.* 2004; Kandlinkar and Risbey 2000). Therefore, area specific adaptation strategies are crucial since farm-level decision making occurs over a very short time period and usually influenced by seasonal climatic variations, local agricultural cycle, and other socio-economic factors.

1.7 Scope and Limitation

Different crop types are affected differently by climate variability, hence the need for further disaggregation of analysis relative to specific crops. The scope of this study was to conduct a crop specific analysis as farm level adaptation is conditioned by local circumstances and the specifics of the available agricultural options. Focusing the study on Rongai district is in itself also another limitation.

The study was mostly concerned with one agro ecological zone and this may not have important implication on extent of adaptation in other different agro ecological zones given the large geographical disparities in the country.

1.8 Definition of Terms

Climate

This is referred to as the prevalent long-term weather conditions in a particular area.

Climate Change

It is defined as any change in climate over time, whether due to natural variability or human activity (IPCC 2001). According to the United Nations Framework Convention on Climate Change (UNFCCC) they define it as “a change of climate attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods

Climate Variability

This is referred to variation in the means state and other statistics of climate on temporal and spatial scales beyond that of individual weather events. Some of the causes of climate variability include industrial pollution, destruction of nature and car gas emissions.

Adaptation Practices

Refer to actual adjustments, or changes in decision environments, which might ultimately enhance resilience or reduce vulnerability to observed or expected changes in climate. (IPCC 2001)

Adaptive Capacity

It is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities, or to cope with the consequences (IPCC 2001). The adaptive capacity of a system or society describes its ability to modify its characteristics or behavior so as to cope better with changes in external conditions.

Vulnerability to Climate Change

It is the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change (IPCC 2001)

CHAPTER TWO

LITERATURE REVIEW

This chapter presents a discussion of approaches that have been used to analyze the adaptation of agriculture to climate change and variability from literature and then followed by a review of factors hypothesized as affecting the extent of adaptation to climate variability

A detailed review of literature and studies with regard to adaptation options in agriculture is undertaken. This review is provided in order to gain insight to the existing knowledge and areas where further research is needed.

2.1 Review of climatic variability and adaptation studies in agriculture

For world food production to maintain or increase its level of output in varying climate, farmers will have to respond to new climatic conditions. Even in areas where productivity is considerably reduced for existing agriculture, the initial impacts of climate variability could be substantially alleviated by adopting appropriate crop and livestock mixes. Some of ways to encourage adoption of appropriate crop and livestock mixes include reducing barriers to trade and implementing commodity support programs that allow farmers more flexibility in production decisions, Lewandrowski and Brazee (1993)

Wall (2001) provided information from Canadian agricultural producers and policy makers. He identified important attributes of climate change for adaptation in agriculture and related insights about decision-making from several fields of scholarship to agricultural adaptation to climate. A critique of the main dimensions of adaptation provides the basis for the typology of adaptation options in Canadian agriculture. Agricultural adaptation types are differentiated primarily according to the actors involved and the form they take. The adaptation types are also considered according to how they are connected to processes already in place to cope with risks associated with climate and other conditions. The importance of this approach is that it systematically characterizes the wide variety of types of adaptation to climate change, and provides some order to these options, in terms of both the forms of adaptations to undertake, and the stakeholders and decision processes involved.

Attri and Rathore (2003) suggest that the possible changes in sowing dates and hybrid selection can reduce the negative impact of projected future potential warming in the current

century. It should be noted that shifting of sowing dates is a no-cost decision that can be taken at the farm level; a large shift in sowing dates probably would interfere with the agro technological management of other crops, grown during the remaining part of the year. Changes in the cropping mixtures, irrigation and agriculture land use can be additional alternative options for adaptation in agriculture.

Seo and Mendelsohn (2007) in their study use a structural equation model to capture the endogenous choices made by farmers and their resulting expected income. They used a model which assumes that farmers choose the profit maximizing level of inputs for each animal, the species that provides the highest net revenue, and the number of animals of that species. The study tests whether these decisions are influenced by climate. The multinomial choice model used reveals that the probability of selecting beef cattle, dairy cattle, and chickens diminish sharply in warmer places. The results give insights into how farmers might adapt to climate variability given the climate condition they are facing.

Kurukulasuriya and Mendelsohn (2008) examine the impact of climate change on primary crops grown in Africa. They present an innovative approach that bridges the gap between agro-economic and traditional Ricardian models. They label it a 'structural Ricardian model'. It first captures the type of crop a farmer will select and then examines the conditional net revenue of that crop. The model is estimated using a sample of over 5000 farmers across 11 countries in Africa. The analysis finds that farmers shift the crops they plant to match the climate they face. Studies that fail to account for crop switching will overestimate the damages from climate change and underestimate the benefits.

Boubacar (2010) estimated the effects of a constructed index of degree-days, precipitation intensity, and a standardized precipitation index (SPI) on the mean yield and yield variability of three major crops in eight countries in the Sahelian region. He uses a Just-Pope stochastic production function of maize, millet and sorghum for the period spanning from 1970 to 2000. The results suggest that the effects of climate change are similar across all crops. The sign of the estimates for acreage variable is crop specific however. The results of this study have implications in farmers' decision to allocate agricultural land because the effects of acreage are found to be crop specific

Thomas (2008) identifies the major methods used by farmers to adapt to climate change in the Nile Basin of Ethiopia, the factors that affect their choice of method, and the barriers to

adaptation. The methods identified include use of different crop varieties, tree planting, soil conservation, early and late planting, and irrigation. Results from the discrete choice model employed indicate that the level of education, gender, age and wealth of the head of household; access to extension and credit; information on climate, social capital, agro-ecological settings, and temperature all influence farmers' choices over the short-term (up to 10 years). Efforts should be concentrated on helping the poor cope with and adapt to climate change rather than placing efforts on predicting in greater detail the effects of climate change on agriculture or on efforts to mitigate emissions of greenhouse gases from agriculture.

Wang *et al.* (2009) examined how farmers have adapted to the current range of climates across China. They find that both irrigation and crop choice decisions are climate sensitive. Chinese farmers are more likely to irrigate when facing lower temperatures and less precipitation. Farmers in warmer places are more likely to choose oil crops, maize, and especially cotton and wheat, and are less likely to choose vegetables, potatoes, sugar and especially rice and soybeans. In wetter locations, farmers are more likely to choose soybeans, oil crops, sugar, vegetables, cotton and especially rice, and they are less likely to choose potato, wheat and especially maize. The analysis of how Chinese farmers have adapted to current climate, provides insight into how they will likely adapt when climate changes. The analysis however does not take into account other background changes that may well occur, including changes in prices, technology, and water availability.

Climate and weather conditions are a good example of factors that require on-going adaptation. With climate variability they take on even more significance. Based on data from Canadian producers, Ellen and Barry (2005) identified several climate and weather risk adaptation strategies currently in use and notes their close links to sustainable agriculture practices. The article concludes that the mutually supportive relationship between sustainable agriculture and climate change adaptation could be used to justify more government support for sustainable agriculture policies and programs.

Clarke (2007) approach to this problem eschews use of probability information and instead uses classical decision theory ideas of minimax and minimax regret to motivate farm level decisions. The quest is to determine robust decision rules that avoid catastrophically large costs or opportunity cost losses and which account for the possibility that policy may prove ineffective and climate change costs may prove to be less expensive than feared.

The specific problem is the derivation of anticipatory, strategies to facilitate adaptation to climate change. Policies with uncertain effectiveness are adopted now to try to ameliorate consequences of severe climatic change.

Kandlinkar and Risbey (2000) found out in their study that adaptation has the ability to significantly contribute to reductions in negative impacts from changes in climatic conditions as well as other changing socioeconomic conditions, such as volatile short-term changes in local and international markets. Therefore, an analysis of adaptation options and constraints to adaptation is important for the wheat sector in Kenya

2.2 Theoretical Framework

Farmers are assumed to maximize expected utility according to a Von Neuman Morgenstern utility function defined over wealth (W). When faced with a choice between two optional practices, the i^{th} farmer compares the expected utility with the modern technology, $EU_{mi}(W)$ to the expected utility with the traditional technology $EU_{ti}(W)$. While direct measurement of farmers' perceptions and risk attitudes on farming technology are unobservable, inferences can be made for variables that control the distribution and expected utility evaluation of the technology. These variables are used as a vector ' X ' of attributes of the choices made by farmer ' i ' and ε_i is a random disturbance that arises from unobserved variation in preferences, attributes of the alternatives, and errors in optimization. Given the usual discrete choice analysis and limiting the amount of non-linearity in the likelihood function, $EU_{mi}(W)$ and $EU_{ti}(W)$ may be written as

$$EU_{mi}(W) = \alpha_m X_i + \varepsilon_{mi} \quad (1)$$

$$EU_{ti}(W) = \alpha_t X_i + \varepsilon_{ti} \quad (2)$$

The difference in expected utility may then be written as

$$\begin{aligned} EU_{mi}(W) - EU_{ti}(W) &= (\alpha_m X_i + \varepsilon_{mi}) - (\alpha_t X_i + \varepsilon_{ti}) \\ &= (\alpha_m - \alpha_t) X_i + (\varepsilon_{mi} - \varepsilon_{ti}) \end{aligned}$$

$$= \alpha X_i + \varepsilon_i \quad (3)$$

Where $\alpha = (\alpha_m \ \alpha_t)$ and $\varepsilon_i = \varepsilon_{mi} \ \varepsilon_{ti}$

A preference for the modern technology will result if

$$EU_{mi}(W) - EU_{ti}(W) > 0 \quad (4)$$

whereas, a preference for the traditional technology will be revealed if

$$EU_{mi}(W) - EU_{ti}(W) < 0 \quad (5)$$

2.3 Conceptual Framework

Information about climate variation forecasting, adaptation options and other agricultural production activities remains an important factor affecting use of various adaptation measures for most farmers. Limitations in information (seasonal and long-term climate changes and agricultural production) increases the risks from failure associated with uptake of new technologies and adaptation measures (Jones 2003; Kandlinkar and Risbey 2000)

