JIMMA UNIVERSITY
BUSINESS AND ECONOMICS COLLEGE
SCHOOL OF GRADUATE STUDIES

Analysis of Determinants of Adaptation Options to Climate Change on Maize Growing Smallholder Farmers in the Central Rift Valley of Ethiopia

(The Case of Adama and Adami Tullu Jiddo Kombolch Districts)

By

Teshome Kumela

June, 2013

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A Thesis Submitted to the School of Graduate Studies of Jimma University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Economics (Policy Analysis)

By

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June, 2013

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DECLARATION

I, the undersigned, declare that this MSC thesis is my original work, has not been presented for a degree in this or other university and that all sources of materials used for the thesis have been fully acknowledged.

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DEPARTMENT OF ECONOMICS

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ACRONYMS AND ABBREVIATIONS

ANOVA	Analysis of Variance
ATJK	Adami Tullu Jiddo Kombolcha
BAU	Business as Usual
CGEM	Computable General Equilibrium Model
CO_2	Carbon Dioxide (the most important greenhouse gas)
CSA	Central Statistical Authority of Ethiopia
EIAR	Ethiopian Institute of Agricultural Research
FDRE	Federal Democratic Republic of Ethiopia
FfE	Forum for Environment
GDP	Gross Domestic Product
GHG	Green House Gas
FPRI	International Food Policy Research Institute
IIA	Independence of Irrelevant Alternatives
IPCC	Intergovernmental Panel on Climate Change
JARC	Jima Agricultural Research Center
MARC	Melkasa Agricultural Research Center
MNL	Multinomial Logit Model
MNP	Multinomial Prohbit Model
MoFED	Ministry of Finance and Economic Development of Ethiopia
NAMA	Nationally Appropriate Mitigation Action
NAPA	National Adaptation Program of Action
TLU	Tropical Livestock Unit
UNFCCC	United Nations Framework Convention on Climate Change
VIF	Variance Inflation Factors

ABSTRACT

This study focused on identification of perception level and determinant factors that influence adaptation options to climate change on maize growing smallholder farmers in Adama and Adami Tullu Jiddo Kombolcha districts of the central rift valley of Ethiopia. Analysis of the study was based on a cross-sectional data collected through household survey from the districts in February to March 2013. Representative samples of 233 households were interviewed, with 54% from Adama and the remaining 46% from Adami Tullu Jiddo Kombolcha districts. Descriptive statistics and Multinomial logit model was used to analyze the data. The finding of the study show that about 86% of interviewed farm households perceived climate change as rise and hot in temperature and 83% perceived the change of rainfall in quantity and timing. Econometric analysis result also reveals that; education level, age and gender of the household head, family size, land holding size and access to information have significant and positive influences on households' decision to employ various adaptation strategies to climate change. The study also identified the most prioritized adaptation strategies by the households which include: soil conservation and management, fertilizers application, off-farm works, crop diversification, agro-forestry and use of improved seeds. Based on the findings, policies and strategies that encourage participation of farmers in planning and application of adaptation strategies with bottom-up approach is required for better anticipation of climate change instead of focusing on reacting the impacts. This can be achieved through increasing access to credit facilities, providing other sources of income for the households, comprising climate change in education policy, access to crop insurance schemes, improving extension system in view of climate change. Enhancing farmers' organization for experience sharing which helps to strength public adaptation capacity and improving institutional capacity to generate weather forecasting information at local level.

Keywords: Adaptation, Central Rift Valley, Climate Change, Determinant, Smallholder

CHAPTER ONE
INTRODUCTION

1.1. Background of the study

Climate change is a global challenge for current and future generation of human beings and natural phenomenon. The definitions of climate change and related issues have broader significance than the terminologies themselves. Several literatures and experts have various definitions for the expressions; climate change, mitigation, adaptation and vulnerability. Among the others, IPCC (2007), defined; climate change is any change in the average daily weather pattern over extended period of time either due to natural variability or as a result of human activity. It is happening now and is already affecting many natural systems around the world. This occurrence resulted in global temprature rise and changes in rainfall variability with adverse impacts on the environment and natural phenomenon. Adaptation is the ability of a system of adjusting to climate change to moderate potential damages and taking advantage of managing the consequences.

Mitigation of climate change is also a global responsibility in which human intervention aimed at reducing the sources or enhancing the sinks of greenhouse gases. Whereas vulnerability is the degree to which a system is susceptable to, and unable to cope with, adverse affects of change of climate, including rainfall variability and extreme droughts. It is also a function of characters and rate of climate change and variation to which a system is exposed with its sensitivity and capacity.

Currently climate change impact is a realistic experience of several countries of the world receiving enormous attention. It is commonly accepted as a global issue that has significant effect on individual activities in general and particulrly on the livelihoods of poor smallholder househods. Nowadays climate change related issues have got a critical debate along with individuals and also through world political leaders and international organizations. The concern and debate starts from 1992 of Rieo de Janeiro's UNFCCC, Kiyoto protocol of 1997, Copenhagen of 2009, Durban of 2011 to the recent event of Doha summit of 2012 and it is supposed to be continued.

Climate change is thus not a specific country's problem but also it became one of the important policy issues of all the nations of the world. The reason why concern of climate change increased is due to rapidly rising of global atmospheric temperature by 0.3-0.6 ^{0}C over the last 100 years, its average rate of increase during the 21st century is predicted at 0.3 ^{0}C per decade (IPCC, 2001). It has also different adverse impacts on human beings and economic sectors of the countries. Agriculture is one of the most affected sectors by impact of climate change since it is still directly dependent on the main essential components of crop production including heat, sun light and water of climate variables.

Climate change does not affect all nations in the same way; the most remarkable adverse impact will likely being experienced by the nations of Sub-Saharan African countries from economic background and geographical locations. It is significantly affects the livelihood patterns and socioeconomic lives of majority of the people in the region particularly smallholder farm households in the agriculture sector (Barnett & Neil, 2007).

Ethiopia, one of the Sub-Saharan African countries is located in the horn with an area of 1.2 million square kilometer having diversified agro-ecologies with hot and arid to cold types of climate. Economically it is still in the category of developing poor countries of the world. This economic level besides to its geographical location made the country vulnerable to the adverse impacts of climate change and associated problems. As a result, climate change is a key policy issue of the country.

In Ethiopia, climate driven agricultural sector accounts about 41% of GDP, 90% of exports, 85% of total employment and it is a means of income for more than 80% of populations living in the rural areas (MoFED, 2012). Despite its high contribution to the overall economy, the sector is sensitive and challenged by numerous factors of climate-related disasters (Deressa, 2009). The major adverse impacts of climate change on Ethiopia include; land degradation, deforestation, loss of biodiversity, erosion, desertification, recurrent drought, floods and water pollutions (NMA, 2007).

In the agricultural sector, cereal crop production plays great role as the means of livelihood for most Ethiopian people both as home consumption and cash crops. Maize is one of the most important cereal crops, taking a major share of area cultivated and volume of production and the main staple food particularly for rural households of the country (CSA, 2002). Furthermore, diffusion of new technologies in Ethiopia has been more widespread for maize than other crops (Till *et al.,* 2010). With subsistent and traditional farming system, maize growing smallholder farmers in the central rift valley of Ethiopia are vulnerable to the impact of climate change.

This is due to households' low adaptive capacity and high sensitivity of their socio-economic factors imposed to climate change through food security and natural resource degradation (NMA, 2007). Farmers living in such areas with erratic rainfall have different level of perception and attempting diverse adaptation strategies with various determinant factors that influence the choices to employ. These problems need further study for policy instruments and betterment of the livelihoods of resource-poor farm households through integration of adaptation and mitigation practices in their day-to-day production activities.

1.2. Statement of the problem

Various studies on adaptation strategies of agricultural households to climate change have been done at regional and national levels in different countries. However, majority of the studies were conducted in developed countries and not yet well addressed the challenges of developing countries agricultural sector at household level (IPCC, 2007). Sensitivity and adaptive capacity of countries depends on sectors, geographic locations, time, social, economic and environmental considerations (IFAD, 2010).

Recently, few studies regarding adaptation options to climate change in Ethiopia have been done by different researchers (e.g., Deressa, 2007; Meseret, 2009; Ashenafi, 2011; Ermiyas, 2011). These studies have good findings in providing information on the knowledge gap considering adaptation methods of farm households and policy makers with multiple crops. However, they are lacking clear information regarding perception level and determinant factors that influence households' adaptation strategies considering specific crop at local level.

Majority of these studies are yet focused either on multiple crops (merged on one category) or at regional and national levels in the top-down approaches. These approaches obviously overlook the possible adaptation strategies to climate change that smallholder farmers employing at household level on single crop. Therefore, it is essential to investigate perception level of smallholders, prioritized types and factors that influence choices of adaptation strategies in view of specific crop at household level, what this study is concerned to address maize as focus crop in the central rift valley of Ethiopia**.**

With this study therefore, it was intended to evaluate the level of perception of smallholder maize growing farmers towards climate change with the hypothesis that awareness and employment of different adaptation strategies have positive economic effects on the livelihoods of the households. Examining prioritized strategies and major determinant factors that influence adaptation strategies of households to reduce negative impacts on their livelihoods is also analyzed with this study. The reason to focus on maize growing smallholder farmers was due to their higher vulnerability to the harmful impacts of climate change, low adaptation capacity and significant composition of farm households at the study area and national level.

To provide appropriate policy direction with the study based on household survey data collected from Adama and Adami Tullu Jiddo Kombolcha districts, two approaches were employed for analysis of the data. The first approach was descriptive analysis to evaluate the level of perception of farmers about climate change and to identify the usual types of strategies being employed by the households. The second approach was econometric (Multinomial Logit) model for analysis of main determinant factors that influence adaptation strategies of households at farm-level.

1.3. Objectives of the study

The general objective of the study is to analyze the maize growing smallholder farmers' adaptation options to climate change in the central rift valley of Ethiopia.

Under this main goal, the specific objectives are:

- To evaluate the level of perception of households on the prevalence of climate change
- To identify types of adaptation options given priority by the local community
- To examine determinant factors that influence the choice of farmers to employ adaptation strategies to climate change

1.4. Scope and limitation of the study

The scope of the study was accomplished by reviewing literatures, gathering important information from different institutions and collecting primary data from Adama and Adami Tullu Jiddo Kombolcha districts. The study was limited to analyze perception of households, to identify the prioritized types and determinant factors on adaptation options focusing on maize potential producing areas of the districts.

However, the study has some limitations including; lack of simulated biophysical data to analyze the impact of adaptation option to climate change on smallholder households in different technologies and climate scenarios. The other limitation was agro-ecologic diversity of the area diminishes the exact representativeness of larger population of the central rift valley of Ethiopia.

1.5. Significance of the study

There are few research findings on adaptation options to climate change on smallholder farmers in Ethiopia. The existing studies have not well identified perception level and potential factors that influence the choice of smallholder farmers to employ suggested strategies. Ethiopian smallholder farm households particularly farmers in the central rift valley are vulnerable to climate change impacts due to low adaptive capacities (NMA, 2007). Thus, it is crucial to increase an understanding of farmers and policy makers on perception level of climate change and factors that affect adaptation options to reduce adverse impacts on the livelihoods of households and environment.

Accordingly, the study raised four main research questions; firstly, which methods of adaptation options typically employed in the area? Secondly, how farmers perceive the prevalence of climate change in their surrounding with agricultural activities? Thirdly, what are the determinant factors that influence choices of households to employ adaptation strategies, and finally what policy measures are required to make the climate change to be sustainably increase productivity of farmers rather than its adverse impacts? These questions have been analyzed by using some descriptive analysis and relevant econometric models. The finding of the study enables to generate essential information and appropriate policy options to employ efficient and sustainable farm-level adaptation strategies.

1.6. Application of the results of the study

The result of this study can be used as relevant sources of information help to implement efficient and effective adaptation strategies to reduce vulnerability of smallholder farmers to climate change. The result was supposed to be employed through extension system of agricultural development offices and agricultural research centers, particularly through Melkasa Agricultural Research Center. For the policy makers, it can be provided through different scientific forums, proceedings, reviews and publications.

1.7. Organization of the thesis

The thesis was organized in six chapters starting from introduction, chapter one. Chapter two focuses on review of some theoretical and empirical literatures. The third chapter presents an overview of the Ethiopian agriculture and climate change followed by chapter four with research designs and methodology, chapter five consists of result and discussion with descriptive and econometric analysis. In chapter six, conclusions, policy implications and further research areas was presented.

CHAPTER TWO
LITERATURE REVIEW

2.1. Theoretical Literature

2.1.1. Climate Change and Theories of Economic Growth

There is a growing trend of scientific evidences and political commitments of climate change related problems of the world (IPCC, 2007). However, the study of adaptation options to climate change is a new area in economic research of today and only few theories have been developed. However, economists who have concerned in adaptation to climate change have associated the theories with the field of adaptation of new technologies as the households will be faced with options of whether or not to adopt a given course of action as profit maximization (Deressa, 2010). Economic theories concerning with models of resource allocation assumes people as a rational consumers expressing self-interest in the market.

Vogel and Reid (2005) confirmed that, through continuous adjustment of price and quantity, allocation of resource steadily moves towards an equilibrium point at which the supply of goods and services equals demand. But does only equilibrium of demand and supply by the past proponents of economic theories sustainable from environmental and natural point of view? How consumers and producers of goods and services act for efficient utilization of resources in general and particularly, climate change verses agricultural activities? The later question is the concern of this study to review literatures in terms of relationship between economic theories and adaptation options to climate change on the livelihoods of smallholder farmers. Of course, the importance of climate change was ignored in most economic theories and models in the circular flow of consumers (households) and producers (firms).

In the new economic growth model, for example, there are hot debates which can be divided in to two schools of thoughts; the Keynesian (institutionalism school) and neoclassical schools. These two schools of economic theories differ fundamentally in views on the ways economic growth brought and sustained. The saving-investment relation is the center of difference of these theories. Neoclassical theory believes as growth comes from savings and aggregate supply, while Keynesian theory argues as growth comes from spending and aggregate demand.

This shows that both approaches of economic theories concern and focus on the equilibrium point of demand and supply of goods and services. However, in the creation of sustainable economic growth, natural environment should be considered and protected. As the fourth report of IPCC (2007), it is alarmingly clear that warming of the climate is now unequivocal of the last 18 years (1995-2013) rank among the eighteen warmest years in the global surface temperatures since 1850. Today as well the only certain truth is that the ambitious human activity for economic development is the main causes of devastating natural resources. As a result, adaptation and mitigation to climate change policy debate has received increase attention to cope with the existing and expected adverse impacts.

Economic development in both theories were, therefore, based on business as usual (BAU), just ignoring sustainability of economic activities which truly challenging existing economic theories. Accordingly, the business-as-usual (BAU) from environmental and climate change point of view is no longer exist in economic theories from the baseline of the development of green economic strategy in a recent time. Similarly, Martin and Leo (2008) has indicated that, essential measures of the success of the economy is not only production and consumption but also the nature, extent, quality, complexity and sustainability of the total capital stock including the state of human minds and natural resources in the system.

It is important to express a few centuries and date of the end of usefulness of economic theory with the scale of global pollution which was realized in the Intergovernmental Panel on Climate Change (IPCC, 2001). The IPCC approved a growing interest of public awareness that green house gases were a threat to mankind and the biosphere. Therefore, the essential part of the success of the economic theory should not be only equilibrium point of production and consumption but also the sustainability of the natural environment. If sustainability of nature is not considered, optimality of production and consumption today will be based on the cost of future generation. That means, as indicated in the report of UNEP (2008), humanity is living beyond its environmental means and running up ecological debts that future generation will be unable to repay as a result of global climate change.

Sustainability of the natural resources can be maintained through adaptation and mitigation to climate change. Adaptation and mitigation are also the policy options to climate change that is affecting economic growth (Martin *et al.*, 2009). Adaptation can take place at farm-level, locally, regionally, nationally and at world level implemented independently or communally. Hence, adaptation is a crucial alternative in reducing vulnerability to climate change to cope with its adverse impacts at farm-level and planned adaptation options nationally.

2.1.2. Impacts of Climate Change on Agriculture

Numerous literatures have attempted to review the overall economic and social impacts of climate change in general and particularly focusing on developing countries those highly vulnerable to its negative impacts. In Africa, there are different studies that have been conducted to estimate the impacts of climate change and methods of adaptations.

Magadza (2000) estimated that the impact of climate change on a range of different economic activities in the southern African countries, but he did not considered the general equilibrium effects of adaptation strategies. His assumption is that little autonomous adaptation is taking place due to poorly functioning of political system, limited planned adaptation and shorter term in character. He was in favor of planned adaptation to reduce the possible adverse impacts of climate change which needs public investment to improve adaptation capacity of the smallholder households.

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2011) predicts that climate change is likely to have a significant impact on agricultural production in most African countries. Boko *et al*. (2007) in their study also projected that, reductions in crop yields of some African countries is approximated to 50% by the end of 2020, and also net crop revenue could fall by 90% by 2100. This is a serious threat to food security and achievements of major developmental goals.

Molua (2008) carried out a study on the impacts of climate change on agricultural sector of Cameroon and his result indicated that 3.5% increase in tempreture and 4.5% decrease in precipitation resulted to the country's loss of 47.7% of the output value. This loss was expected to neagtive impact on the country's economy since a country's 30% of GDP based on agricultural sector. He also made a similar study on climate change impact on the smallholder farmers of Cameroon with the use of Recardian model. In the study he also found that a 2.5 ^{0}C rise in tempreture would reduce the net revenues of the country by amount estimated to 79 billion US dollar. The study indicats that how climate change was significantly challenging the economy of Cameroon and other similar Sub-Saharan African countries.

In Ethiopia although climate resielent green economy is retified as one of national policy options, numerous climate change pressures are already threating the existing natural resources at the smallholder farm levels. The major climate change impacts of the country include; population pressure, lack of non-farm job opportunities, lack of alternate crop vrieties, credit facilities, lack of technical support leading to reduction of agricultural productivities (IBC, 2005).

2.1.3. Perception of Farmers to Climate Change

Various literatures indicated that farmers are aware of climate change through their long experiences, existing local and economical situations. In developed countries also (e.g., America and Europe) climate change has been known and percieved by majority of the people and they are taking different actions to mitigate its effects. A study by Battaglini *et al.* (2009) considering the wine growers of European farmers, perception on climate change over the past decades was reported that there is significantly higher percentage of farmers have better perception and adapting to climate change.

In Asia, Sharma (2010) conducted study on perception of farmers on climate change in Himalaya and he revealed that a significant number of farmers have knowledge about various impacts of climate change such as increasing pollution, cyclones incidents, increased crop failure and rise in the sea-level. Concidering agriculture, majority of farmers percieved that the use of fertilizer and pesticides had increased due to climate change. This was certainly indicates increasing households' perception about the climate change from their day to day activities.

Nyanga *et al*. (2011), evidence from Zambia indicated that most farmers have a perception of climate change attributed to a supernatural forces. In this study, actions that follow perceptions of climate change are informed by different processes like perception of risk associated with climate change, resource endowment, cultural values, institutional and political environment.

A study conducted by Deressa *et al.* (2010), in Ethiopia as well revealed that perception of smallholder farmers on climate change are more likely dependent on their exeprience, education, wealth, access of extension, credit and social networks to percieve and employ different adaptation methods in Ethiopia. Similarly, Belay (2010) made a study on farmers perception level to climate change in East-Gojam of Ethiopia based on survey data. His result also confirmed that farmers in the area were aware of temprature getting warmer and drier with increased frequency of drought and changes in the timing of rainfall. Therefore, these literatures confirmed that smallholder farmers have different level of perception on climate change from their farming experiences, geographical locations and existing situations.

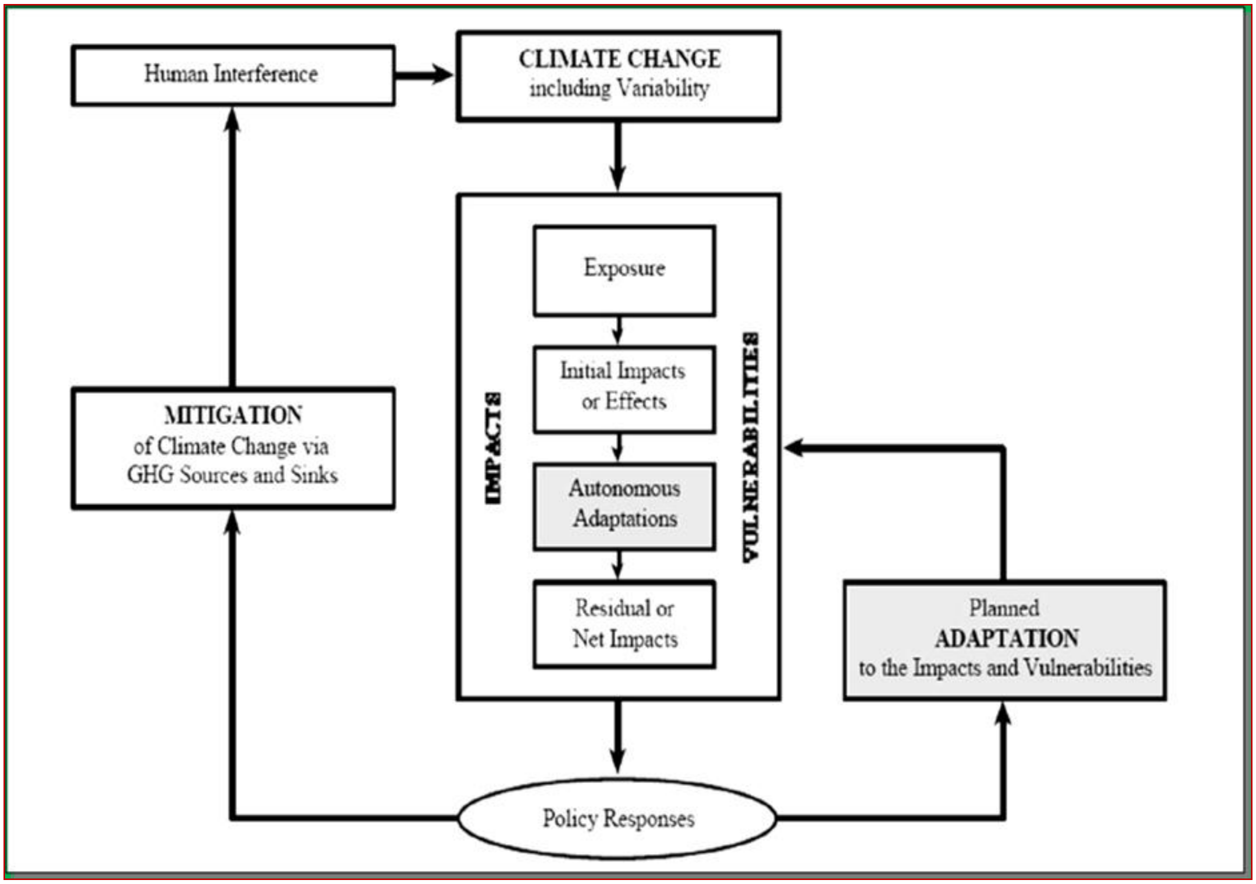
2.1.4. Mitigation and Adaptation to Climate Change

Farmers those perceived the existences of climate change and policy makers have different reactive and proactive responses to reduce its adverse impacts. Nowadays, mitigations and adaptations are the most globally known responses to the impacts of climate change and variability. Mitigation refers to reducing climate change harms by reducing the emissions of green house gasses. While adaptation on the other hand is to adjust the life style with natural or human induced climate change related problems, which could reduce harms or exploits beneficial opportunities (IPCC, 2007). Even though mitigation targetes avoiding the major causes of climate change and offers long run solutios, adaptation is necessary given to the current state of the world particularly for smallholder farm households of developing countries.

Both approaches are important and widely used for reducing potential damages and possible costs from climate change adverse impacts. Policy makers, planners and farmers choose an optimal efficient point of combination of the two approaches. In this regard, Ingham *et al.* (2005) use the expected utility maximization framework which captures economic behaviour to analyse adaptation and mitigation as a single economic variable.

Mitigation and adaptation approaches have therefore higherly interalted roles in the responses to reduce adverse impacts of climate change (Figer 1). Prefering mitigation will reduce the need to adaptation and vice versa. Ingham *et al.*(2005) projected a view that mitigation and adaptation are economic substitutes. Accordingly, it is important to analyse an economic optimization problems by choosing the optimum and efficient level of combinations of the two. If the cost of mitigation falls relative to that of adaptation, it is economically advisable to implement more mitigation than adaptation strategies.

Figure 1: Roles of mitigation and adaptation in the climate change



Source: (IPCC, 2001b, cited in Belay, 2010)

Fussel (2007), recommended that better emphasis should be given to adapation than mitigation because of the fact that: human actions have already affected climate and therefore climate change continues a given past trends; the effect of emmission reduction or mitigation takes a lots of time (several decades) and adaptation can be done at local or national level as it is less dependent on the actions and willingness of others. Hence, for smallholder resource-poor farm households adaptation is more prefarable than mitigation to improve their immediate livelihoods.

According to the report of IPCC (2011), adaptation to climate change is classified in to two broad catagories; automomous (reactive) and planned (proactive) adaptations. Autonomous adaptations are adjustments that are already being practiced by the society due to climate change effects including local or indigenous adaptation strategies. While planned adaptation deals with the trgeted future impacts of climate change. All forms of adaptation options require a sound knowledge base incorporating long term climate change impacts on economic sectors like agriculture on which the livelihoods of most smallholder farm households denpedent on.

IFAD (2010) has also made an arguement that neither adaptation nor mitigation only can avoid all climate related adverse effects. The report idicates that the solution to react with the problem, is necessary to focus on awarness creation about climate change impacts and adaptation options to local communities. Actions intended to increase the rural society's resilience has vital importance to help their capacity to choose the best adaptation and sustainable options to react with the impact of climate change.