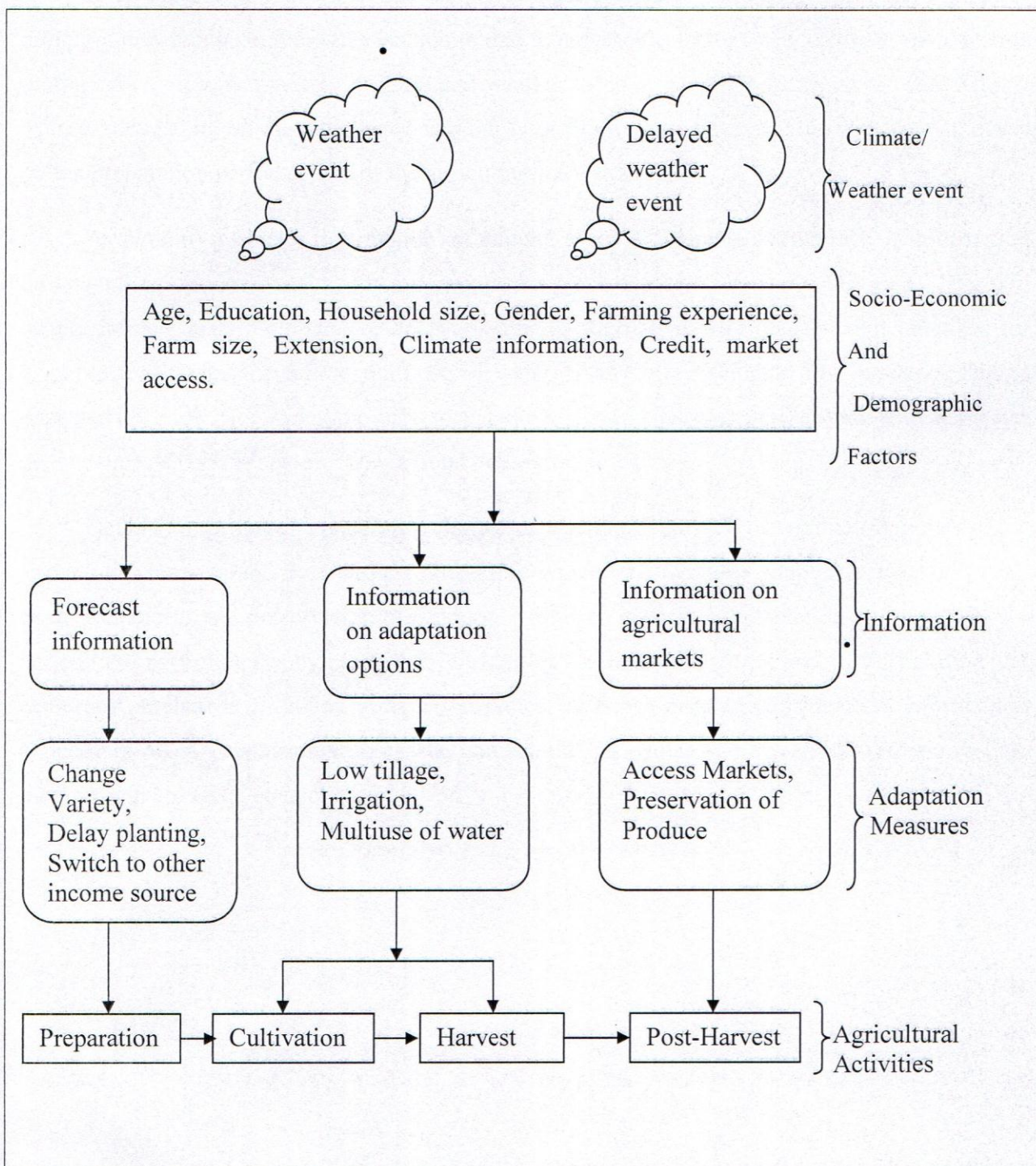


Figure 2: Conceptual framework

Adapted from Jawahar and Msangi, (2006)

It is postulated that clear and detailed weather forecast covering the period prior to cropping depending on the socio-economic and demographic factors will facilitate the decision on the choice of wheat variety to grow and weather to delay planting or switch to other income sources, depending on the anticipated variability of the weather pattern. This will have an effect on the preparation period as one of the agricultural activities.

Availability of better information on climate event will enable availability of information on adaptation options suitable for a particular crop for example wheat for this case. This will enable farmers make comparative decisions among alternative crop management practices for example low tillage, irrigation, multiuse of water or any other suitable farm practice. This is expected to have a considerable effect on cultivation and harvest periods but with a greater dependence of various socio-economic and demographic factors.

Detailed information concerning climate or weather event will provide guiding data about agricultural markets and post harvest processing which will facilitate adaptation measures such as market access and preservation of produce. Failure to implement adaptation options and poor agricultural performances by many African farmers has been blamed on lack of information and resources (Archer *et al.* 2005). Adaptation policy measures need to consider how information concerning adaptive measures, forecasts, and production cycles can best reach farmers to help them respond to changes in climate.

CHAPTER THREE

METHODOLOGY

3.1 Area of Study

Rongai is one of the districts that make up Nakuru County. It lies within the Great Rift Valley and borders five other districts namely; Koibatek to North, Nakuru North to the South, Molo to the North West, Njoro to the South West and Laikipia to the North East as shown in figure 3 below . The area receives rainfall that average 600 to 700 millimeters annually. The district covers an area of 1221.9km² and is located between Longitude 35 ° 85` and 35 ° 51` East and Latitude 0 ° 10 and 1° 05` South. The district is divided into five divisions namely Kampi Ya Moto, Ngata, Rongai, Solai and Mbogoini. The climatic conditions of this area are influenced by altitude and physical features (Escapement, lake and mountain). The farmers here practice mixed farming where they grow crops and keep animals. The main crops grown in the area are maize, wheat and horticultural crops (GoK, 2009). Rongai District was selected as the study area because it is one of the major wheat growing regions in Kenya.

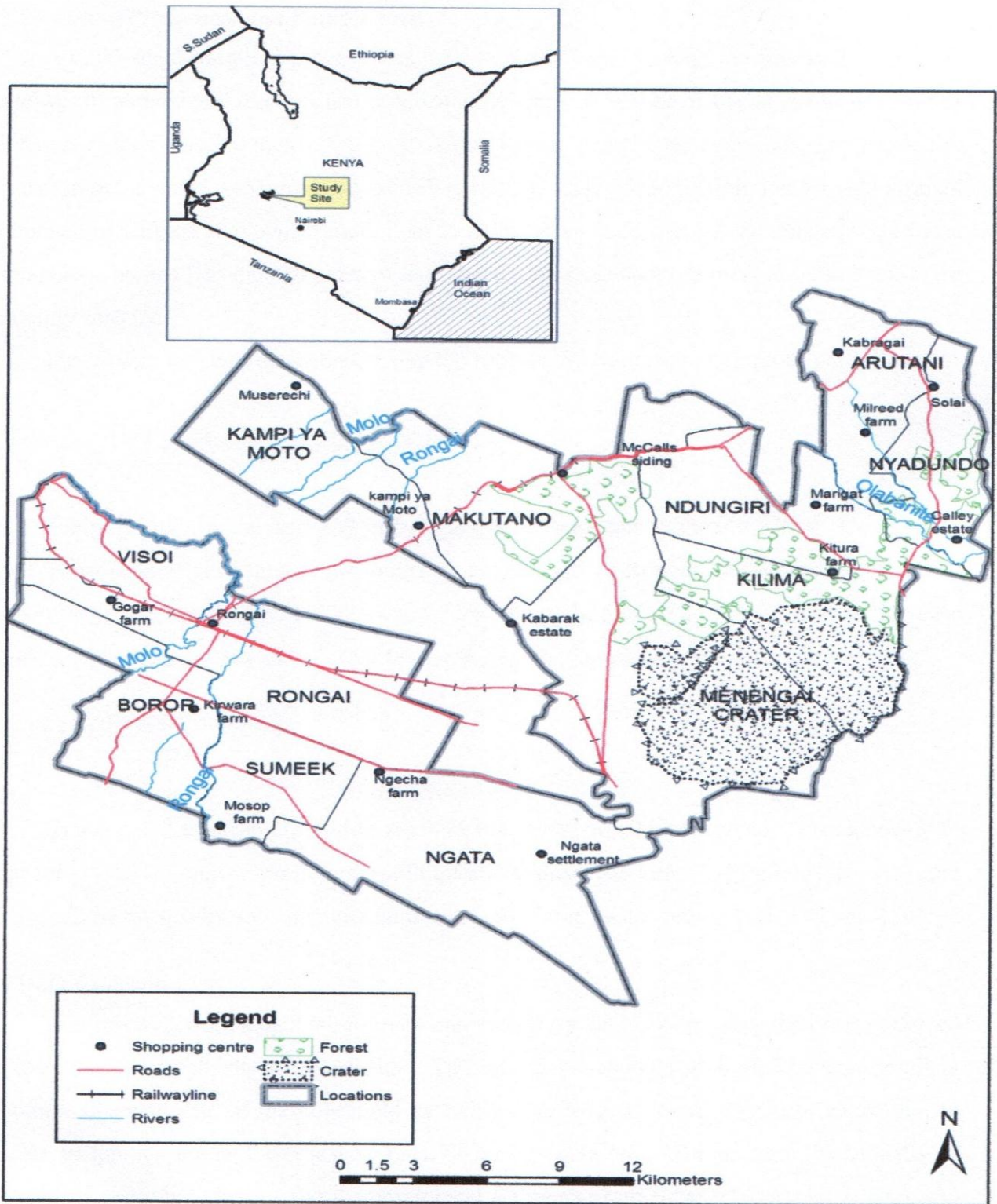


Figure 3: Map of Rongai District

3.2 Sampling Procedure and Sample Size

A multi-stage sampling process was used to select wheat farmers for this study. The first stage was to purposively select wheat producing divisions within the district. For this case out of the five divisions, three of them, (Kampi ya Moto, Rongai and Ngata) were selected. Secondly, farmers in these zones were stratified according to their scale of production. Large-scale farmers comprised of farmers who owned more than 20 acres of land and small-scale farmers were those farmers who owned less than 20 acres of land. Lastly the respondent farmers in these strata were randomly selected.

The sample size was determined using the formula by Anderson *et al.* (2007) as follows;

$$n = \frac{(Z_{\alpha/2})^2 P(1-P)}{E^2} \tag{6}$$

The population of farmers (N) in Rongai district was approximately 25000. The number (x) of wheat farmers according to the ministry of agriculture in Rongai was approximately 2400. Proportion (P^*) is thus; $x/N = 2400/25000 = 0.096$ the desired margin of error (E) = 0.05, while Confidence interval is 95% and $z_{\alpha/2} = 1.96$. Therefore the sample size for wheat farmers was:

$$n = \frac{(1.96)^2 0.096(1 - 0.096)}{0.05^2} = 133$$

This resulted to a sample of 133 respondents. There was an additional 17 respondents to cater for variability, non-response and spoilt questionnaires. The larger the sample size, the more robust will be the results, thus the total number of individuals who were interviewed was 150.

3.3 Data Collection

This research work used both primary and secondary data. The primary data was collected by use of a structured interview schedule. The interview schedule was used to capture socio economic characteristic of the household as well as the perception and extent of adaptation to climate variability among the wheat farmers. Secondary data was obtained from the Ministry of Agriculture in Rongai district and meteorological stations at Menengai feedlot, Gogar farm and Kikawa field school. Climate data on mean monthly precipitation and temperature data covered the period from January 1996 to December 2009.

3.4 Data Analysis

The study employed descriptive statistics to analyze the wheat farmers' perception to climate variability using SPSS computer program while the extent of adaptation was analyzed using the double-hurdle model which is already programmed in the STATA computer program.

3.4.1 Analysis of wheat farmers' perceptions to climate variability

To assess farmers' perceptions of climate variability, descriptive statistics based on the summary counts of the questionnaire structure was used to provide insights into wheat farmers' perceptions to climate variability. This involved the use of SPSS computer programs to work out the frequencies of each adaptation strategy as well as their percentages relative to the total number of farmers who had adapted to climate variability.

3.4.2 Analysis of adaptation and extent of adaptation to climate variability among the wheat farmers

The analytical model that was used for this study is the Double-Hurdle model. The Double-Hurdle model examined the wheat farmers' adaptation decision to climate variability as well as the extent of adaptation to climate variability in Rongai district. The other statistical models that could be used to analyze farmer's adaptation and intensity of adaptation are the Tobit and the Heckman models. However, the Tobit estimator applies to a special case of the two processes, where the first hurdle is irrelevant. For this case the Tobit model cannot determine why the farmers adapted or not. The limitation of the Tobit model is the assumption that the adaptation decision is irrelevant. The Double-Hurdle model relaxes this assumption. The Tobit model forces the adaptation decision to be identical to the intensity decision. The Double-Hurdle model is more general than the Tobit model because the Tobit model is nested in the Double-Hurdle model. On the other hand the Heckman model may not be appropriate because of the first hurdle dominance; a condition in which the adaptation decision receives greater importance than the intensity decision. The Double-Hurdle model treats the adaptation decision and the intensity of adaptation decisions separately thus the relevance of this model.

3.4.2.1 Double-Hurdle Model

The Double- Hurdle model, originally proposed by Cragg (1971), assumes that two separate hurdles must be passed before a positive level of consumption can be observed. According to the double-hurdle model, participation and consumption decisions are assumed to stem from two separate individual choices and the determinants are allowed to differ. In the

context of adaptation to climate variability analysis, those farmers who had perceived climate variability were asked if they had adapted to climate variability or not and therefore the first hurdle involves the decision on whether or not they had adapted to the perceived climate variability. This was based on the assumption that adaptation is not only due to economic factors, but also influenced by social and demographic factors, which are independent of a particular measure taken by the farmer. The first part of the double-hurdle model will be used to model the discrete choice of whether the farmer has adapted to climate variability or not, with a specification similar to that of the probit model.

The second hurdle concerns the extent or the level of adaptation which is determined by the percentage number of options undertaken relative to the total number of adaptations that were available within the household with a specification similar to that of a tobit model. Some the adaptation options or response probabilities that were considered for this study included the following; crop switching, changed planting dates, implemented soil conservation techniques, took out insurance, put trees for shading, irrigated, changed from crop to livestock, reduced the number of livestock, migrated to urban area, looked for off-farm job, switched variety used and leased out land among others. Therefore, the specification of the generalized double-hurdle model is as shown below:

$$Y_{i1}^* = \omega_i' \alpha + v_i \quad \text{Adaptation decision} \quad (7)$$

$$Y_{i2}^* = x_i' \beta + u_i \quad \text{Extent of adaptation} \quad (8)$$

$$Y_i = x_i' \beta + u_i \quad \text{If } Y_{i1}^* > 0 \text{ and } Y_{i2}^* > 0 \quad (9)$$

$$Y_i = 0 \quad \text{Otherwise}$$

Where Y_{i1}^* is the latent variable describing the household adaptation decision on climate variability, Y_{i2}^* is the parametrized latent variable describing the extent of adaptation to climate variability (percentage number of options undertaken relative to the total number of adaptations that were available within the household). Y_i is the observed dependent variable (extent of adaptation to climate variability), ω_i is a vector of variables explaining the climate variability adaptation decision. x_i is a vector of variables explaining the extent of adaptation decision. v_i

and u_i are the respective error terms assumed to be independent and distributed as $V_i \sim N(0,1)$ and $u_i \sim N(0, \sigma^2)$

The model was estimated using the maximum likelihood estimation procedures. However, to overcome the inconsistency of such estimates in the presence of heteroscedasticity and non-normality of the error terms, necessary adjustments were made. To account for heteroscedasticity, the variance of the errors was allowed to vary across observation by specifying it as a function of a set of continuous variables:

$$\sigma_i = \exp (Z_i' h) \tag{10}$$

Z_i are elements of X_i ($W_i \in X_i$) and h is a conformable vector of coefficients (Jones and Yen 1997) an inverse hyperbolic sine (IHS) transformation of the dependent variable produced consistent estimates for both models in the presence of non-normality (Burbidge *et al.* 1988).

For the double-hurdle model the transformation was

$$T(QY_i) = \log \left[\frac{QY_i + (Q^2 Y_i^2 + 1)^{\frac{1}{2}}}{Q} \right] \tag{11}$$

whereby Q is an unknown parameter. When both v_i and u_i are normally distributed and independent random variables with zero mean and constant variance, the likelihood function for the double hurdle model is:

$$L(\alpha, \beta, h, \theta) = \prod_0 \left[1 - \Phi(\omega_i' \alpha) \Phi\left(\frac{x_i \beta}{\sigma_i}\right) \right] \times \prod_1 \left[(1 + Q^2 Y_i^2)^{-\frac{1}{2}} \Phi(\omega_i' \alpha) \sigma_i^{-1} \Phi\left(\frac{T(QY_i) - x_i \beta}{\sigma_i}\right) \right] \tag{12}$$

The estimated coefficients in the double-hurdle model cannot be interpreted like the linear regression model. In order to assess the impact of the explanatory variable, it necessitated the analysis of their marginal effects. This involved the decomposition of the unconditional mean into the effect on the probability of adapting to climate variability and the effect on the conditional extent or level of adaptation and differentiating these components with respect to each explanatory variable. The unconditional mean can be written as

$$E(Y|x_i) = A(Y_i > 0) E(Y_i|Y_i > 0) \tag{13}$$

The probability of adapting to climate variability conditional on the percentage number of measures taken is given by:

$$A(Y_i > 0) = \Phi(\omega_i \alpha) \Phi\left(\frac{x_i' \beta}{\sigma_i}\right) \quad (14)$$

While the probability of attaining a particular level of adaptability conditional on the percentage number of measures taken is given by:

$$E(Y_i | Y_i > 0) = \Phi\left(\frac{x_i' \beta}{\sigma_i}\right)^{-1} \int_0^\infty \left(\frac{Y_i}{\sigma_i \sqrt{1 + \theta^2 Y_i^2}} \phi\left(\frac{T(\theta Y_i) - x_i' \beta}{\sigma_i}\right) \right) dY_i \quad (15)$$

For the continuous explanatory variables the marginal effects are used to calculate elasticities at the sample means. For the discrete or categorical variables, the marginal effects are used to calculate percentage changes in the dependent variable when the variable shifts from zero to one, *ceteris paribus*

3.4.3 Empirical Model and Specification

The percentage number of adaptation strategies to climate variability relative to the total number of adaptations that were available within the household was aggregated for each household resulting in a final cross-sectional data set containing the percentage of adaptation decision and the corresponding socio-economic and demographic characteristics. The empirical model is as shown below

First hurdle

$$ADTP(\text{Yes/No}) = \alpha_0 + \alpha_1 HHHEDU + \alpha_2 SCL + \alpha_3 HHSIZE + \alpha_4 WHTEXPRN + \alpha_5 WHTLADZS + \alpha_6 MEMGRP + \alpha_7 CRTD + \alpha_8 TRAING + \alpha_9 DSEOCC + \alpha_{10} INMKT + \alpha_{11} HHHAGE + \alpha_{12} TEMPCH + \alpha_{13} RAINCH + v_i \quad (16)$$

Second hurdle

$$EXADTP = \alpha_0 + \alpha_1 HHHEDU + \alpha_2 SCL + \alpha_3 HHSIZE + \alpha_4 WHTEXPRN + \alpha_5 WHTLADZS + \alpha_6 MEMGRP + \alpha_7 CRTD + \alpha_8 TRAING + \alpha_9 DSEOCC + \alpha_{10} INMKT + \alpha_{11} HHHAGE + \alpha_{12} TEMPCH + \alpha_{13} RAINCH + v_i \quad (17)$$

3.4.4 Factors hypothesized as affecting the extent of adaptation to climate variability

Higher level of education is believed to be associated with access to information on improved technologies and higher productivity (Norris and Batie 1987). Evidence from various sources indicates that there is a positive relationship between the education level of the household head and the adoption of improved technologies (Igoden, *et al.* 1990; Lin 1991) and adaptation to climate variability (Maddison 2006). Therefore, farmers with higher levels of education are more likely to adapt better to climate variability.

Male-headed households are more likely to get information about new technologies and undertake risky businesses than female-headed households (Asfaw and Admassie 2004). Moreover, Tenge and Hella (2004) argue that having a female head of household may have negative effects on the adoption of soil and water conservation measures, because women may have limited access to information, land, and other resources due to traditional social barriers. A study by Nhemachena and Hassan (2007) finds contrary results, arguing that female-headed households are more likely to take up climate change adaptation methods. The authors conclude that women are more likely to adapt because they are responsible for much of the agricultural work in the region and therefore have greater experience and access to information on various management and farming practices. Thus, the adoptions of new technologies or adaptation methods appear to be rather context specific.

Age of the head of household can be used to capture farming experience. On the one hand, studies in Ethiopia have shown a positive relationship between number of years of experience in agriculture and the adoption of improved agricultural technologies (Kebede *et al.* 1990), while a study by Shiferaw and Holden (1998) indicates a negative relationship between age and adoption of improved soil conservation practices. On the other hand, studies by Maddison (2006) and Nhemachena and Hassan (2007) indicate that experience in farming increases the probability of uptake of adaptation measures to climate change. This study hypothesizes that experience increases the extent of adapting to climate variability.

The influence of household size on use of adaptation methods can be seen from two angles. The first assumption is that households with large families may be forced to divert part of the labor force to off-farm activities in an attempt to earn income in order to ease the consumption pressure imposed by a large family (Yirga 2007). The other assumption is that large family size is normally associated with a higher labor endowment, which would enable a

household to accomplish various agricultural tasks. For instance, Croppenstedt, *et al.* (2003) argue that households with a larger pool of labor are more likely to adopt agricultural technology and use it more intensively because they have fewer labor shortages at peak times. Here it is expected that households with large families are more likely to have more options for adapting to climate variability.