From global point of views about mitigation, setting international mitigation targets has been done by signing the Kyoto Protocol in 1997. According to the report of CEC (2007), the protocol mandated that by the period from 2008 to 2012 (developed countries and economic transition) committed to reduce their greenhouse gas emissions approximately by 5% compared to their 1990 levels. At the European level, the European Union (EU) set a 2^0C target, aimed at limiting the global average tempreture increase to less than 2^0C compared to pre-industrial levels. But still this protocol is debatable trade-off as a choice between enironmental protection and economic growth through industrialization particularly by developed countries.

As Henry (2009) report, thinking like an economist, the Kyoto protocol has fundamentally changed the way we do business and our economic value by carbon trade (making carbon dioxide emissions) monetarily costly and clean development finally profitable. That means, people especially from developing world, are demanding that carbon polluters pay from developed ones. Besides the pollution, as a result of carbon emission climate changes in temperature, rainfall and extension of drought periods will have negative impacts on weather dependent agricultural production which is the main concern of the developing poor countries. Accordingly, there is a trade-off in terms of reducing environmental pollution and increasing economic development. Countries of the south, including Brazil, China, India and Indonesia have signed the protocol, but have not yet set targets for reducing emissions so as not to hamper their rapid economic development.

As Martin *et al*. (2009) reviewed, adaptation planning particularily for developing countries international community has embarked on a series of adaptation studies for the most vulnerable countries of the world, called National Adaptation Program of Actions (NAPA). Ethiopia is one of the 40 countries NAPA's have so far been completed to identify priority of adaptations and initiate a methods of planning and implementation in exposed developing countries. The study also revealed as priority of NAPA was predominantly cover preparatory measures and capacity building, mostly on agriculture and water resources. By itself, NAPA can not be a good indicator of the ultimate adaptation expenditure in most susceptible countries, even though they can give a rough indication of what the initial outlay may be as the global adaptation effort is rised up.

Adaptation theories hypothesized that social, economic, ecological and institutional systems and individuals can do adaptation to the changing environment. The degree of sustainability of adaptation depends on the adaptive ability, knowledge about climate change, level of the livelihoods and alternatives, access to appropriate technology, resource and institutions accessible to enable to undertaking effective adaptation strategies (IPCC, 2007). Adaptation capacity is also a factor of vulnerability of the smallholder farmers to the adverse impact of climate change.

Smallholder household farmers particularly in developing countries are the most vulnerable economic agents as a result of their low capacity to adaptation. Smit and Wandel (2006) stated the level of vulnerability (V) of farm households to climate change risks as a function of exposer (E), sensitivity (S) and adaptive capacity (AC) including adaptation strategies.

Symbolically;

$$V = f(E,S,AC)$$

Where;

V= Vulnerability of farmers to climate change riskis

E= Exposer (the nature and level to which a system is exposed to climatic variation)

S= Sensitivity (the extent to which a system is likely to be affected by climate change),

AC= Adaptive Capacity (including adaptation strategies)

In the short term, E and S can be assumed to be the same and hence the focus is how to improve the AC. But in the long-run time (time tn), E, S and AC can all to be changed.

Most studies existing in developing countries concerning adaptation planning focused on the future and long term scenarios and their recommendations tend to have littile relevance for the current situation of smallholder farmers and find littele policy alternatives for immediate needs (IPCC, 2007).

In addition, there is an assumption that adaptive capacity is a constant while climate exposure is changing. Therefore, the vulnerability of current climate risks (at time t_1) can be expressed as (Smit and Wandel, 2006):

$$V_{t1} = f(E_{t1}, S_{t1}, AC_{t1})$$

Smallholder farm households are currently highly vulnerable to climate risks. In this case V_{t1} (vulnerability at time one or primarly) is higher since AC_{t1}(adaptive capcity at primary) is low. Assuming that E and S are constant in the short term and it is imprical to change them, then the way to reduce vulnerability increases adaptive capacity of farmers.

Then it is possible to predict a condition at time t_2 where the vulnerability of small farmers is lowered to acceptable level:

$$V_{t2} = f(E_{t2}, S_{t2}, AC_{t2})$$

Where V_2 is the acceptable level of vulnerability; $V_{t2} < V_{t1}$.

The adaptation challenge is therefore how to attain AC_{t2} through different policies and project interventions. Accordingly, policies and decisions on adaptation to climate change need to focus on how to to improve adaptive capacity of farmers to acceptable levels so that they are able to adapt to current climate risks.

In this case, Smit and Wandel (2006) have concluded that once the vulnerability of small holder farmers to current climate ricks have been reduced to acceptable levels, then it is hypothesized thet they will be able to cope with the gradual change in climate. It is based on the assumption that change in climate (ΔE ans ΔS) will be so slow as to allow small changes in the farming systems.

2.2. Empirical Literatures

There are various literatures on analysis of climate change adaptation strategies. Application of different methodologies by researchers resulted in to different outcomes brought adaptation strategies to climate change studies to be continuing. Research works undertaken at macro level, could not be able to generalize the strategies of specific farm households particularlly smallholder farmers. Hence, it was important to review earlier studies that have considered smallholder farmers' perception level and major determinant factors of adaptation strategies.

Fosu *et al.* (2010) used household survey data to analyze farmers' perceptions and adaptation to climate change in Sekydumase district of Northern Ghana in 2009. A logit model was used for analysis; the dependent variables were perceptions and adaptation. Temperature, crop diversification and changing crop planting calendar were identified as major adaptation options to warmer climate. The study also revealed that land tenure, soil fertility stage, extension services and access to credit were those influence smallholder farm households to adapt climate change although household size was excluded in the model.

Study made on adaptation strategies to climate change by Bryan *et al*. (2009) in South Africa and Ethiopia also identified potential determinants that influence decision of farmers to adaptation strategies as a common factors: use of different crops and varieties, tree plantation, soil conservation and management, changing planting dates and irrigation are among the well known practices. Their study also revealed that, the main barriers to adaptation strategies mensioned by farmers were lack of access to credit in Republic South Africa and lack of access to land, information, and credit in Ethiopia. Potential determinants of influencing farm housholds for adaptation include; wealth, access to extension, climate information in Ethiopia; and wealth, government farm support, and access to fertile land and credit in the Republic of South Africa.

Climate change can reduce the length of growing season of crops and water for livestock rearing. However, not all changes in climate and associated climate variability will be negative. In some areas, such as parts of the Ethiopian highlands and highland area of Mozambique, climate change may extend crops growing seasons as a result of increased temperatures and rainfall (Thornton *et al*., 2006). Therefore, perception and determinant of climate change and its adaptation options need further research works to identify economic cost and benefit as a consequence of the climate change.

Deressa (2010) analyzed major determinants of farm-level climate change adaptation measures and factors influencing perceptions of climate change on cross sectional survey data collected from 1000 households during the 2004/05 production season in the Nile Basin of Ethiopia with Heckman's prohibit selection model. On perception level of farmers of the area, the study indicated that 50.6% of surveyed farmers have observed increasing temperature while 53% of them have observation on decrease in rainfall over the past 20 years. Those who observed the changes have responded to climate change with various adaptation strategies including planting trees, soil conservation, use of different crop varieties, changing planting dates and irrigation. These adaptation measures by farmers in the Ethiopian Nile Basin area have some difference with our findings in the central rift valley of Ethiopia, except with soil conservation and use of different crop varieties. This variation of adaptation options across the area indicates the need of specific adaptation strategies for local specific areas based on agro-ecology and geographical difference in a given country.

With the same study of the Ethiopian Nile Basin, education of the household head, household size, gender, ownership of livestock and temperature are some of most important determinant factors that influence farmers' adaptation choices. However, the study aggregated all crops of the household in to one category and therefore the findings may not be relevant for crop specific adaptation options to climate change.

The study by Belaineh *et al.* (2010) in Doba district West Harargie of Ethiopia with multinomial logit model, revealed that potential determinants of household on adaptation options include; plot size, livestock holding and frequency of extension contacts are some of the significantly and positively associated. However, family size, off-farm income and training were significantly and negatively associated with adaptation options to climate change in the study area.

In the northern Ethiopia, Tigray, with multivariate Probit model analysis on a survey data of 160 farm households, determinant factors that influences smallholder households' adaptation strategies have been identified. The study revealed that major adaptation strategies include; use of crop varieties, external fertilizer, borrowing of lost crops from community and use of short duration crops. Also extension service, livestock ownership and access to climate information are important determinant factors of adaptation strategies that influence the choices of households (Deressa, 2007).

Generally, the findings of empirical literatures indicate that adaptation options to climate change is very site specific which means there can be no one-size-fits-all approach. Hence, there is a need of participating smallholder farmers to build on their local knowledge and indigenous experiences to make appropriate mitigation and farm-level adaptation policies to the changing climate.

CHAPTER THREE
AN OVERVIEW OF CLIMATE CHANGE IN THE ETHIOPIAN AGRICULTURE

3.1. Impacts of Climate Change on the Ethiopian Agriculture

The importance of agriculture in the Ethiopian economy needs considerable and dynamic government policy to help the sector to be sustainable from environmental point of view. Agricultural production remains the main source of livelihood of rural community and contributing a lion share of gross domestic product (GDP) of the country. Existing studies indicated that, agriculture is the most affected sector by climate change from its dependency on weather variables such as heat, temperature and rainfall.

The challenges that agricultural sector facing includes; declining productivity due to backward technology, reduction of the size of agricultural land from population pressure and dependency on rain-fed farming system. These problems put together resulted in inability of the agricultural sector to ensure the country's food self sufficiency and poverty reduction.

It is well known that farming is a risky business the world, even with countries having improved weather forecasting which may confirm destructive for resource-poor smallholder farm households. Conversely, agricultural production is one of the most adaptable human actions to changing climate condition. This can be achieved through improved agricultural technologies such as climate change resilient crop varieties through research and development. There is also elasticity in agricultural farming practices through application of fertilizer, irrigation and use of other inputs. Because of these situations, agriculture at the global level can probably adapt to a moderate amount of global warming (Ian, 2006).

According to the study by Deressa (2010), vulnerability of smallholder farmers to climate change in Ethiopia is attributed to their dependence on rain-fed agriculture and high poverty. Rain-fed agriculture, which supports the livelihoods of majority of the population of the country, is highly sensitive to climate factors. It is also distinguished by erratic rainfall, frequent droughts that often cause famines, and higher rainfall causing floods. Given the dependence of the agricultural sector on climatic conditions, especially rainfall, the macroeconomic performance of Ethiopia also follows rainfall patterns. Therefore, in years where there is good rainfall, the economy performs well and in years of bad rainfall the economy performs very poorly (Petherick, 2012). This leads farmers to use different adaptation strategies which may harm the environment and then the national economy country. Smallholder farmers therefore react to the impact of climate change based on their local knowledge and experiences through various farm level local adaptation methods.

Meseret (2009) has also evaluated economic impact of climate change on crop farming activities using the Ricardian model on household survey data. The study, estimated marginal impacts of the climate variables on crop net revenues indicated different results for temperature, precipitation and irrigated dry land farms. The finding of the study has provided an idea about increasing temperature and decreasing precipitation that are detrimental to the agricultural productivity. Actually, the study considered productivity of the whole aggregate crops in the area with less attention on the impacts of adaptation options that farmers practiced in terms of a given specific crop to their locality.

3.2. Climate Change Policies in Ethiopia

The impact of climate change in Ethiopia is significant due to economic structure of the country and low adaptation and mitigation capacity of the socio-economic agents. Thus, the country has recently established a national climate-change forum and a civil society network on climate change as a policy option. Both national adaptation program of action (NAPA) and a Nationally Appropriate Mitigation Action (NAMA) plan has been submitted to the United Nations Framework Convention on Climate Change (UNFCCC) focusing on agricultural productivity (Zenebe *et al.*, 2011). The country has also commenced different international agreements to protect from possible adverse impact of climate change.

There is an urgent need for local and regional climate change and adaptation policies to limit or reduce the possible adverse effects on the existing and future generations.

Relevant research information on the possible impacts of climate change on the micro and macro economy of a given country needs a critical dedication for planning adaptation options and formulating effective international climate related policy agreements.

Ethiopia, being one of developing countries highly vulnerable to climate change, particularly with its agricultural sector. As agriculture is the back-bone and dominant sector of the country, in one or the other ways it has direct impact on the national economy with varying scope and magnitude. The country has planned a policy framework of Climate Resilient Green Economy (CRGE) that will work up to 2030, the first of its kind in Africa. The policy framework draws on two diametrically opposite strategies reducing emission of the GHGs on the one hand and increasing productivity on other hand, termed a win-win situation (FDRE, 2011).

The Ethiopian current ambitious development plan, Growth and Transformation Plan (GTP) for 2010-2015, issued by the ministry of finance, anticipated to ensure the country's attainment of middle income status by 2025. The plan was considered the global clean development efforts through better environmental services. In the document though it is sensitive to climate, the agricultural sector is identified as a key driver of the growth and development of the country.

Ethiopia has ratified and proactive in negotiations on various international conventions and protocols of climate change related issues. The country has also a number of national policy initiatives structured at federal and regional levels that are concentrated on climate change mitigation and adaptation strategies. These include: Environmental Protection Authority (EPA) - governmental agency that coordinates climate change issues at national level; Climate Change Forum-Ethiopia (CCF-E) - civic society organization that coordinates climate research and development nationwide; Agricultural Research Centers generating appropriate agricultural technologies in line with climate change; National Meteorological Agency (NMA) and other various institutions. This indicates how the country gives significant consideration to environmental protection within the domain of climate change.

Despite the existence of these institutions, currently environmental degradation and climate change impacts become the key policy issues of the country. To solve such problems, a recent and globally known action program National Adaptation Program of Action (NAPA) was initiated and coordinated by the national meteorological agency. NAPA of Ethiopia was established as a mechanism within the UNFCCC and designed to identify priority adaptation options to climate change. It has now identified about thirty seven potential adaptation options for further prioritization and ranking to address immediate adaptation needs of the country (NMA, 2007).

As a result, the Ethiopian government gives a great attention to soil conservation even as a campaign by mobilizing majority of agricultural stakeholders through entire of the country. It is a very pleased practice on conservation of forest starting from trees plantation by every citizen from the Ethiopian unique Millennium celebration (2008). The other well appreciated practices include almost all farmers of the country have voluntarily started digging erosion control terracing, ditches and water shade management as a way of conserving soil degradation particularly in hilly areas and river basins.

3.3. Costs and Benefits of Adaptations to Climate Change

In broad sense, climate change strategies include mitigation and adaptation options alternatively base on achievable costs and benefits. For people whose livelihoods previously affected by climate change, adaptation is more preferable approach than mitigation and should be given priority. Recently, adaptation became an issue that is as essential as basic needs of human beings particularly for smallholder farm households of developing countries. This is the reason why various studies are going on at global and national levels to improve the response to climate change through both mitigation and adaptation strategies. Ethiopia is implementing different strategies both in mitigation and adaptation to reduce the sector-wise and economy-wide of costs from climate change.

Economic costs resulted from impacts of climate change have been estimated to be quite a lot on GDP of countries if no more measures either adaptation or mitigation employed against the effects of climate change. However, these days there are several debates among the policy makers to answer the questions like; where the impacts will happen, what will happen, who will be affected more and in what ways. These are some of challenges of decision makers to take sustainable measures (Solomon *et al.*, 2009).

Ian (2006) revealed that people vulnerability to natural or human-induced climate change reflects its degree of exposure and its capacity to adapt. Accordingly, exposure to climate change has two principal elements: the first one is the climate conditions themselves and the second one is the extent of population in terms of wealth and development exposed to it. Different kinds of societies have different types of capacity to adapt to changing climate conditions, whether by reducing harm, exploiting beneficial opportunities, or just using both. This ability to adapt is mostly a function of society's level of wealth, education, institutional strength, policy and access to technology. The nature and the degree of economic and social development, therefore, greatly influence both its level of exposure to climate risks and its ability to adapt to the changes.

Adaptation to climate change as a result, has now received increasing attention in economics and policy debate, especially in terms of evaluation of adaptation strategies. Some scientific literatures like Smit and Wandel (2006) have been done on the areas of climate change impacts, vulnerability and constraints of adaptation. However, only little is known about the potential determinants of adaptation options at smallholder farm households to evaluate possible costs to be incurred on the strategies.

Martin *et al.* (2007) defined adaptation costs as the costs of planning and employing adaptation strategies, including transition costs. The report was also defined benefits from adaptation as the accrued benefits following adoption and implementation strategies. Hence, adaptation methods usually not completely contradict the negative impacts of climate change, so the cost of residual damage that remains after implementation of an adaptation option should be taken into account. After comparing the options, those with the highest estimated net benefits are selected for implementation of a given strategy.

Another study conducted by Krishana (2011) revealed that farmers face three types of costs of climate change impacts; firstly, direct costs from the effects of climate change on crop and livestock production, and risks of natural hazards. Secondly, indirect costs from the effects of climate change on socioeconomic conditions and lost opportunities for their advancement of the living conditions and thirdly which the concern of this study is the potential determinants on adaptation strategies to keep themselves away from or to minimize the negative impacts of the climate change.

Generally, from adaptation cost-benefit point of view deciding how much to adapt now comparing with waiting to do more in the future also depends on difficulty to evaluate tradeoffs related to uncertainty. Waiting more time for adaptation can bring benefit from gaining additional information on the impacts of climate change and the strategies for improving expected impacts. Therefore employment of any adaptation needs prior analysis of cost and benefit for decision.

Till *et al.* (2010) simulated the future outcomes of the Ethiopian economic costs from climate change by 2050 expected to cause 8-10% smaller than under climate base scenario. It could bring a two fold increase in growth of income from agricultural sector. Adaptation to climate change can cost an annual average of 0.8-2.8USD billion and an additional 1.2-5.8USD billion if residual damaged may not be addressed with adaptation options of the existing development pan of the country

CHAPTER FOUR
RESEARCH METHODOLOGY

4.1. Description of the Study Area

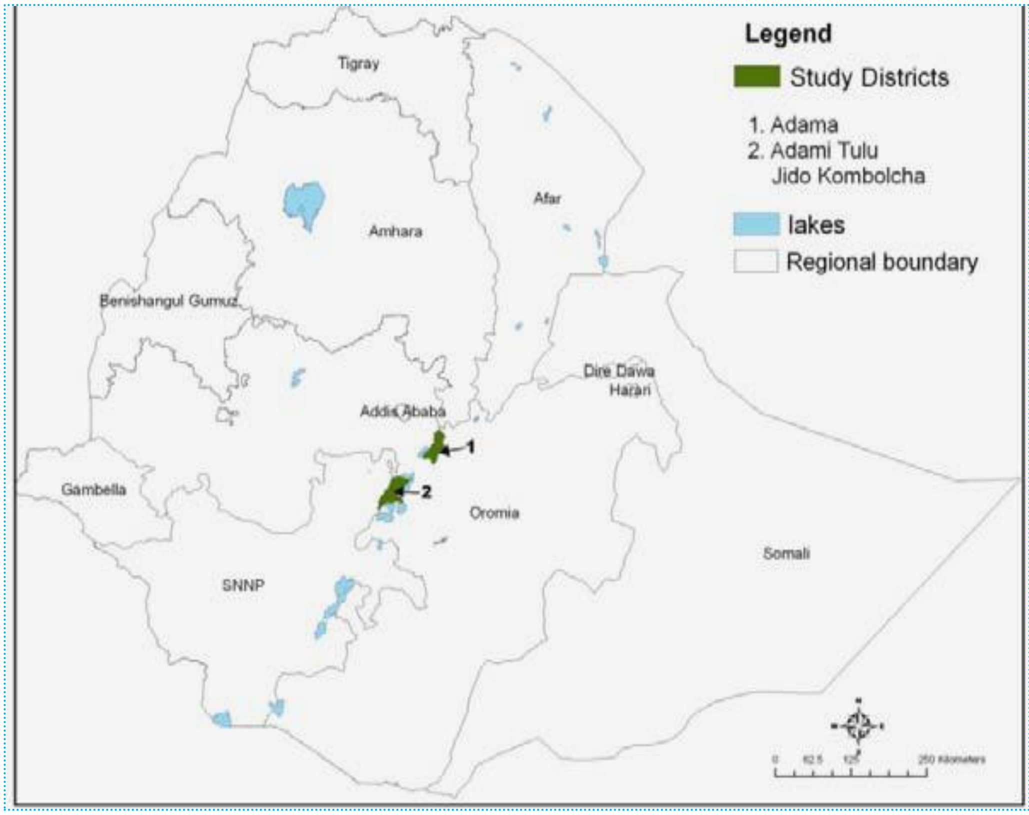
The study was conducted in the central rift valley of Ethiopia one of the most climate change vulnerable areas of the country. Specifically the study was carried out in Adam and Adami Tullu Jiddo Kombolcha districts located in the Oromiya regional state in the central rift valley of Ethiopia (Figure 2).

The Ethiopian central rift valley is a part of Great African Rift located between $38^0 00'$-$39^0 30'$ east longitude and $7^0 00'$-$8^0 30'$ north latitude, it covers an area between the Yerer fault from the western edge and Abjiata Lake (Shashamane) on the southern side to Miesso on the eastern edge. The area is also known with its potential of cereal crops characterized by semi-arid type of climate with erratic and low rainfall averaging between 500 and 900mm per annum (FfE, 2010).

Adama and Adami Tullu Jiddo Kombolcha districts are known in their potential maize production with rain-fed dependent farming system. Adama district has a total area of 1008 km^2 with a population of about 456,637. Whereas Adami Tullu Jiddo Kombolcha district have a total population of 178,204 with the total land area of 1275 km^2. The population density of the districts of Adama is 453 while for Adami Tullu Jiddo Kombolcha district is 139 persons per km^2 (Getachew et al., 2010). The major crops grown in the area include maize, teff, sorghum, haricot beans and the main livestock in the area also includes cattle, sheep, goats, donkey and chickens.

Note: *Household is a basic unit of member of family living together in one home and production and consumption decision is made by the household head (unit of analysis for this study)*

Figure 2: Study districts in the map of Ethiopia



Source: Getachew *et al*. (2010)

4.1.1. Adami Tullu Jiddo Kombolcha District

Adami Tullu Jiddo Kombolcha is one of the districts of East Shewa Zone of Oromiya regional states located in the central rift valley of Ethiopia. In the south, the district is bordered by Arsi Negele district with which it shares the shores of Lakes Abijatta and Langano; on the west by South Nation and Nationality of Regional State of Ethiopia, on the north by Dugda district, on the northeast by Lake Zeway, and on east by west Arsi zone. The district's capital city is Batu, located 150 km from Addis Ababa to the south direction along the main road to Hawasa and then Kenya (Moyale).

According to the district's agricultural office, its altitude ranges from 1500 to 2300 m.a.s.l, in the woynadega (mid-altitude) of the agro-ecology. About 27.2% of the land in the district is arable, 21.6% pasture, 9.9% forest, 15.7% swampy and the remaining 25.6% is considered degraded or otherwise unusable. The minimum and maximum annual mean temperature is 14 and 27 ^{0}C respectively. The rainfall pattern of the district is characterized as bimodal (from February to April short rain and from June to September is known with long rainy season). Usually, the rain pattern is erratic with fluctuation of starting and ending time. It is some time characterized with total absence of rainfall. Hence, these whether and agro-ecological characters made the district one of climate change vulnerable in Ethiopia.

Figure 3: Overview of maize farms in the central rift valley of Ethiopia

4.1.2. Adama District

Adama district shares border lines with Lume and Boset districts and west-Arsi zone. The district's capital city is Adama, located 100 km from Addis Ababa to the east along the main road to Djibouti. The whole areas of the district found within the altitude range of 1500-2300 m.a.s.l. The district is dominated by ups and downs of plains with extended ridges along its western part. The district comes under a sub-tropical agro-climatic zone. It is dominated by sub-tropical grasslands.

As the report from the district's agricultural office, that about 30% of the total area of the district is under crops cultivation. Grazing, forests and degraded lands accounted for about 6.5%, 5.2% and 4.2% respectively. Cereals and pulses accounted for 96% of the cultivated land in the 2011/12 cropping year. Among cereal crops, maize accounts for the largest area of production followed by teff.

4.2. Data Sources

Primary data based on cross sectional household survey was collected from a randomly selected 233 maize growing smallholder households from Adama and Adami Tullu Jiddo Kombolcha districts in the central rift valley Ethiopia. A comprehensive questionnaire was prepared keeping the objectives of the study as a central point to collect necessary information. The questions were formulated to contain information regarding demographic characteristics of farm households (sex, age, marital status, level of education and family size), households' activities and income (occupation, farming behavior including land size and its use, agricultural inputs and outputs, livestock ownership non-farm income) and agricultural technologies (fertilizer, manure, chemicals, improved seeds etc) used. Matters relating perception and determinants of farmers in terms of sensitivity to climate change perception and adaptation options (frequency of drought, extent of the loss of yield of maize, main adaptation options preferred, determinant factors that influence adaptations) were also included in the questionnaire (Appendix 1). Accordingly, the face-to-face interview took place from February to March 2013 at the home or in the village of smallholder farmers.

Before execution of the main survey, pretest has been done by consulting socioeconomics researchers of Melkasa Agricultural Research Center (MARC) and agricultural offices of both districts. Pretest of the questionnaire has helped to check the consistency, duplication and clarity of questions and to plan the time and other required resources to execute the survey work on time.

The motives in this study to use the survey data, was to get relevant information directly from vulnerable farmers based on their recent practices and perception. Survey is an important method of data collection through face to face interviews and/or through well prepared questionnaires. As definition by Dooley (2003), a survey is a means of collecting information from a sample of target people by administering a questionnaire. Some of the advantages of survey are to make collected information more real, factual and detailed with close supervision of the researcher. In addition, it also helps to obtain more information through probing personal details, attitudes, past behavior and views of the respondents.