Farm and nonfarm income represent wealth. It is regularly hypothesized that the adoption of agricultural technologies requires sufficient financial wellbeing (Knowler and Bradshaw 2007). Other studies that investigate the impact of income on adoption found a positive correlation (Franzel 1999). Higher-income farmers may be less risk averse and have more access to information, a lower discount rate, and a longer-term planning horizon (CIMMYT 1993). Thus, for this study, farm and nonfarm income are hypothesized to increase the level of adaptation to climate variability.

Extension on crop and livestock production and information on climate represent access to the information required to make the decision to adapt to climate change. Various studies in developing countries, including Ethiopia, report a strong positive relationship between access to information and the adoption behavior of farmers (Yirga 2007), and that access to information through extension increases the likelihood of adapting to climate variability (Maddison 2006; Nhemachena and Hassan 2007). Thus, this study also hypothesizes that access to information increases the extent of adapting to climate variability.

Availability of credit eases the cash constraints and allows farmers to buy purchased inputs such as fertilizer, improved crop varieties, and irrigation facilities. Research on adoption of agricultural technologies indicates that there is a positive relationship between the level of adoption and the availability of credit (Yirga 2007; Pattanayak *et al.* 2003). Likewise, this study also hypothesizes that there is a positive relationship between availability of credit and the level of adaptation.

Social capital is represented by farmer-to-farmer extension. Informal institutions and private social networks play three distinct roles in adoption of agricultural technologies, Katungi (2007). First, they act as conduits for financial transfers that may relax the farmer's credit constraints. Second, they act as conduits for information about new technology. Third, social networks can facilitate cooperation to overcome collective action dilemmas, where the adoption of technologies involves externalities. Isham (2002) shows that ethnically based and

participatory social affiliations act as forms of social capital in the decision to adopt fertilizer. Thus, this study hypothesizes that social capital positively influences adaptation level to climate variability.

Studies on adoption of agricultural technologies indicate that farm size has both negative and positive effects on adoption, showing that the effect of farm size on technology adoption is inconclusive (Bradshaw *et al.* 2004). However, because farm size is associated with greater wealth, it is hypothesized to increase adaptation level to climate variability.

It is hypothesized that as distance to output and input markets increases, adaptation level to climate variability decreases. Proximity to market is an important determinant of adaptation, presumably because the market serves as a means of exchanging information with other farmers (Maddison 2006).

To be successful, adaptation planning cannot be undertaken as a separate exercise from other planning processes in Kenya. “Mainstreaming” climate change planning into other planning processes is the key to successful adaptation and limiting the negative effects of climate variability. For example, the anticipated effects of climate variability need to be factored into poverty reduction strategies and rural development strategies. (National Environment Management Authority 2002)

The analysis of the level of adaptation takes into account the various issues and factors raised in the discussion above. Some of these factors are considered as explanatory variables in the model to help assess their impact on the propensity of adoption of various adaptation strategies. Examples of factors considered include farmer education level, access to markets and information (extension services) and other household characteristics.

Table 3: Measurement and description of the double hurdle model variables

Variable	Description	Value	Expected sign
Dependent Variables			
Adaptation decision (ADPT)	Whether the farmer has made adjustments or not in the farming activities due to climate variability	Dummy	
Extent of adaptation to climate variability (EXTADPT)	Number of adaptation strategies to climate variability relative to the total number of adaptations that were available within the household	Continuous	
Independent Variables			
Household Characteristics			
Education (HHHEDU)	Level of schooling attained by the head of the household	Years	Positive
Age (HHHAGE)	The age of the household head	Years	Positive
Household size (HHZ)	Number of family members of a household	Number	Positive or negative
Farm Characteristics			
Wheat experience (WHTEXPRN)	Number of years of wheat farming for the household	Years	Positive
Wheat land size (WHTLADZS)	Land size under wheat production in 2009	Acres	Positive
Scale (SCL)	Whether the wheat farming is under large scale or small scale production	1= Large scale, 0=Small scale	Positive or negative
Institutional Factors			
Group membership (MEMGRP)	If any member of the household is involved in farming group activities	1=yes, 0= no	Positive
Credit (CRTD)	If household has access to credit from any sources	1=yes, 0= no	Positive
Input market (INMKT)	Distance to the nearest input market	Kilometers	Positive
Farmer training (TRAING)	If any member of the household attended a farmers' training	1=yes, 0= no	Positive
Climatic and other Factors			
Temperature (TEMPCH)	Average change in temperature between two measurement points	Continuous	Positive
Rainfall (RAINCH)	Average change in rainfall between two measurement points	Continuous	Positive
Disease occurrence (DSE)	Observed change in disease occurrence	1=yes, 0= no	Positive

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Farmer and farm characteristics

The details of farmer and farm characteristics presented in Table 4 give an insight into the conditions of farmers and farm characteristic at the household level. For the case of this study age showed a positive influence on the decision of whether to adapt or not to climate variability. The overall mean age of the household head was 47.13. For the farmers who had not taken up any measure against climate variability, the mean age of the household head was found to be 38.28 years and the mean for those who had adapted to climate variability was 52.72 years. The mean age of the household head had a p value of less than 0.1 (at 10% level of significance) indicating that there was significant difference between adapters and non adapters in terms of age of the household head. According to Teklewold *et al.* (2006), there is no agreement in the adoption literature on the effect of age. The effect of age is generally location- or technology specific. The expected result of age is an empirical question. We may find that age negatively influence the decision to adopt new technologies. It may be that older farmers are more risk-averse and less likely to be flexible than younger farmers and thus have a lesser likelihood of adopting new technologies. In another case, we may find that age positively influence the decision to adopt. It could also be that older farmers have more experience in farming and are better able to assess the characteristics of modern technology than younger farmers, and hence a higher probability of adopting the practice. Experience in wheat production plays an important role in decision making. The mean experience for non adapters was 6.21 years while for the adapters it was 17.82. The p value for experience in wheat production was less than 0.1 indicating that there was significant difference between adapters and non adapters in terms of experience in wheat production. The results showed that the more experienced the farmer the more likely he is to make adjustments to climate variability. The same was indicated by Maddison (2006) and Nhemachena and Hassan (2007) in their studies on climate change which showed that experience in farming increases the probability of uptake of adaptation measures to climate change.

The mean of the household size was found to be 3.59 members for those who had not adapted and 4.22 members for those who had adapted to climate variability. The p value for household size was less than 0.1 indicating that there was significant difference between adapters

and non adapters in terms of the household size. Overall, the mean was 3.97 members. Household size as a proxy to labor availability may influence the adoption of a new technology positively as its availability reduces the labor constraints (Teklewold *et al.* 2006).

Table 4: Farmer and farm characteristics and test of equality of means

Variable	Adaptation to Climate Variability Means				Mean Difference	Standard Error Difference
	N	Group	Yes	No		
Age of household head	150	47.13	52.717	38.276	-14.44	1.660
Household size	150	3.97	4.217	3.586	-0.63	0.268
Experience	150	13.33	17.815	6.207	-11.61	0.866
Total land size	150	37.89	54.174	12.052	-42.12	24.832
Wheat land size	150	12.13	17.065	4.293	-12.77	6.966
Credit granted in 2009	150	30413.3	47304.3	3620.69	-43683.66	21158.879
Distance to input market	150	11.3	10.086	12.071	-1.98	1.198

Source: Survey data 2010

The overall land size was 37.89 acres. As indicated in Table 4 the non adapters had mean land size of 12.05 acres while the adapters had 54.17 acres. The p value for land size was less than 0.1 indicating that there was significant difference between adapters and non adapters in terms land size. The size of land under wheat during the reference period of study was 4.29 acres for non adapters and 17.07 for the adapters compared to an average of 5.3 acres of the wheat growers in Kenya, Economic Review (2010). The p value for land size under wheat was less than 0.1 indicating that there was significant difference between adapters and non adapters in terms land size under wheat during the reference period. Adoption of an innovation will tend to take place earlier on larger farms than on smaller farms. Daberkow and McBride (2003) showed that given the uncertainty and the fixed transaction and information costs associated with innovation, there may be a critical lower limit on farm size that prevents smaller farms from adapting. As these costs increase, the critical size also increases. It follows that innovations with large fixed transaction or information costs are less likely to be adopted by smaller farms.

The overall mean amount of credit that was granted to wheat farmers in 2009 was 30413.3.The mean amount of credit that was granted to non adapters in Rongai district was 3620.69 while for the adapters was 47304.3. The p value for amount of credit granted in 2009 was less than 0.1 indicating that there was significant difference between adapters and non

adapters in terms credit granted to wheat farmers in 2009. Credit access showed a positive effect on adaptation behavior. Any fixed investment requires the use of owned or borrowed capital. Hence, the adoption of a technology requires a large initial investment, which may be hampered by lack of borrowing capacity (El Osta and Morehart 1999).

As distance to input market increases, adaptation to climate variability decreases. The mean distance in kilometers to the input market for the non adapters is 12.07 while for the adapters is 10.09. The p value for distance to the input market was 0.1 indicating that there was significant difference between adapters and non adapters in terms of distance to the input market. Proximity to market is an important determinant of adaptation, presumably because the market serves as a means of exchanging information with other farmers (Maddison 2006).

As indicated in Table 5 below, 86.21% of the non adapters were male headed households while 13.8 were female headed households. For the case of adapters 86.96% were male headed households and 13.04 were female headed households. Similar results were found by Asfaw and Admassie (2004) who argued that male headed households are more likely to get information about new technologies and undertake risky businesses than female-headed households. Moreover, Tenge De Graffe and Heller (2004) also argue that having a female head of household may have negative effects on the adoption of soil and water conservation measures, because women may have limited access to information, land, and other resources due to traditional social barriers

Table 5: Gender of household head among adapters and non adapters

		Variable		Frequency	Percentage
Adapted to climate variability	No	Gender	Males	50	86.207
			Females	8	13.793
	Yes	Gender	Males	80	86.957
			Females	12	13.043

Source: Computed from survey data, 2010.

Table 6 below presents the results for the educational level of the household head. In this study, education level was used as a proxy for access to information on adaptation to climate variability. In Rongai district only 7.33% of the household heads did not have any kind of formal

education, implying that at least 92.67% of the household heads are educated. Table 7 indicates that a higher number of household heads attained primary and secondary education compared to those who attained tertiary and university education. Among the non adapters those who did not have any formal education; primary and secondary were 5.17%, 56.90% and 20.69% respectively, while 15.52% and 1.72% attained tertiary and university education respectively. On the other hand, among the adapters those who did not accessed any formal education; primary and secondary were 8.70%, 36.13% and 26.09% respectively, while 25% and 1.09% attained tertiary and university education respectively. Therefore, farmers with higher levels of education are more likely to adapt better to climate change. Maddison (2006) also found a positive relationship between the education level of the household head and the adoption of improved technologies and adaptation to climate change.