Accordingly, the data collection was accomplished through close supervision of the researcher with six well trained enumerators, agricultural development agents and managers of respective peasant associations. Agricultural development agents and peasant association managers were participated in facilitating and providing the records of the households and selected farmers for the interview. Besides the survey data, relevant secondary information was also collected from various literatures, agricultural offices, research centers and other related institutions.

Figure 4: numerators (left) and one of respondent farmers on interview (right)

4.3. Sampling Procedure

The study area, Adama and Adami Tull Jiddo Kombolcha districts of the central rift valley of Ethiopia was purposively selected in this study for; the area is characterized by extensive low and unpredictable rainfall and high extent of maize production in the area (Vilalta, 2010). Moreover, the existence of Melkasa Agricultural Research Center (MARC) and Adami Tullu Agricultural Research Center (ATARC) located in Adama and Adami Tull Jiddo Kombolcha districts respectively helps in access of providing different farming technologies to farmers as various adaptation options than other districts. In fact, the districts are not representative of entire central rift valley of Ethiopia as the area has diverse micro-ecologies, economic situation, cultural and political matters. Therefore, the selected districts represent mid and lowland potential maize producing farming system in the central rift valley of Ethiopia.

To select sample households from the population, a two stage sampling technique was employed. In the first stage, potential maize producing peasant associations were identified from each districts based on information from the districts' agricultural offices. And then three peasant associations from identified potential maize growing peasant associations of each district were selected randomly.

Accordingly, Adama district with a total of 36 peasant associations six of them with 2490 households are potential in maize production which are located in the central rift valley of Ethiopia. Then from identified potential peasant associations, three (Adulala, Merebe and Geldiya) were selected randomly for this study. Similarly for the case of Adami Tullu Jiddo Kombolcha, the district has 43 peasant associations and six of them particularly Bulbula area, the southern and south-eastern parts of the district are characterized as potential maize producers, with the total household number of 2116. Three peasant associations (Hurufa, Arba and Oda Anshura) were also randomly selected from identified potential maize producer peasant associations.

In the second stage, sample households (using probability proportional to size sampling method 30-45) were selected for the interview with systematic random sampling technique from each peasant association. Systematic random sampling procedure in this case is practical as the names of household heads' are available in the form of lists in peasant association offices. In such a design the selection process was done by picking some random point in the list and then every n^{th} element was selected until the desired number of households secured. Such sampling method uses to solve the systematic bias, failure of sample to represent the population it was intended to represent (Kothari, 2004).

Proper sample size for the household survey was determined from a total population size of the two districts 4606 (2116 of Adami Tullu Jiddo Kombolch and 2490 from Adama districts) smallholder maize growing households at the survey time (February 2013) based on information obtained from kebeles and extension agents. And finally a total of 233 households were selected from the specified number of population.

The simple size determination was computed based on the formula developed by Cochran (1977) as follows;

$$n = \frac{(t)^2 * (p)(q)}{(d)^2}$$

Where;

n = number of sample households

t = value for selected alpha level of 0.025 in each tail = 1.96 (the alpha level of 0.05 indicates the level of risk willing to be taken that the true margin of error may exceed the acceptable margin of error).

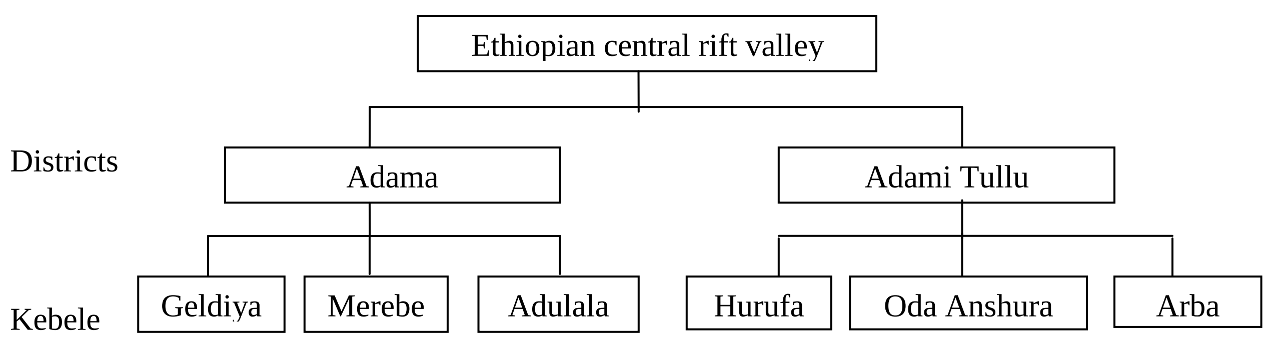
d = acceptable margin of error for proportion being estimated = 0.05 (error to be excepted)

(p)(q) = estimate of variance = .25 (taking possible proportion (0.5)*1 – maximum possible proportion (0.5) produces maximum possible size.

$$n = \frac{(1.96)^2 * (0.5)(0.5)}{(0.05)^2} = 384$$

Therefore, the sample size is greater than 5% of the population (4606*.05=230.3) which indicates that sample size is properly representing the population.

Figure 5: Structure of the sample



Note: *Peasant Associations or "Kebele" is the lowest administrative unit of Ethiopia.*

Table 1: Distribution of respondent households by districts and peasant association

District	Peasant association	Respondent households number	Percentages
Adama	Geldiya	36	15
	Merebe	45	19
	Adulala	45	19
ATJK	Hurufa	30	13
	Arba	41	18
	Anshura	36	15
Total		**233**	**100**

4.4. Method of Analysis

Both descriptive statistics and econometric models were used to analyze the quantitative household survey data collected from Adama and Adami Tullu Jiddo Kombolch.

4.4.1. Descriptive Statistics

Descriptive statistics were used to characterize farmers' perception and their prioritized types of adaptation strategies to climate change. Statistical instruments including frequency, percentage, crosstabs, and standard deviation was used to summarize collected data. In the data entry, computation, descriptive and econometric regression analysis, computer software EXELL, Statistical Packages for Social Studies (SPSS) version 16 and STATA version 11 was employed.

4.4.2. Econometric Model

The Multinomial logit model (MNL) was used for analysis of dependent variables that takes more than two values to investigate the major determining factors of selected adaptation options. The assumption behind this econometric model is that farmers' decision of any adaptation strategies is influenced by a variety of socioeconomic factors and farmers' perceptions about variables related to climate changes. Theoretical concepts and empirical studies indicated that factors influencing agricultural adaptations involve a mixed set of qualitative and quantitative data. Models normally used for examining relationships between qualitative dependent variables and mixed independent variables are qualitative response regression models (Greene, 2002). In this study, therefore, Multinomial Logit (MNL) model was employed to identify determinate factors that influence choice of farmers to employ adaptation options in the study area.

Multinomial Logit Model (MNL) and Multinomial Probit (MNP) regression models are the two most important and commonly used analytical models for analysis of adaptation studies involving multiple choices. Both Multinomial Logit Model and Multinomial Probit models can be used interchangeably for analyzing farmers' adaptation decisions. For this study Multinomial Logit (MNL) model was used for analysis of determinants of households' decision to employ some adaptation methods. The reason of using this model in this study was it's widely used in many fields than the probit model and its easiness for computation (Tazeze, 2012). However, the MNL model suffers from problems of lack of independence of irrelevant alternatives (IIA), which states that the ratio of the probabilities of choosing any two alternatives is independent of the attributes of any other alternative in the choice set (Creel, 2002).

Empirical specification of the Model (MNL)

Following Greene (2002) the general form of the multinomial logit model for this study was justified according to the following equations:

- Let **y** denote a random variable taking on the values {1, 2, . . .j} for choices j, is positive
- Let x denotes a set of conditioning variables

In this case, **y** representing the adaptation measures chosen by any farming household in the study area. Assume that each farmer faces a place of discrete, mutually exclusive choices of adaptation choices. Accordingly, a person chooses exactly one of the strategies and these measures are assumed to depend on factors of **x**. Therefore, **x** represents a number of climate elements, environmental and socioeconomics of households and other factors.

The question here is how changes in the elements of **x** affect the response probabilities;

P(y = j/x), j = 1,2, . . . j

Since the probabilities must sum to unity, p(y=j/x) is determined once with the probabilities for

j = 2, . . . j.

Let x be a 1xK vector with first element unity.

The multinomial logit model has a response probabilities:

$$P(y = j / X) = \frac{\exp(x\beta_j)}{1 + \sum_{k=1}^{J} \exp(x\beta_k)}, \quad j = 1,\ldots, J$$

Where *B*j is Kx1, j ==1 . . . . , ji

The marginal effects or marginal probabilities are functions of the probability itself and measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from the mean (Tazeze, 2012).

Variables included in the model

The dependent variables included in the model are those adaptation strategies that were selected by respondent farm households of the study area to reduce possible negative impacts of climate change. Independent explanatory variables are household characteristics and resources of the household that assumed to have most association with adaptation strategies of the household.

i. Dependent variables (Adaptation strategies)

Climate Change National Adaptation Program of Action (NAPA) of Ethiopia has identified 37 potential adaptation options for Ethiopia (NMA, 2007). But for this study, adaptation options (dependent variables) were obtained from the smallholder farmers through survey questions, information obtained from agricultural research centers, agricultural development offices and literatures.

The variables includes; off-farm work that the households engaged to get additional income out of agricultural activities, changing crop variety (using some of improved varieties released from agricultural research centers), changing crop technique/calendar (changing time of cultivation, harvesting and etc.), soil management and conservation (help for maintaining productivity of land, which otherwise would deteriorate due to erosion and other land degradation factors) credit services (to capacitate farm households so that they can adopt available agricultural technologies), crop diversification (dividing land into different plots to grow different crops to spread crop failure risks), government assistances (support provided by government), agro-forestry (plantation of trees important for soil and water conservation and sources of income) and irrigation (to supplement rain-fed crop production system) options.

ii. Independent (Explanatory) variables

Different natural, socioeconomic, social, political, institutional and household characteristics are some of the factors influence farmers' preferences and ability to implement adaptation options to climate change. The explanatory variables from the survey data was; sex (being male or female), age (number of years), education level (grade of learning in the school) of the household head, family size (number of people in a household), land holding size (area of land in hectare per household) and occupation (profession) of the household head were found to be statistically significant.

CHAPTER FIVE

RESULT AND DISCUSSION

5.1. Household Characteristics

i. Age of Household Head

The survey result indicated that the age of household head in the study area fall in the age range of 21-78 years old with average of 39.3 years and standard deviation of (12.5) most of them about 91% are male headed and the rest 9% households are female headed. It is assumed as old age associated with more experience and it is expected that older farmers make more adaptation strategies to climate change compared to younger ones that have lower farming experiences.

The age proportion of the family members in the study area was; children less than 14 years are 49.11 %, people with the age range in 15-64 years (usually active labor forces) are 49.04 % and above 64 years old are 1.85 %. This proportion of age indicates that nearly half of the population was in the working age and the other 50% are dependent on the rest of the family members, child less than 14 years and the old above 64 (Table 2).

Table 2: The age structure of the family in the households

NO.	Age category	Number of people in the households	Percentage
1	Children less than 14 years old in the family	716	49.11
2	People in the age range of 15 to 64 years	715	49.04
3	Household member above 64 years old	27	1.85
4	**Total**	**1458**	**100**

Source: Computed from own survey data (2013)

ii. Educational Level of Household Head

Education is one of the most important factors influencing decision of farmers to carry out adaptation options to climate change. Majority of the farm households in the study area fall in primary education level including read and write (66%), no formal school (10%) secondary education (21%) while only (3%) of household heads have completed secondary education (Table 3).

Table 3: Education Level of Household Heads

Variable	Number of household heads	Percentage
No formal school	23	10
Primary education and read &write	153	66
Some secondary education	50	21
Post secondary education	7	3
Total	**233**	**100**

Source: Computed from own survey data (2013)

iii. Family Size of the Household

The farm households have small land holding, an average of 2 hectare per household. This could be from high population growth rate with fixed area of land. Population pressure, therefore, increased over exploitation of the land and natural resources in the area. The family size of the sampled households varies from 1 to 20 with the average of 6.3, which is above the Ethiopian national average family size of 5 persons per household (CSA, 2002). Generally, the basic socioeconomic characteristics of the population in the study area are summarized with mean and standard deviation in (Table 4).

Table 4: Basic characteristics of interviewed the households

Variable	Mean	Standard Deviation (SD)
Age of the household head	39.39	(12.49)
Years of education	3.82	(3.44)
Size of household family	6.26	(3.16)
Gender of household (1=male, 0=female)	0.91	(0.33)

Source: Computed from own survey data (2013)

iv. Resource Ownership

The major natural resources and important asset of the household is land for crop production and livestock grazing. The size of land also used as indicator of household's wealth in the community. However, the land holding size is getting low due to high rate of population growth. The average area of land holding for Adama and ATJK districts are 2.10 and 2.16 hectare respectively. Farm households generally own the land area varies from 0.25 to 10 hectare, of which 88% (0.2 to 9.5 ha) cultivated, 0.55% fallow, 2.62% grazing and the remaining 8.88% is used as homestead land (Table 5). This indicates all farm households are smallholder and none of the households have more than 10 hectare in both districts.