Table 6: Education level among the Adapters and Non Adapters

			Not gone to school	Primary	Secondary	College/Tertiary	University
Adapted to climate variability	No	Frequency	3	33	12	9	1
		Percentage	5.172	56.897	20.690	15.517	1.724
	Yes	Frequency	8	36	24	23	1
		Percentage	8.696	39.130	26.087	25	1.087
	Total	Frequency	11	69	36	32	2
		Percentage	7.333	46	24	21.333	1.333

Source: Computed from survey data, 2010.

Training on crop and livestock production and information on climate represent the institutional factors necessary to make the decision to adapt to climate variability. As shown in table 8 below, majority of wheat farmers who did not access any kind of farmer training in 2009 were subsequently those who had not adapted to climate variability. Among the non adapters 87.9% did not attend any farmers training in the year 2009 implying that only 12.1% were trained compared to 26.1% of the adapters who were trained while 73.9% were not trained among the adapters. Access to training increases the probability of adapting to climate

variability. Various studies in developing countries, including Ethiopia, report a strong positive relationship between access to information and the adoption behavior of farmers (Yirga 2007).

Table 7: Training and membership to local organizations among the adapters and non adapters

		Variable		Frequency	Percentage
Adapted to climate variability	No	Training	Yes	51	87.9
			No	7	12.1
	Yes	Training	Yes	24	26.1
			No	68	73.9
	No	Membership to local organization	Yes	8	13.793
			No	50	86.207
	Yes	Membership to local organization	Yes	44	47.826
			No	48	52.174

Source: Computed from survey data, 2010.

Group membership as a proxy for Informal institutions and private social networks was also considered as a variable influencing adaptation to climate variability. Groups and social networks act as conduits for financial transfers that may relax the farmer’s credit constraints. Second, social networks can facilitate cooperation to overcome collective action dilemmas, where the adoption of technologies involves externalities, Katungi (2007). As shown in table 7 above, among the non-adapters only 13.80% of the farmers engaged themselves in group activities compared to 47.83% of the adapters who involved themselves in group activities. On the other hand 86.21% of the non-adapters did not participate in group activities compared to 52.17% of the adapters. The function of organizational membership in producing support for uptake of new technology is attached as a result of information sharing, resource mobilization and higher market bargaining power, Shiferaw and Holden (1998).

4.2 Forms of getting information apart from extension agents

The other alternative sources of information on climate are presented in Table 8. The results reveal that 44.67% of the wheat farmers acknowledged that the main source of information is from neighbours followed by radio at 42.67%. Newspaper and family recorded an equal percentage response at 6%. The results indicate that there is a strong social capital among the farmers. Social capital is represented by the farmer-to-farmer extension which acts as conduits for information about new technology, Katungi (2007).

Table 8: Forms of getting information among the adapters and non adapters

Adapted to climate variability	No	Frequency	None	Radio	Neighbors	Newspaper	Family
			0	23	28	4	3
		Percentage	0	39.655	48.276	6.897	5.172
		Frequency	1	41	39	5	6
	Yes	Percentage	1.087	44.565	42.391	5.435	6.522
		Frequency	1	64	67	9	9
	Total	Percentage	0.667	42.667	44.667	6	6

Source: Computed from survey data, 2010.

Table 9 below focuses on the various constraints that were cited by wheat farmers in trying to change their farming ways. Majority of farmers' (37.33%) cited insufficient climatic information as the main problem in changing their farming ways followed by unpredictable weather, lack of sufficient capital and lack of farm implements at 35.33%, 16% and 6.67% respectively. Among the non adapters, the claim of unpredictable weather was cited by majority of farmers at 36.21% while among the adapters, insufficient information was mentioned by the majority at 37.33%. A considerable number of non-adapters and adapters mentioned lack of sufficient capital at 17.24% and 16% respectively while a few non-adapters and adapters designated lack of farm implements as a barrier to changing their farming ways. Most of the constraints mentioned above limit the ability of farmers to get the necessary resources and technologies they might want in order to adapt their activities to varying climatic conditions.

Table 9: Main constraints in changing the farming ways among the adapters and non adapters

			None	Lack of farm implements	Lack of sufficient capital	Unpredictable weather	Insufficient information
Adapted to climate variability	No	Frequency	7	2	10	21	18
		Percentage	12.07	3.45	17.24	36.21	31.03
	Yes	Frequency	0	8	14	32	38
		Percentage	0	8.7	15.22	34.78	41.3
	Total	Frequency	7	10	24	53	56
		Percentage	4.67	6.67	16	35.33	37.33

4.3 Analysis of wheat farmers’ perceptions to climate variability

Descriptive statistics based on summary counts of the questionnaire structure was used to provide insights into wheat farmers’ perceptions of climate variability. The farmers were asked if they had noticed any changes with respect various weather and environmental conditions for the period they have been engaged in wheat production. In the literature several studies have undergone the same type of analysis. For example, Hageback *et al.* (2005) assessed small-scale farmers’ perceptions of climate change in the Danagou watershed in China by comparing the local precipitation and temperature data trend with the responses given by farmers to the question “Do you feel any changes in the weather now compared to 20 years?” They conclude that farmers’ perceptions of climatic variability correspond with the climatic data records.

Table 10: Farmers' perception to climate variability in Rongai district

Type of perception	Division	Increased (%)	Decreased (%)	No change (%)
Perception of changes in temperature	Ngata	62	0	38
	Rongai	58	0	42
	Kampi ya moto	66	0	34
	Total	62	0	38
Perception of changes in rainfall amount	Ngata	0	62	38
	Rongai	0	58	42
	Kampi ya moto	0	66	34
	Total	0	62	38
Perception of changes in vegetation cover	Ngata	0	62	38
	Rongai	0	58	42
	Kampi ya moto	0	66	34
	Total	0	62	38
Perception of changes in disease occurrence	Ngata	20	24	56
	Rongai	28	12	60
	Kampi ya moto	50	6	44
	Total	32.7	14	53.3
Perception of changes in pest infestation	Ngata	52	4	44
	Rongai	36	2	62
	Kampi ya moto	66	0	34
	Total	51.3	2	46.7

Source: Computed from survey data, 2010.

Farmer perceptions regarding long-term changes in temperature and precipitation are presented in Table 11. Perceptions on long-term changes in temperature, precipitation, vegetation cover, disease occurrence and pest infestation changes were divided into three categories, which are increase, decrease and no change as can be seen in the table above. The results indicate that most farmers perceive that long-term temperatures are increasing. On the other hand, the overall perception on long-term changes in precipitation is that the region is getting drier and that there are pronounced changes in vegetation cover, disease occurrence and pest infestation.

4.3.1 Temperature Changes

Most of the respondents perceived long-term variability in temperature. Most of them (62 % or 92 farmers) perceived the temperature in Rongai to be increasing. Only 38 % did not notice any change in temperature. Across the three divisions of the district, the same pattern was noticed with respect to the temperature increase. The highest proportion of farmers who perceived an increase in temperature was from Kampi ya Moto division at 66 % which according to the climate data also recorded the highest variability in temperature as shown in Figure 4 below compared to the data for Ngata division. Unfortunately the temperature data for Rongai was not available. The percentage of respondents from Ngata who perceived an increase in temperature was 62 while that for Rongai was 58%.

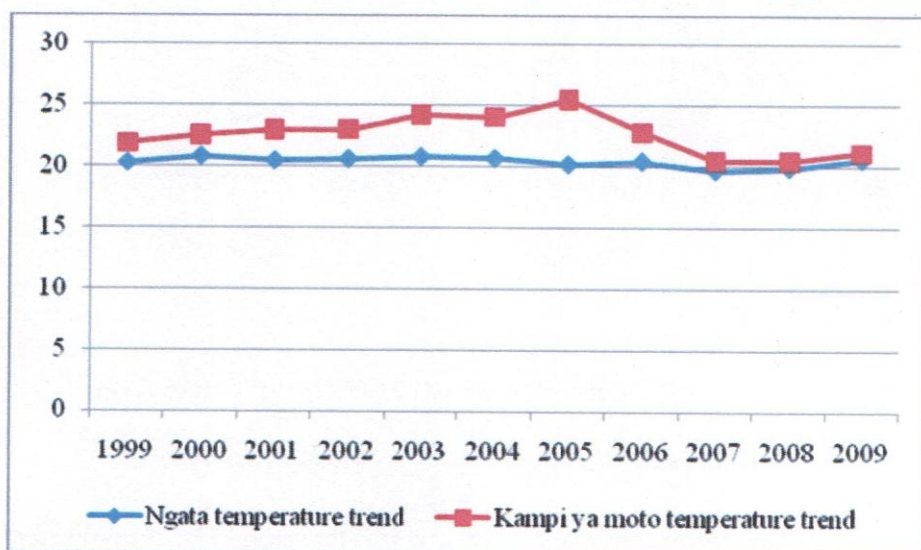


Figure 4: Temperature trends for Rongai district.

Source: Computed from survey data, 2010.

4.3.2 Precipitation and vegetation cover Changes

The perception of both rainfall and vegetation cover was the same across the three divisions of the district. In total, 62 percent of the respondents observed changes in rainfall patterns as well as vegetation cover for the period they had engaged in wheat production, and 38 percent did not notice any change in the amount of rainfall and the intensity of the vegetation cover. The same pattern of rainfall amount and vegetation cover decreases was noted across all the three divisions. The perception of decrease in rainfall and vegetation cover was cited by

majority of the informants from Kampi ya Moto division, (66%) followed by Ngata and Rongai at 62% and 58% respectively.

The recorded data on rainfall from 1996 to 2009 shows that there was wide variation of the precipitation levels in the district. Indeed, there is a large variability in the amount of precipitation from year to year. The same pattern is observed in each division (Figure 5). The high proportion of farmers noticing a decrease in precipitation could be explained by the fact that during the last few years of the study (2007 to 2009), there was a substantial decrease in the amount of rainfall (Figure 5). Thus, farmers' perception of a reduction in rainfall over the 15-year period is explained by the fact that, as Maddison (2006) noticed, some farmers place more weight on recent information than is efficient

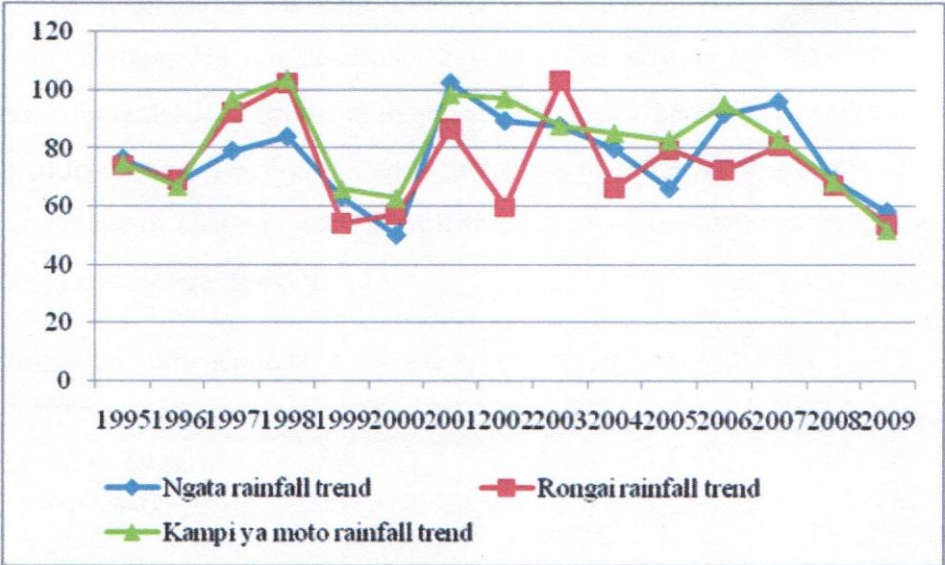


Figure 5: Rainfall trend for Rongai District

Source: Computed from survey data, 2010.