Being the households are owners of small land size, farmers forced to cultivate maize as mono-cropping techniques, farming practices of replanting a single crop year after year on the same plot of land. Literatures argue that mono-cropping can damage the soil ecology through depletion and reduction of diversity of soil nutrients. However, teff, haricot beans and sorghum are some of important crops usually cultivated in the area and also used as crop rotation by few farm households.

Though the role of maize takes the main concern for domestic food consumption, it is also use as cash crop for majority of households in the area. Some of households sell expected surplus or when they are certain that the next crop will give high yield as a major source of income. In Adama district, about 77% of income for the household was generated from maize, and Adami Tullu Jiddo Kombolcha district close to 68% of family income obtained from sale of cultivated maize. Its high value as a cash crop is due to its increased nation-wide demand, as well as higher prices offered for other food crop like teff and beans. Furthermore, some of households prefer storing the yield for a long time as means of saving for risk management measure in case of low production in the following crop season.

Table 5: Land use of the household

Land use	Area (ha)	Percentage
Cultivated land	443.63	87.96
Fallow land	2.75	0.55
Grazing	13.19	2.62
Homestead	44.81	8.88
Total land owned	**504.38**	**100.00**

Source: Computed from own survey (2013)

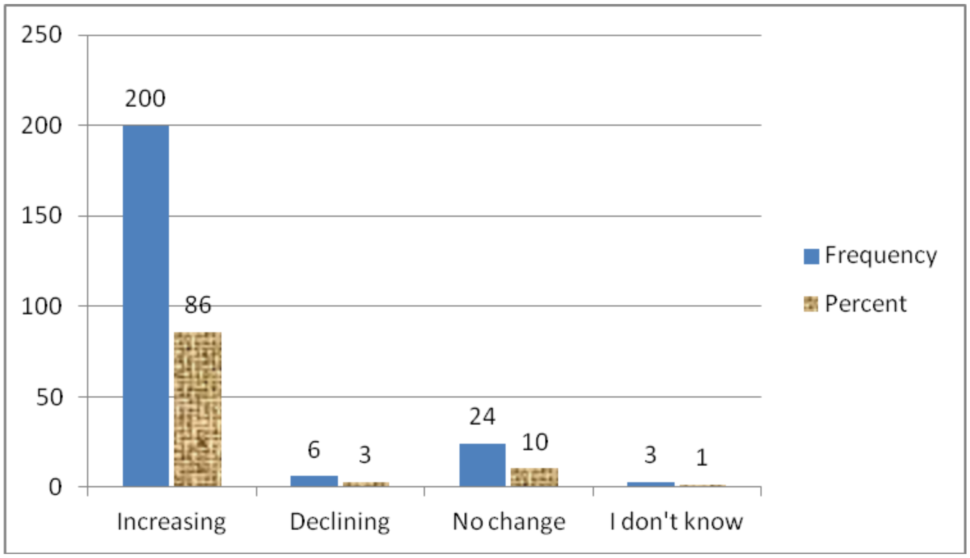
5.2. Perception of Farmers on Climate Change

Perception of smallholder farm households of climate change is the starting point for attempting local adaptation strategies to reduce possible harmful impacts. Smallholder maize growers have been affected by climate change in one or the other ways. Based on perception level, socioeconomic and demographic factors households employ different adaptation strategies wcich they considered appropriate to reduce adverse impacts.

As the survey result indicates, farm households with different magnitude of knowledge are employing various adaptation strategies individually and as a community. Interviewed households have observation of climate change in terms of increasing in temperature and rain fall intensity and variability for the last ten years. Accordingly, 86%, 3% and 10% of farmers have noticed as change in the average temperature is increasing, decreasing and no change respectively. However, 1% of them have thought as there is no change in temperature in their surrounding areas (Figure 5). This indicates that the farm households in the study area perceived the reality of climate change.

The implication of the large numbers of households having awareness on increasing of temperature in the study area, was similar with the argument made by Jarraud (2011) which confirmed that over the last ten years from 2001 to 2010, the global temperature have increased on average by 0.46 ^{o}C above the 1961-1990 global average temperature.

Figure 6: Household perception on the changes of temperature (percentage)

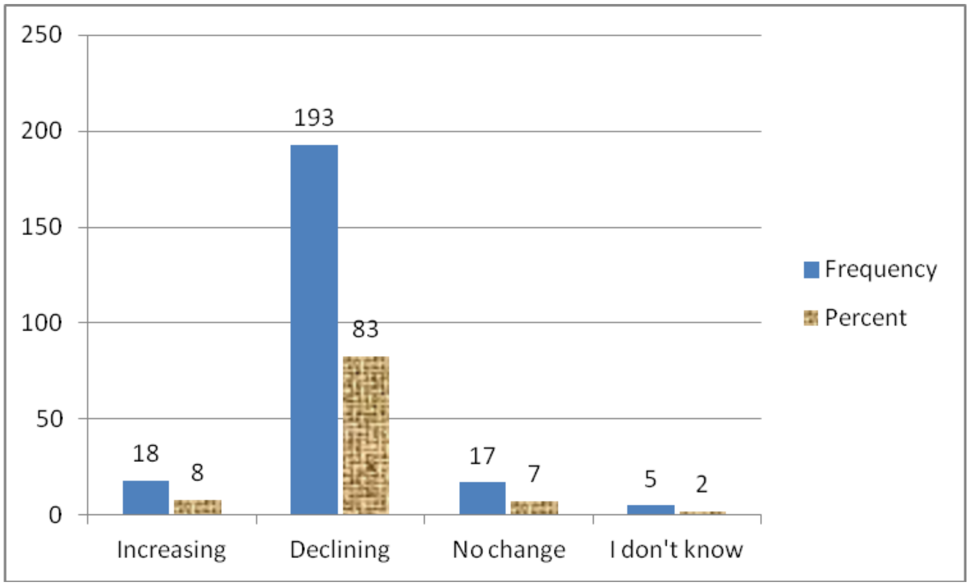


Source: Computed from own survey result (2013)

The response for the variability of rainfall (precipitation) level also indicates that 82.8%, 7.7%, and 7.3% of selected farmers also perceived decreasing, increasing and no changes on the level of precipitation respectively. On the other hand, 2.1% of selected farmers answered they do not know whether there is change in precipitation or not (Figure 7). Generally, majority of the households have better perception on climate change in terms of both temperature and rainfall variability. The study indicates that farmers perceived as there are increasing in temperature and a decrease in precipitation in the Ethiopian central rift valley.

This is true from some literatures that the two most important direct agricultural inputs of climate change variables in Ethiopia was becoming dynamic and unpredictable. Example, the National Meteorological Service of Ethiopia (NMA, 2007) showed that the average annual minimum temperature over the country has been increasing by about 0.25 ^{0}C every century and average annual maximum temperature has been increasing by 0.1 ^{0}C every ten years. Then, the rise in temperature and reduction and variability of precipitation level of the rainfall could be resulted in a negative impact of maize production and the livelihoods of the households.

Figure 7: Household perception on the changes of rainfall (percentage)

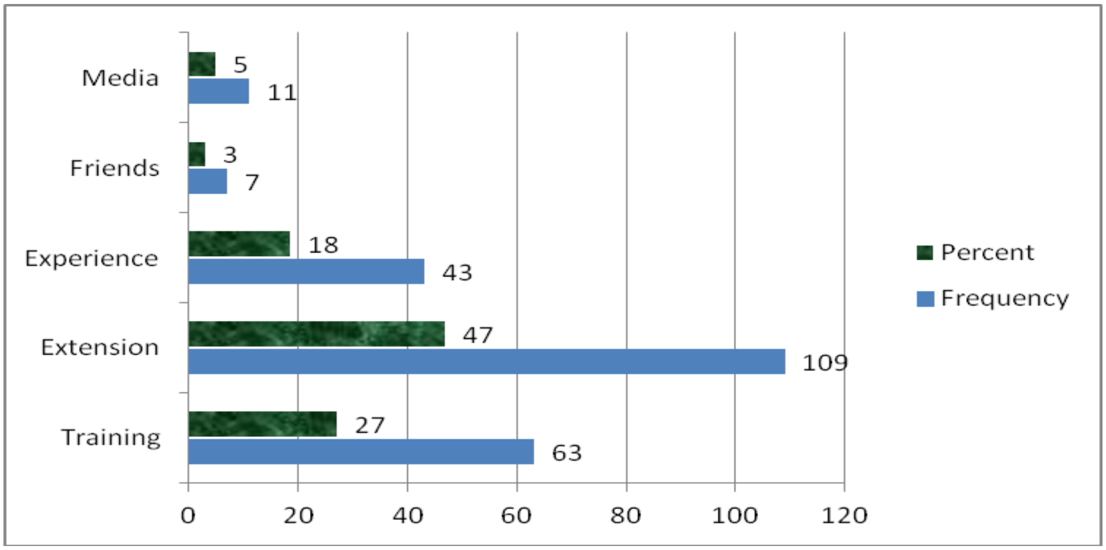


Source: Computed from own survey result (2013)

Household sources of information

Households get information on climate change and adaptation options from different sources for farm-level decisions. The result (Figure 8) shows that major source of information to households are extension workers (47%) and training provided by different stakeholders (agricultural offices, research centers, NGOs and others) 27%. Farmers also promote to employ adaptation strategies from own experience (18%) and the rest 3% get information from their friends or neighborhood farmers. Media such as television, local FM and national broadcasting radio programs play role a source of information for 5% of interviewed households.

Figure 8: Household's main sources of information regarding climate change

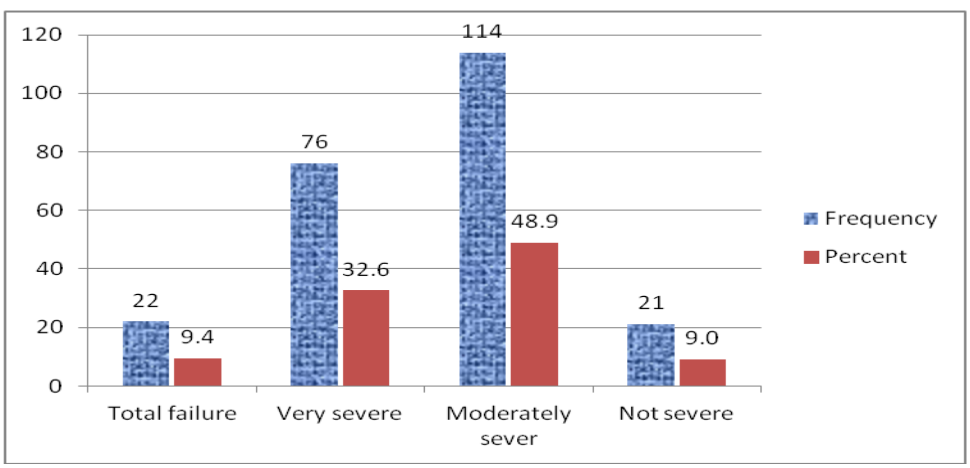


Source: Computed from own survey result (2013)

Perception on impacts of climate change

Majority of farm households have awareness on the level of maize yield failure due to climate change from their personal observation for the last ten years. The levels of perception of farmers have different ratios in terms of the severity of crop failure. Accordingly, 9.4% total failure, 32.6% vey sever, 48.9% moderately sever the rest 9% not sever of the yield failure as the impacts of climate change on productivity of maize (Figure 9).

Figure 9: Impact of climate change on maize farmers



Source: Computed from own survey result (2013)

5.3. Prioritized Adaptation Strategies by Farmers

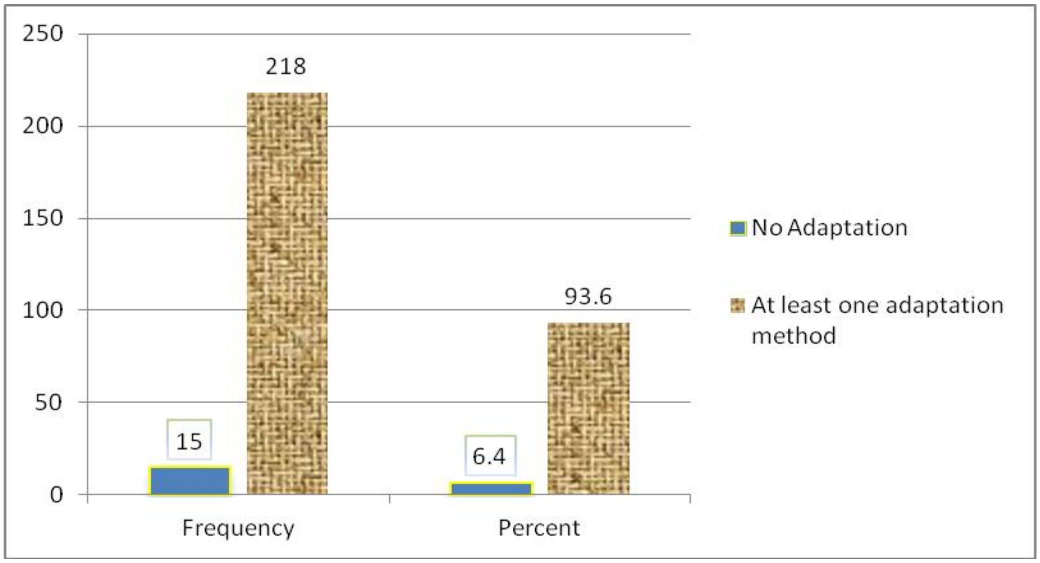
Various adaptation strategies have been employed by smallholder maize growing farmers in the central rift valley of Ethiopia. Some of usual adaptation strategies used by farmers are evaluated in this study.

Farm households have employed adaptation strategies that enable to improve their livelihoods through diversification of sources of income and changing farming practices with utilization of improved agricultural technologies. As the survey result indicates, majority of interviewed farmers are dependent on rain-fed agriculture and had not yet employed irrigation system for maize production.

The level and types of adaptation strategies were affected by economic resources and demographic factors of the households including age and educational level of household head, occupation of the household head, size of land, family size and ownership of livestock. In fact, most of adaptation strategies reported by households are not exactly come from the cause of climate change, but for improvement of yield of the crops. However, it is assumed that the experiences of farmers are driven from climate change factors, just as confirmed on the study by Maddison (2006).

In general, 93.6% of interviewed farm households have employed one or more adaptation strategies to climate change in their farming practices (Figure 10). However, the rest few farm households (6.4%) have not yet employed any adaptation options assuming that climate change is a concern of supernatural forces. They are assumed as reluctant to use agricultural technologies rather than praying for supernatural forces as an alternative to cope with the impact of climate change.

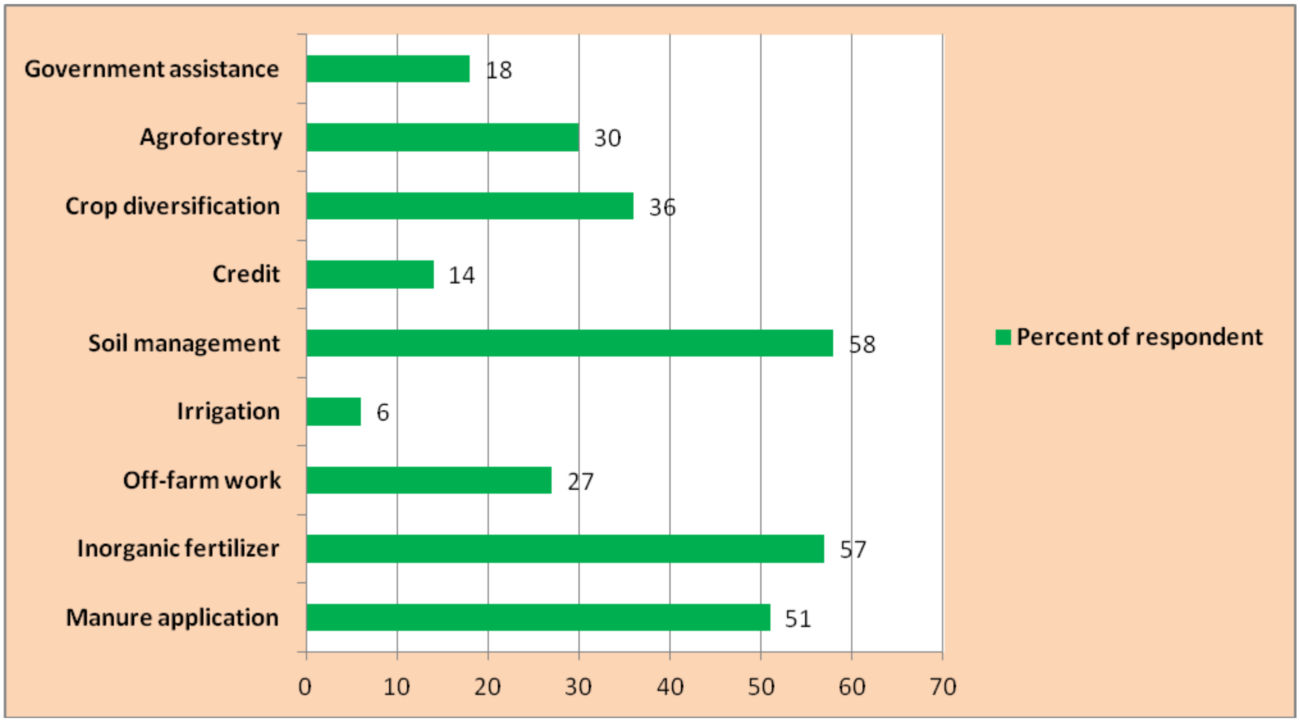
Figure 10: Ratio of Households employed adaptation options



Source: Computed from own survey result (2013)

Understanding of adaptation options by smallholder farmers help to identify and employ appropriate and feasible adaptation strategies of local specific and farm-level methods in the long-run based on their perception on climate change. That means local level adaptation analysis contributes to create more sustainable and equitable production environment. Major adaptation strategies prioritized in the area includes; application of synthetic fertilizer, manure, use of improved seed, off-farm works, soil management and conservation, crop diversification, irrigation (for horticultural crops), agro-forestry, credit and government assistance with different magnitudes (Figure 11 and table 6).

Figure 11: Major adaptation strategies of households



Source: Computed from own survey result (2013)

As indicated in figure 11, soil conservation and management is the most prioritized adaptation strategy of the households (58%), while irrigation is the least option used from identified adaptation strategies in the central rift valley of Ethiopia. The use of soil conservation with majority of farm households could be interrelated with the promotion and attention recently given by government at national and regional level to meet the Ethiopian ambitious climate resilient green economy in the Growth and Transformation Program. The lowest level of use of irrigation for adaptation in the area could be associated with limited access of water and suitable land by smallholder farmers.

Table 6: Households' adaptation strategies to climate change

No. Adaptation strategies	Number of household	Percentage (%)
1. Manure application		
Yes	119	51
No	114	49
2. Inorganic fertilizer		
Yes	132	57
No	101	43
3. Off-farm works		
Yes	64	27
No	169	73
4. Irrigation		
Yes	13	6
No	220	94
5. Soil management		
Yes	136	58
No	97	42
6. Credit		
Yes	32	14
No	201	86
7. Crop diversification		
Yes	84	36
No	149	64
8. Agro forestry		
Yes	71	30
No	162	70
9. Government assistance		
Yes	42	18
No	191	82
Total	**233**	**100**

Source: Computed from own survey data (2013)

5.3.1 Manure Application

As the summary indicated in table 6, about half of the interviewed farmers (51%) prefer manure application for maize production instead of the synthetic fertilizers. The reasons why farmers favor to use manure is easily availability and cheaper price than synthetic fertilizers. Practically all synthetic fertilizer used in Ethiopia has been limited to Di-Ammonium (DAP) and urea. Use of manure as opposed to relying on synthetic fertilizer enhances agro-ecosystem and increases organic matters that allow soil to capture and retain more water. Application of manure to the soil in turn reduces vulnerability to climate change extremes such as floods and to regulate soil erosion. Livestock is also the main sources of manure for smallholder farmers from mixed crop-livestock agricultural system. Livestock provides not only milk and meat, but also manure that can improve soil fertility. This can be considered as a best option of the types of linked strategies that fit well smallholder production system (Mowo, *et al.*, 2010).

5.3.2 Inorganic Fertilizer

Inorganic fertilizer is a type of crop production inputs widely used in agricultural sector to increase yield when applied with full recommendation given by soil researchers. As seen in table 6, about 57% of interviewed farm households use synthetic fertilizer to improve their adaptive capacity through increasing marginal productivity of land in terms of maize yield. Improvement of maize yield by inorganic fertilizer could be again resulted from increasing of essential macro-nutrient (nitrogen and phosphorous) to the cultivable soil.

But contrary to manure, chemical fertilizers are potential cost to the GHG emission of CO_2 (IPCC, 2011). Synthetic fertilizers used by farmers in the study area are urea and DAP, farmers using such fertilizer are claiming against increasing dependency on expensive external input since the soil is adapted to it and unaffordable price. Furthermore, farmers are claiming use of synthetic fertilizer for the yield getting decreasing because of similar rate they are using without consideration of soil change over time.

5.3.3. Off-farm Income

The sources of income of the households come either from farm or non-farm or both activities. Off-farm work would be a better income diversification option for households of climate-vulnerable agricultural producers. However, most manufacturing industries having higher labor demands are available in towns far away from the villages of farm household is often costly and may require temporary migration of the family member from rural to be employed, thereby removing their contribution to the farm (Ivanic, 2008).

Therefore, non-farm income in addition to farm income can increase the likelihood of households' use more of adaptation strategies to climate change. In the study area, the most important off-farm activities include petty trading (trading of livestock and grain), wage income and own business income (e.g., cart driving), being employed by large scale public and private farms in the area (such as sugar factory for Adama and floriculture for Adam Tullu Jiddo Kombolcha) are some of potential sources of income for the households.

5.3.4. Irrigation

Access of irrigation scheme in crop production can reduce dependence of farm households on rain-fed agriculture decreasing the adverse impacts of climate change. Though climate change affects water resource, studies (Krishana, 2011; Nyanga *et al.*, 2011) confirmed that crop production with irrigation is positively affected by climate change than rain-fed agriculture if there is sustainable available water and suitable land. In both Adama and Adam Tullu Jiddo Kombolcha districts no one of smallholder farmers often used irrigation for maize production. However, irrigation is widely used in the central rift valley of Ethiopia for horticultural crop production. In this case only 6% of interviewed farmers have employed of irrigation as a potential adaptation option to climate change.

5.3.5. Soil Management and Conservation

Loss of fertility of the soil is a great challenge of farmers in crop production of the central rift valley of Ethiopia. Therefore, soil management and conservation is one of identified adaptation options for climate change. Such soil conservation and management strategies particularly in countries like Ethiopia have vital importance to withstand climate change associated problems of erratic rainfall and soil degradation (NMA, 2007). As the survey result indicates, about 58% of selected households were employed soil management and conservation practices as adaptation option individually and jointly with the society. Actually, in recent time, soil and water conservation has got high consideration and priority by the Ethiopian government in its growth and transformation plan.

5.3.6. Credit

Majority of farm households in the study area have low income and thus, have few or no saving tradition. Therefore, they could be forced to seek credit from better-off persons, or formal and informal credit sectors during crop failure due to climate change. They also require credit to purchase inputs for maize production such as improved seed of maize varieties, chemical, fertilizers and others. Majority of farm households in the study area are not familiar with saving and access to formal credit services. Farm households are usually getting informal credit services from friends and better-off farmers in their neighborhoods. Whereas, few of them are access to formal credit from micro financial sectors like Oromiya Credit and Saving Association through organizing themselves as a collateral one for the other households. It needs policy intervention which enables individual households to get credit for employment of farm-level adaptation strategies.

5.3.7. Crop Diversification

Family labor and farm land are the two most important diversification opportunities of smallholder farm households. Crop diversification in terms of mixed cropping system is one of identified potential farm level adaptation options to climate change and variability in the study area. However, only 36% of respondent farmers moved towards crop diversification through production of vegetables and other horticultural crops on different plots of land. Furthermore, the households' farming system was characterized by mono-cropping farming pattern with dominant of maize cultivation.

The reason for less practice of crop diversification by the households would not only from their farming preferences but also from limited land size to cultivate different annual and perennial crops. This requires policy resolution through voluntary resettlement of landless farm households and family having large members to move other area where extra land is available and ready for farming within the region. This policy option helps to ease population pressure on the land and environment. Though Ethiopia has a long experience on resettlement, its implementation needs further cost-benefit analysis and possible impacts on the community and natural resources.

5.3.8. Agro Forestry

There are numerous households farming practices that can contribute to both a private benefit (adaptation to climate change) and a public good (mitigation of greenhouse gases). Agro-forestry, plantation of trees as agricultural crops is one of such prominent practices encouraged by policy makers and environmentalists. On one hand, agro-forestry play a vital role in mitigating climate change by reducing atmospheric accumulation of green house gas (GHG) through its capacity of carbon sequestration (Louis. *et al.,* 2007). On the other hand, it helps smallholder farmers adapting to climate change through changing unproductive marginal land to productive that can generate additional income. However, in this study only 15% of interviewed households have employed agro-forestry in the study area. This is due to small land size which is occupied for maize production and limited knowledge of efficient land management which needs policy intervention in appropriate land use management.

5.3.9. Government Assistance

Smallholder farm households usually rely on traditional risk sharing mechanisms of local social institutions such as (idir), borrowing from relatives and better-off individuals, "iqub" and other social networks. But, when adverse weather events affect the whole society and severe crop failure happens, government subsidy is required. In the study area, even though there are no food aid dependent households, 18% of respondents were still highly vulnerable to climate change and they are in need of government aid for climate change related effects (for example as safety net program in Adami Tullu Jiddo Kombolcha district). The rest 82% of interviewed households use different adaptation options to climate change rather than relied on government aid and assistance.