4.3.3 Changes in diseases occurrence

The percentage of farmers interviewed who perceived increased changes in disease occurrence was 32.7 as indicated in table 11. Most of them reported not to have realized any change (53.3%). Only 14% noticed the contrary, a decrease in disease occurrence. Across the three divisions of Rongai district, the majority of farmers who perceived increased changes in disease occurrence were from Kampi ya Moto division then Rongai and lastly Ngata at 50%, 28% and 20% respectively, relative to the temperature changes in the three divisions.

4.3.4 Changes in pest infestation

For the case of pest infestation, majority of farmers interviewed perceived increased changes at 51.3% as shown in table 11. 46.7% reported not to have realized any change. Only 2% noticed the contrary, a decrease in disease occurrence. Within the three divisions of Rongai district, the majority of farmers who perceived increased changes in pest infestation were from Kampi ya Moto division then Ngata and lastly Rongai at 66%, 52% and 36% respectively.

4.4 Analysis of adaptation and extent of adaptation to climate variability among the wheat farmers

This section focuses on the various adjustments that farmers in Rongai district made in their farming activities if they perceived variation in climate as well as the extent of adaptation to climate variability. Even though a large number of farmers interviewed noticed changes in climate, majority of them did not undertake any remedial actions against changes in various weather and environmental scenarios that they had observed. Generally the percentage of farmer who had adapted to climate variability was higher (62%) compared to the non adapters (38%). The highest percentage of adapters were from Kampi ya Moto division (66%) followed by those from Ngata (60%) and Rongai (58%).

Table 11: Adapters and non adapters to climate variability in Rongai district

Adapted to climate variability		Division	Frequency	Percentage
No		Ngata	20	40
		Rongai	21	42
		Kampi ya moto	17	34
	Total for No		58	38.7
	Yes			
Yes		Ngata	30	60
		Rongai	29	58
		Kampi ya moto	33	66
	Total for Yes		92	61.3

Source: Computed from survey data, 2010.

4.4.1 Adaptation options in response to variability in temperature

Six adaptation measures could be identified in Rongai district as farmers' responses to increased temperature (Figure 6). These options include changed wheat variety (6%), planted trees (5%), switched to other crop (20%), changed planting dates (14%), performed soil

conservation (3%), and switched to livestock (9%). The other 43% of respondents who reported to have seen variations in climate did not undertake any remedy against changes in temperature.

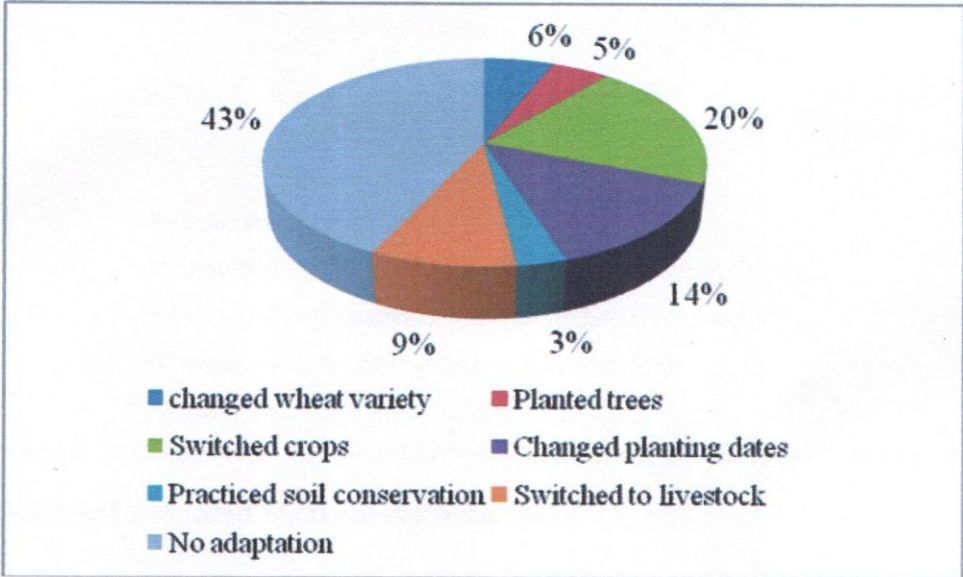


Figure 6: Percentage of adaptation options in response to variability in temperature
Source: Computed from survey data, 2010.

4.4.2 Adaptation options in response to variability in rainfall

Among those who did adjust to changes in rainfall patterns (Figure 7), 5 % of the farmers changed the type of wheat variety they planted, 1% engaged in tree plantation and 8% switched to other crops. Farmers also shifted their planting dates to match the delay in rainfall (14%), practiced soil conservation (1%), invested in water harvesting schemes (21%) and invested in livestock (2%). The remaining 48% of the farmers who had perceived variation in climate did not undertake any measure against changes in rainfall pattern. The adaptations induced by perceptions of changing rainfall patterns seem to differ from those induced by perceptions of changing temperature. While switching to other crops was the main strategy used to adapt to increasing temperature, building water-harvesting schemes was a popular adaptation strategy to those experiencing the effects of decreased precipitation.

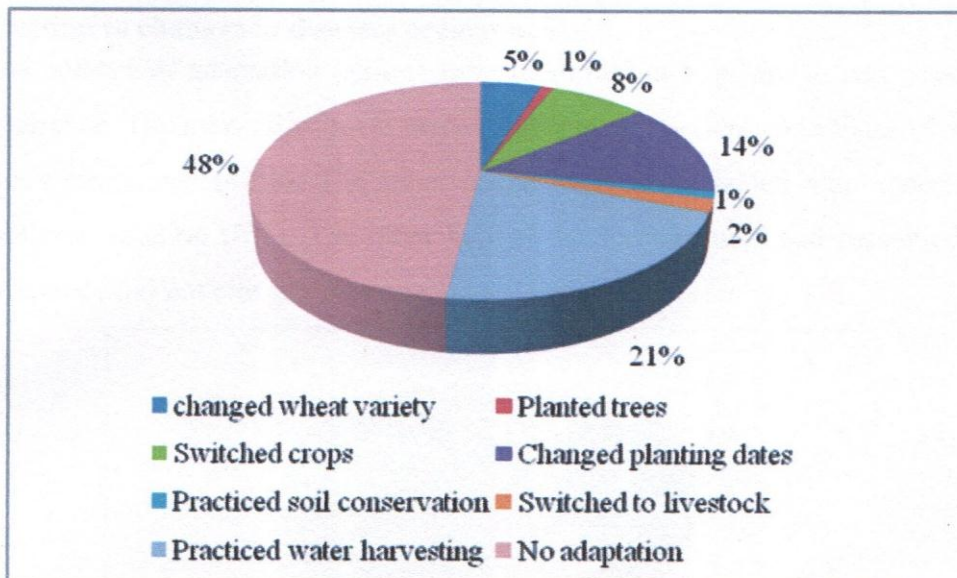


Figure 7: Percentage of adaptation options in response to variability in rainfall

Source: Computed from survey data, 2010.

4.4.3 Adaptation to changes in vegetation cover

As indicated in the Figure 8 below, 45 percent of the farmers did not take up any adaptation strategy to changes in vegetation cover. Majority of those who had adapted (31%) had planted trees to curb the reduction in vegetation cover. A number of farmers did practice soil conservation (19%), while others reduced the number of livestock (2%) and practiced minimum tillage (3%) in their farms.

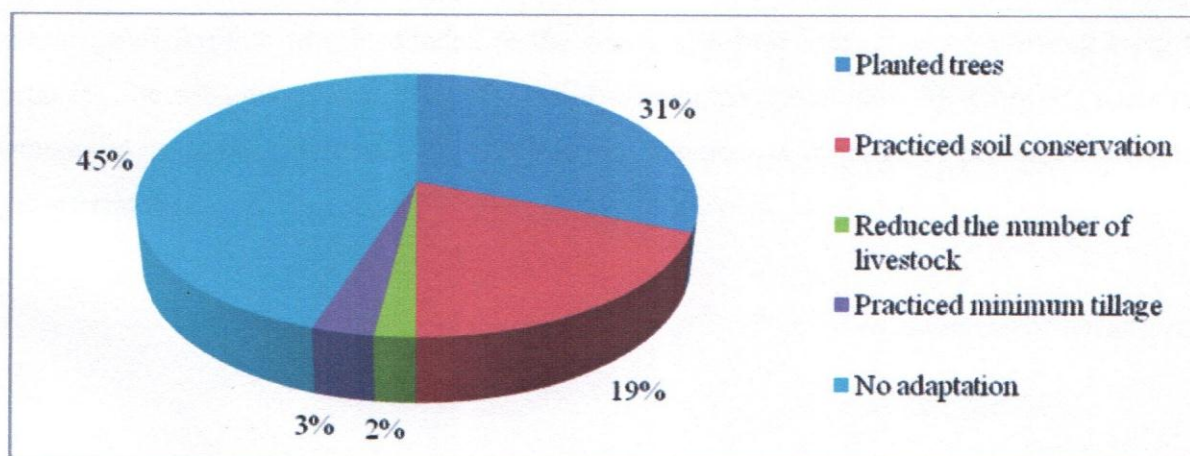


Figure 8: Percentage of adaptation to changes in vegetation cover

Source: Computed from survey data, 2010.

4.4.4 Adaptation to changes in diseases occurrence

A few number of adaptation options were identified in response to perceived changes in disease occurrence. The main adjustment made by the farmers as shown in Figure 9 was spraying the crop with herbicides (42%). The other minor adjustment which was undertaken by the farmers was crop rotation (8%). The other half of the farmers who had perceived changes in disease occurrence did not cite any measure.

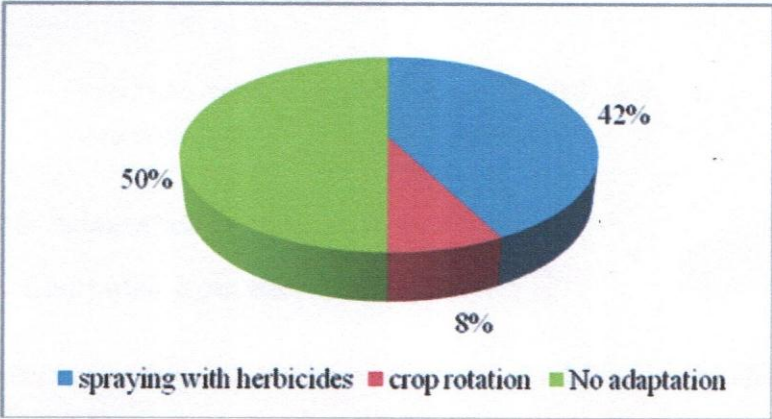


Figure 9: Adaptation to changes diseases occurrence

Source: Computed from survey data, 2010.

4.4.5 Adaptation to changes in pest infestation

In Rongai district farmers responded to perceived changes in pest infestation (70%) than any other occurrence seemingly indicating its sensitivity to wheat farming. The high response to pest infestation could be explained by the damage and losses caused within a shorter period. The percentage of farmers who responded to the changes in pest infestation by planting early and uprooting the affected plants were 9% and 5% respectively (Figure 9). Only 16 percent of farmers did not make adjustments to their farming practices in response to perceived changes in pest infestation.

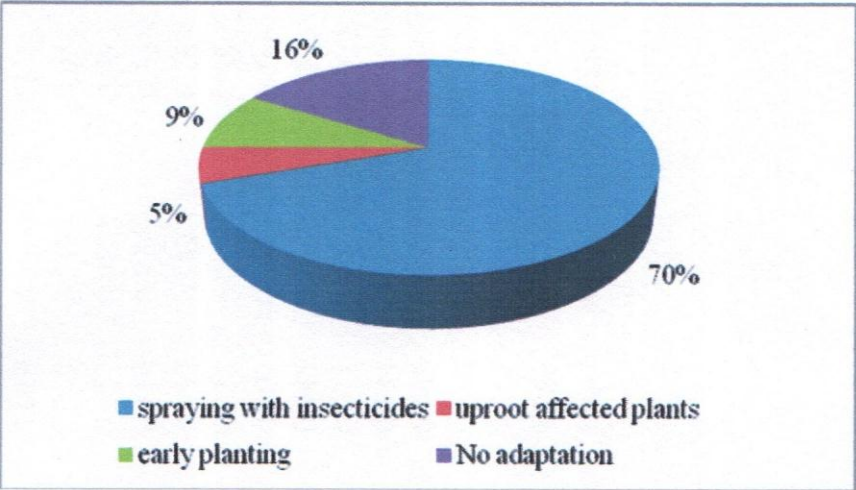


Figure 10: Adaptation to changes in pest infestation

Source: Computed from survey data, 2010.

4.5 Analysis of factors affecting adaptation and extent of adaptation to climate variability among the wheat farmers

The analyses of the estimated parameters depend on the maximum likelihood parameter estimates of the independent double-hurdle model, as this was the model found to be the appropriate specification to identify the determinants of adaptation and extent of adaptation to climate variability among the wheat farmers

The double-hurdle model is estimated by maximizing the log-likelihood function (equation 12). The results are presented in Table 12. The coefficients in the first tier indicate how a given variable affects the likelihood (probability) to adapt to climate variability. Those in the second tier denote how a variable influences the extent of adaptation given that a decision is made to adapt to climate variability

Table 12: Maximum likelihood estimation of the Double Hurdle Model

Variable	Coefficient	Standard error	P> Z	Marginal effects	Coefficient	Standard error	P> Z	Marginal effects
	Tier 1: Probability of adapting to climate variability				Tier 2: Extent of adaptation to climate variability			
Experience in wheat	0.422	0.149	0.005***	0.422	0.018	0.019	0.335	0.018
Household head education	0.383	0.368	0.298	0.383	-0.058	0.089	0.517	-0.058
Household size	0.208	0.241	0.388	0.208	-0.096	0.051	0.058*	-0.096
Disease occurrence	1.748	0.737	0.018**	1.748	-0.101	0.114	0.377	-0.101
Training	1.211	0.908	0.182	1.211	0.283	0.192	0.142	0.283
Credit	-0.053	1.06	0.96	-0.053	0.585	0.213	0.006***	0.585
Group membership	1.304	0.727	0.073*	1.304	-0.146	0.167	0.381	-0.146
Temperature change	0.335	0.944	0.723	0.335	-0.702	0.245	0.004***	-0.702
Rainfall change	-0.04	0.05	0.422	-0.040	-0.022	0.011	0.041**	-0.022
Scale of production	0.301	0.772	0.697	0.301	0.291	0.184	0.113	0.291
Wheat land size	0.024	0.026	0.364	0.024	0.003	0.002	0.107	0.003
Household head age	-0.001	0.036	0.988	-0.001	-0.032	0.011	0.003***	-0.032
Input market	0.056	0.075	0.457	-0.056	0.001	0.014	0.966	0.001
Constant	-7.326	2.682	0.006	-	4.727	0.781	0.000	-

Log likelihood = -112.783; Wald chi2 (13) = 20.42; ***, **, * significant at 1%, 5% and 10% probability respectively.

Source: Computed from survey data, 2010

4.5.1 Effect of household characteristics on extent of adaptation to climate variability

Given that decision is made to adapt to climate variability, experience in wheat production significantly increases the probability of adapting by 0.5% and the extent of adaptation but not at a significant level. This is because experienced wheat farmers have high skills in farming techniques and management and are able to spread risk when facing climate variability by exploiting strategic complementarities between activities such as changing planting dates, changing the wheat variety or even reducing the number of livestock. These results confirm the findings of Nhemachena and Hassan (2007) in a study of adaptation in the Southern Africa region. Experienced farmers are usually leaders and progressive farmers in rural communities and they can be targeted in promoting adaptation management to other farmers who do not have such experience and are not yet adapting to varying climatic conditions.

Household size variable had conflicting effects in terms of signs. Though positive, it was not found to be a significant determinant of adapting to climate variability but it was significant in determining the extent of adaptation but rather negatively at 5.8% all else held constant. Contrary to the idea that the larger the family size the more “own farm” labour is available to try out various farming options (Teklewold *et al.*, 2006) This is based on the assumption that households with large families may be forced to divert part of the labor force to off-farm activities in an attempt to earn income in order to ease the consumption pressure imposed by a large family (Yirga 2007).

Although the probability of adapting to climate variability tends to be negatively affected by the age of the household head, this effect is not statistically significant. On the other hand, the extent of adaptation is significantly but negatively affected by the age of the household head. This could be an indication that older farmers are more risk-averse and less likely to be flexible than younger farmers and thus have a lesser likelihood of adapting to climate variability. A study in support of this view by Shiferaw and Holden (1998) indicates a negative relationship between age and adoption of improved soil conservation practices.

4.5.2 Effect of institutional factors on extent of adaptation to climate variability

Access to credit is negatively related to the probability of adapting to climate variability though not significantly. In contrary, this variable is positively and significantly related to the extent of adaptation to climate variability. Having access to credit indeed increases the extent adapting to climate variability by 0.6 percent. Lack of financial resources is one of the main

constraints to adjustment to climate variability. Similar results were reported in Tanzania by O'Brien et al. (2000) that, despite numerous adaptation options that farmers are aware of and willing to apply, the lack of sufficient financial resources to purchase the necessary inputs and other associated equipment (e.g., purchasing seeds, acquiring transportation, hiring temporary workers) is one of the significant constraints to adaptation.

Being a member of group significantly and positively increases the likelihood of adapting to climate variability by 7.3 percent *ceteris paribus*. This is because social networks increase awareness of climate variability through information sharing among the wheat farmers. As indicated by Shiferaw and Holden (1998), the role of organizational membership in producing support for uptake of new innovation is attached as a result of information sharing, resource mobilization and higher market bargaining power.

4.5.3 Effect of Climatic and other factors on extent of adaptation to climate variability

Whereas the influence of temperature changes between two measurement points is positively related to the probability of one adapting to climate variability, there is no indication of any significance. On the other hand this variable shows a strong significance (0.4%) though negative on its influence on the extent of adaptation. The fact that adaptation to climate variability increases with higher temperatures is not in line with the expectation that it as well increases the extent of adaptation. Increasing temperature is damaging to African agriculture and farmers respond to this through the adoption of different adaptation methods (Kurukulasuriya and Mendelsohn 2006). This is not the case in Rongai district possibly because the numbers of available household adaptation options are few.

Higher levels of precipitation over the survey period appear to work in the opposite direction with regard to the likelihood of adaptation to climate variability as well as the extent of adaptation techniques. The effect of precipitation is neither positive nor significant on the probability of adapting to climate variability, but it is significant on the level of adaptation at 4.1% level though negatively. The probable reason for the negative relationship between average annual precipitation and the adaptation level could be due to the fact that, like any African country, Kenya's agriculture is water- scarce, and higher levels of precipitation, therefore, will not constrain agricultural production and promote the need to adapt (at least using the main adaptation options considered in this study).

Farmers who perceive changes in disease occurrence have higher chances of taking adaptive measures in response to observed changes. A unit change in perception of disease occurrence increase the probability of adapting to climate variability by 1.8% *ceteris paribus*. This is because perception indicates that wheat farmers are aware of the changes in disease occurrence. Awareness is an important precondition for farmers to take up adaptation measures (Madison 2006). It is evident from these results that raising the awareness of changes in disease occurrence among the farmers would have greater impact in increasing adaptation to variability in climatic conditions. This variable is negatively related to the extent of adaptation though it is insignificant.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The main aim of this study was to analyze the perception and the adaptability level to climate variability among the wheat farmers in Rongai district. Farmers' perceptions to climate variability are in line with climatic data recorded in their respective divisions. Indeed, farmers in the area were able to recognize that temperatures have increased and there has been a reduction in the volume of rainfall as well the vegetation cover. They were also able to note changes in disease occurrence and pest infestation. The percentage of farmers who perceived the changes was 62% while those who did not were 38%. The percentage of farmers who perceived changes in temperature, precipitation and vegetation cover were all equal. This indicates that the farmers were able to relate all the three indicators of climate variability similarly. However the perception on disease occurrence and pest infestation significantly differed from the other indicators. The percentage of farmers who perceived increased changes in disease occurrence was 32.7 % while those who perceived increased changes in pest infestation was 51.3 %. The reason that may be attributed for this is that farmers' do not have control over climatic factors but they can have it over pest and diseases in their wheat farms.

To this end, this study used the double-hurdle model to address the issues involved. The double-hurdle estimation was carried out on the total adaptations that were available within the household using the data from wheat farmers in Rongai district. The estimation results reveal that the probability of adapting to climate variability is mainly positively determined by experience in wheat production, group membership and perception about disease occurrence. On the other hand, the extent of adaptation to climate variability was primarily determined by the composition of the household and temperature changes positively but negatively related to credit, rainfall change and the age of the household head.

In general, the study shows that the majority of the variables under investigation affect the extent of adaptation rather than the probability of adapting to climate variability. This implies that the extent of adaptation decisions is central in adaptation to climate variability at farm level.

5.2 Recommendations

The results of this study indicated that factors influencing the adaptation and extent of adaptation to climate variability are not the same for the wheat farmers, implying the need for targeting them with different packages of policies. Specific measures that can be taken to adapt to climate variability, including both those generated by climatic forces and those initiated by governments, can be predicted with some certainty. As one of the measures this study suggests the need to focus on experienced farmers as lead farmers to ensure greater adaptation to climate variability. This is because as a farmer learns more about the technology through own experience, the scale of adaptation increases. Therefore, having experience after adaptation decisions makes farmers more efficient in carrying out the tasks necessary to expand the intensity of the adaptation tasks such as the gathering and interpretation of information relevant to making the decisions.

It is also very important to focus on the development and dissemination of awareness information on various environmental phenomena such as diseases in order to achieve maximum adaptation in the hazard prone areas. On the other hand, government policies should as well ensure that farmers have access to affordable credit to increase their ability and flexibility to change production strategies in response to the forecasted climate conditions as this is an important variable in determining the extent of adaptation to climate variability. Furthermore, government should improve and offer better opportunities for the formation of the self help groups among the wheat farmers. This will ensure improved development as well as diffusion of appropriate technologies to help farmers adapt to variability in climatic conditions.

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APPENDIX

QUESTIONNAIRE

This questionnaire is totally for academic research purpose. Your participation is voluntary and you are also assured that the information you provide will be treated with confidentiality and used for the sole purpose of the research. Your support by participating in this interview is highly appreciated.

**TITLE: EVALUATING ADAPTABILITY LEVEL OF WHEAT FARMERS TO
CLIMATE VARIABILITY IN RONGAI DISTRICT OF KENYA**

Questionnaire Code _____

Name of Enumerator -----

Date of Interview -----

District -----

Location -----

Sub-location -----

SECTION A: SOCIO-DEMOGRAPHIC

(1) Respondent's name -----

(1.1) Respondent's gender Male ☐ Female ☐

(1.2) Age _____ yrs

(1.3) Educational level, tick as appropriate

None ☐

Primary ☐

Secondary ☐

College/tertiary ☐ University ☐

(2.0) Are you the head of the household?

Yes ☐ No ☐

(2.1) If no please provide the information below regarding the household head

(2.2) Name of Household Head

(2.3) Sex Male ☐ Female ☐

(2.4) Age _____ Years.

(2.5) Educational level, tick as appropriate

None ☐

Primary ☐

Secondary ☐

College/Tertiary ☐

University ☐

(3) When did you start wheat production? *Please state the year you began.*

(4) Please, fill the following table with the information regarding the household members.

Table1. Household composition

No.	Name of household member	Relation to HH head. 0=Head 1= Spouse 3=Brother/Sister 4= Child 5= other	Sex 1=M 2=F	Year of birth	Educational level 0=None 1=primary, 2=secondary 3=college/tertiary 4=university	Experience in wheat production (Years)
1						
2						
3						
4						
5						
6						

SECTION B: INCOME SOURCES

(5) Please list the top three sources of income for the household.

Income sources:	Tick	Rank
1. Production/sale of crops	☐	☐
2. Production/sale of livestock & livestock products	☐	☐
3. Agricultural output trading,	☐	☐
4. Agricultural input trading	☐	☐
5. Salaried employment	☐	☐
6. Casual laborer	☐	☐
7. Pension	☐	☐
8. Remittances (income from relatives/friends etc)	☐	☐
9. Others (specify).....		

SECTION C: WHEAT PRODUCTION

(6) How much total land do you have? Please state in acres.

.....acres

(7) How much of this land was under wheat last year?

.....acres

(8) How many fields of wheat did you cultivate last season? Please state the size of each field in acres and variety planted.

Table2: Wheat fields and varieties

Field number	Size of the field (acres)	Variety of wheat planted	Number of years planted	Reason for choosing the variety
1				
2				
3				

(9) Has the timing of the following agricultural activities changed or remained the same with respect to wheat production

Table 3: Agricultural activities

AGRICULTURAL ACTIVITY	SAME	CHANGED	REASON
Land preparation			
Cultivation			
Harvest			
Post-harvest			

Farm inputs

(10) Did you use any inputs (fertilizers, manure, pesticides) in wheat production last season?

Yes ☐

No ☐

(10.1) If yes which ones did you use and how much in all fields?

Table 4: Input table

Input type (see codes below)	Quantity used	Quantity units (see codes below)	Cost per unit

Input type codes: 1=DAP fertilizer 2=NPK fertilizer 3=CAN fertilizer 4=Foliar feeds 5=Manure 6=Lime 7=Pesticides 8=Fungicides 9=Herbicides 10=Gunny bags 11= Other (specify)

Table 5: Farm implements

Type of equipment	Number owned	Year bought	Current Value per unit (Ksh).	Total current value (ksh)
Tractor				
Combine harvester				
Ox plough				
Harrow				
Seeder				
Knapsack sprayer				
Boom sprayer				
Cereal store				
Others				

Units: 1=90 Kgs bag 2=50 Kgs bag 3=Litres 4=Grammes 5=Kgs12.

(11) What farm implements do you have for use in wheat production?

SECTION D: CLIMATE CHANGE AND ADAPTATION OPTIONS

(12) Has the amount of temperatures stayed the same, increased, or declined for the period you have been practicing wheat production? Tick as appropriate

Same ☐ Increased ☐ Declined ☐

(13) Has the **number** of rainfall days stayed the same, increased, or declined for the period you have been practicing wheat production? Same ☐ Increased ☐ Declined ☐

(14) Has the **amount** of rainfall stayed the same, increased, or declined for the period you have been practicing wheat production. Same ☐ Increased ☐ Declined ☐

(15) Have you seen changes in the vegetation cover for the period you have been practicing wheat production? Yes ☐ No ☐

(16.) What adjustments in your farming have you made to these long-term shifts in temperature? Please list below.

(17.) What adjustments in your farming have you made to these long-term shifts in rainfall? Please list below.

(18.) What adjustments in your farming have you made to these changes in vegetation cover? Please list below.

(19.) What changes have you witnessed with regard to pest infestation in your farm?

No change ☐ Increase ☐ Decrease ☐

(19.1.) Have you witnessed new strains of pests in your farm that have not been known to be there before? ☐ ☐

(19.2) If yes which ones? -----

(19.3) What have you done to control these pests? -----

(20.) What changes have you witnessed with regard to disease occurrences in your wheat farm?

No change ☐ Increase ☐ Decrease ☐

(20.1) Have you witnessed new strains of diseases in your farm that have not been known to be there before? Yes ☐ No ☐

(20.2) If yes which ones? -----

(20.3) What have you done to control these diseases? -----

(20.) Check the answers for **16, 17** and **18** and then ask for the ones not yet listed there: What additional measures would you consider in the future

Table 6: Adaptation options

Why did you not (20.1)	Reason (Key) (20.2)
Change wheat variety	
Build a water harvesting scheme	
Implement soil conservation techniques	
Buy insurance	
Put trees for shading	
Irrigate	
Change from crop to livestock	
Reduce number of livestock	
Migrate to urban area	
Find off-farm job	
Lease your land	
Plant different crops	
Change planting dates	
Others	

Codes for reasons 1: lack of money, 2: lack of information, 3: shortage of labor, 5: Other [write into the lines provided above]

(21) What were the main constraints/difficulties in changing your farming ways? List them below.

SECTION E: INSTITUTIONAL SUPPORT

(22) Please indicate the following on road conditions in the region

Table 7: Road conditions

	Distance for all weather portion (Kms)	Distance for tamarked portion (Kms)
Nearest output market		
Nearest input market		

(23) Did the household receive extension contact last year?

Yes ☐ No ☐

(23.1) If yes, fill in the details in the table below. If no skip to 23

Table 8: Extension services

Extension services offered (See codes below)	Extension provider (See codes below)	Number of times in 2009	Did you pay? 1=YES 0=NO	Cost per each time

Extension service codes: 1=crop production (specify the crop) 2=livestock production

Extension service provider: 1= government extension worker 2= private extension providers 3= development agencies/NGOs 4= private company 5= other farmer 6= university 7= other (specify)

(24) Did anyone in the household attend a farmers training last year?

Yes ☐ No ☐

(24.1) If yes, how many times for the whole year?

(24.2) What was the training about?

1. Soil erosion ☐ 2. Fertilizer use ☐ 3. Wheat production ☐
4. Tree planting ☐ 5. Other (specify)

(25) Apart from extension agents how else do you get information on production of wheat and climate change?

Radio

Neighbors

Newspapers

Family

Other (specify).....

SECTION F: CREDIT ACCESS AND GROUP MEMBERSHIP

ACCESS TO CREDIT

(26) Did the household try to access credit last year?

Yes

No

(26.1) If yes, fill in the table below

Table 9: Credit access

Credit source	Granted 1=YES 0= NO	Credit type 1=money 2=in kind	Amount of credit requested (ksh)	Purpose of the credit	Repayment period	Interest rate	If not granted give reason

Source codes: 1=commercial bank 2=AFC 3=cooperative 4=MFI 5=Input store 6=local money lender 7=Other (specify)

Purpose codes: 1=School fees 2=Business capital 3=Household consumption 4=Farm inputs (wheat) 5= Hospital/medication 6=livestock 7=Other (specify)

Not granted reasons code: 1=Lack of security 2=Hand outstanding loan 3=Lack enough Savings 4=defaulted previously 5=other (specify)

Repayment periods codes: 1=weekly 2=Monthly 3=Fortnightly 4=Quarterly 5=Annually 6=Semiannually7=Other (Specify)

(27) Did any member of the household belong to a local or external organization or committee in 2009?

Yes

No

(27.1) If yes please fill the table below.

Table 10: Group participation

Group type	Year started	Group activities	Meetings per month	Savings per month

Group types: 1=self help group 2=Welfare group 3=cooperative society 4=other (specify)

Group activities: 1=Farming 2=Business 3=HIV/AIDS 4=Advocacy 5=other (specify)