5.4. Determinants of Adaptation Options to Climate Change

Adaptations to climate change do not necessarily changed into end result, since the strategies can be affected by other biophysical and social barriers (IPCC, 2007). Adaptation options based on indigenous knowledge of farmers incorporated with modern technologies are essential to create appropriate and applicable policies which enable the society to reduce adverse effects of climate change. Adaptation choices of farm households are affected by various socioeconomic and demographic factors. In this subsection therefore, estimation results of Multinomial Logit (MNL) model on major determinant factors of farm-level adaptation strategies that are statistically significant at 5% and better was discussed.

5.4.1. Overall Performance of the Model

Multinomial logit model specification was used by different researchers (e.g. Deressa *et al.*, 2009; Tazeze *et al.*, 2012) to model adaptation options to climate change on smallholder farmers. The independence of irrelevant alternatives (IIA) assumption needs that the probability of using a certain adaptation method by a given household is independent from the probability of choosing another adaptation option. In this study for specification of the model, it was tested for the validity of IIA assumptions using Hausman's test with STATA software computer program. Finally, the test was failed to reject the null hypothesis of independence of adaptation methods to climate change. This implies that the model specification is appropriate to model adaptation options to climate change of smallholder farmers in the central rift valley of Ethiopia.

Before running the model for analysis, existence of multicollinearity was checked by using Variance Inflation Factors (VIF) to taste associations of continuous explanatory variables and contingency coefficients for the dummy variables. As Gujarati (2003), if the value of VIF is above 10, there is a multicollinearity problem. Whereas in this study, the variables' VIF were less than 10 (in the range of 1.010 to 1.834) confirmed the absence of multicolinearity (Appendix 2a). Contingency coefficient also computed for dummy variables with SPSS from chi-square values and no strong association among explanatory variables (Appendix 2b). Therefore, in this case multicollinearity is not a problem in the estimation of the model as they are treated independently. The outliers were also checked through computation of SPSS but no variables whose values differ substantially from the other observations that can distort estimation of regression coefficients.

As a result, most of the hypothesized explanatory variables were included in the model except livestock ownership which was dropped because of its statistically insignificant. The estimation coefficients of the model, standard error and their level of significances are presented in table 7. The variables that are statistically significant at less than 5% probability levels of significant are discussed.

The result of analysis of the study shows that age, sex, occupation and education of the household head, size of household family and total land size of the household have significant impact with different magnitude, at least on one of farm-level adaptation options by smallholder farmers. The coefficients represent impacts of each explanatory variable on the ratio of the probability households to employ an adaptation method relative to the probability of no adaptation.

The overall performance of the fit measure of the model were checked and validated to confirm as the model fits the data. Accordingly, computation of SPSS (v.16) output indicated that; the log likelihood ratio test statistics exceeds the Chi-square critical value at less than 1% probability level. This implies that the null (all coefficients are zero) hypothesis was rejected. The value of the Pearson Chi-square tastes also show that the overall appropriateness of fit of the model at less than 1% level of significance. This shows the strong explanatory power of the model (Table 7). Adaptation options or response probabilities used for this study are; no adaptation, off-farm work, crop variety change, crop cultivation technique, soil conservation, credit, crop diversification, agro forestry, synthetic fertilizer application and use of manure.

Table 7: Parameter estimates of the multinomial logit model for adaptation decision

Explanatory	Off-farm			Variety change			Technique/calendar			Soil cons.			Credit			Diversification			Agro-forestry			Fertilizer			Manure		
Variable	Coef.	S.E	P-value	Coef.	S.E	P-value	Coef.	S.E	P-value	Coef.	S.E	P-value	Coef.	S.E	P-value	Coef.	S.E	P-value	Coef.	S.E	P-value	Coef.	S.E	P-value	Coef.	S.E	P-value
Sex	.529	.517	.307	.886	.443	.045	-.534	.444	.001	-.354	.420	.399	.369	.591	.532	-.112	.554	.045	-.784	.528	.137	-.706	.444	.112	-.636	.453	.160
Age	.011	.013	.398	-.019	.012	.117	-.008	.013	.501	-.007	.012	.567	.039	.017	.019	-.010	.013	.458	.001	.013	.924	-.021	.012	.085	-.018	.012	.140
Education	.029	.020	.146	-.032	.019	.097	.053	.021	.013	-.019	.018	.266	.017	.028	.531	-.048	.023	.039	.016	.018	.394	-.020	.018	.259	-.060	.024	.011
Occupation	.712	.282	.012	.307	.259	.235	.005	.247	.985	.467	.018	.143	.502	.252	.047	.437	.023	.069	.024	.018	.927	.094	.909	.998	.080	.234	.732
Family size	.004	.056	.042	.128	.054	.017	.023	.053	.659	.016	.049	.748	.127	.067	.056	.073	.052	.159	-.011	.052	.028	.007	.050	.883	.022	.050	.660
Land size	-.336	.158	.040	.019	.117	.873	-.023	.119	.849	.036	.113	.750	-.147	.940	.363	.238	.123	.013	.087	.118	.461	.255	.123	.038	.206	.117	.033

Diagnostic

Base category = No adaptation

Number of observation = 233

LR Chi square (52) = 221.475

Pseudo R_ square = 0.631

Log Likelihood = 273.941

Prob. > Chi square = 0.0000;

(*, **, ***, Significant at 1%, 5%, and 10% respectively)

Source: Computed from own data (2013)

5.4.2 Explanatory Variables

The study confirmed that adaptation options to climate change of the households are associated with their socioeconomic, family and institutional characters that mutually determine the ways in which the household come to a decision to choose or not the strategy.

Table 8: Description of independent variables

Explanatory variable	Mean	Standard deviation
Age of household head	39.27	12.5
Education of the household head	4.11	8.7
Household size	6.26	3.1
Gender of the household head (1=male, 0=female)	0.87	0.3
Farm size of the household	2.04	1.9
Livestock ownership (TLU)	4.31	3.6
Main occupation of the household head (1=farming, 2=employed, 3=business)	1.32	0.6

i. Sex of Household Head

Gender of the household head (being male) was significantly and positively associated with three adaptation strategies; change in crop variety, change in farming techniques like adjusting planting dates (calendar) and crop diversification at 5%, 1% and 5% significant level respectively. Being male-headed household have better likely for access to new crop varieties and accept diversifying crops with risk taking than that of female-headed household due to traditional matters which limits the social interaction of female and awareness on new agricultural technologies. This finding is agreed with the study by Admassie (2004), male-headed households are more likely to get information about new agricultural technologies and also carry out risky business than female-headed. Likewise, Deressa *et al.* (2010) revealed that male headed households can affect the household's capacity to cope with diverse impacts of climate change in their local areas.

ii. Age of the household head

Age of household head, the number of years of the household head can correspond to farming experiences of the family which could affect adaptation strategies to climate change. In this study, age of household heads was associated positively and significantly with credit services. This could be because of the older household head have better social net works which enables them to have more relatives and resources to be used as collateral to get credit services. This is because, in the study area and also nationally, only organized groups of people are able to get credit services from micro finances.

However, age is negatively and significantly affects fertilizer application. Fertilizer application is a modernization symptom leads aged people to hesitate about the new technology while younger household heads more prefer the new technological inputs.

iii. Education Level of the Household Head

Level of education is the number of years spent by the household head and acquired grade of classes attained. Education has a positive and significant relationship with most of dependent variables; off-farm works, changes of farming technique, and manure application at 5%, 5% and 1% significant level respectively. The relationship shows that education increases the likelihoods of adaptation capacity of households to the adverse impacts of climate change. Educated farmers have better access to information to get more opportunities of adaptation methods. This result has conformity with other empirical evidences. Tazez (2012), for example, revealed that educated farmers are more likely to respond to climate change through employing best adaptation strategies based on their knowledge and motivation to accept new agricultural technologies. Similarly the study by Maddison (2006) revealed that education of the household head increases the likelihoods of adaptation to climate change.

iv. Occupation of the Household Head

In Ethiopia, where agricultural production is main source of income, risks that comes from socioeconomic and climate change necessitates diversification of occupation for the smallholder farm households across different farm activities and non-farm works. However, majority of farmers in the study area are principally engaged on farming and few of them have additional job opportunities besides their farming practices. It is expected that households with additional profession can diversify their income and increase their capacity to do more adaptation options. Accordingly, having other profession has a positive and significant effect on adaptation methods including off-farm work and credit similarly at 5% of level of significance. Although the dominant activity of the area is mixed farming (crop-livestock), households have a tendency to diversify to other occupation through other family members who are in active labor force to non-farm works including wage employment, handcrafts, petty trading, cart driving, being employed as a government employee and others.

v. Land Holding Size

Farm (land) size of the household is significantly associated with different types of adaptation strategies of the households. Hence, land holding negatively affects off-farm work as an adaptation strategy at 5% level of significant. However, it is positively associated with crop diversification and manure application at 5% and 10% level of significant respectively.

The negative relationship of land size with off-farm work explains the fact that households having large farm size prefer to cultivate their own land instead of looking for other off-farm works. Households with small size of cultivable land seek other means of income generating jobs such as (off-farm work) to cope with the impact of climate change. On the other hand, households with larger size of land take risk to diversify different types of crops they grow and encouraged to apply manure to increase productivity of their plots of land and also to increase yield.

vi. Household Size

Household size is significantly associated with some adaptation strategies from more access of family labor. In this study also household family size have positive and significant relation with off-farm work, crop variety change and agro-forestry at statistical significance level of 5% all. By mobilizing active labor force of the family farm households have been employed labor intensive activities like plantation of different seedlings of trees as agro-forestry. These results are similar with some findings of the past researches. For example, the study done by Hassan and Nhemachena (2008) revealed that households having larger family number are expected to have more capacity to do various types of adaptation options than those with small family number.

Usually off-farm work is one of important adaptation options broadly employed by individuals to reduce adverse impact of climate change as far as opportunities accessible in the area. Policy measure needs to access some labor intensive agro-industries which could be employee large number of household members as off-farm work nearby their village.

CHAPTER SIX

CONCLUSION AND POLICY IMPLICATIONS

6.1 Conclusion

In this study, it was started to explore the concept of climate change through identification of perception, adaptation strategies and determinant factors that influence smallholder farmers to employ some of available adaptation strategies. Majority of smallholder farm households have sufficient observation on climate change in terms of increased in temperature, reduction in volume and unpredictability of rainfall, and also increased frequency of drought in their living areas. This observation is related with literatures that verified global climate change challenges of these days.

Households perceived the existence of climate change have employed different farm-level adaptation strategies against to reduce its adverse impacts on their farming activities. However, some inappropriate farming practices can harm the natural resources and likely to be in turn the case for climate change. This interdependence indicates the existence of two ways relationship between smallholder farming system and climate change. On one hand, smallholder farmers are potential causes of the climate change and on the other hand they are vulnerable for the impact of climate change. This relation shows the importance of simultaneous application of adaptation and mitigation strategies through integration of indigenous knowledge of farmers and improved agricultural technologies with bottom-up approaches.

The reality of communities being affected collectively to climate change calls for joint actions of coping strategies. However, the existing responses of farmers are based on individual households' interests with autonomous and uncoordinated approaches. The sources for differences of adaptation strategies come from varieties of determinant factors that influence households' choices.

In this study, the most important identified determinant factors of households to employ adaptation strategies to climate change include; gender, age, educational level and occupation of the household heads and also family size and land holding size of the households. This is therefore an indication of the need of urgent and appropriate policy intervention to organize and coordinate existing responses for sustainability of environment and betterment of the livelihoods of society and future generation.

There are institutions mandated in coordinating and supporting responses of households through providing capital investment of infrastructures, awareness creations, improved agricultural technologies, credit services, and other important logistics to improve adaptive capacity. But still they are reacting in top-down approaches and thus failed to bring the required change and results for climate change impacts.

Existing research findings and recommendations are still could not solved the backward traditional farming system of smallholder farmers with changing climate. Maize growing smallholder households in the central rift valley of Ethiopia for instance are still using uniform recommendation rate of fertilizers and only two types (Urea and DAP) over the years. But the soil character is changing from climate variability indicate the need of updated soil based test fertilizer recommendation and use of other important types of fertilizers fit existing soil conditions.

Population pressure on the area is also one of the problems of the society and environment which reduces income and per household farm size. Land holding size of the study area was still small, an average of 2 hectare per household whereas family size is large with an average of 6.3 per household which is greater than the national average family size of Ethiopia (5 persons per household). This indicates as the number of family member increased, household farm size is reduced and this in turn resulted in higher population pressure on the land and environment. In this case farm households are in need of extra land such as grazing, marginal land and forest plots diminishing natural vegetation cover, soil quality and water resources leading to environmental degradation which could be a cause for climate change.

Multinomial logistic (MNL) regression analysis was used to determine factors that influence households' adaptation strategies to climate change. The result of analysis reveals that; education level, age and gender of the household head, family size, land holding size and access to information have a significant and positive effect on decision of households to employ various adaptation strategies to climate change.

6.2. Policy Implications

Policy interventions in the climate change response should focus on application of both mitigation and adaptation options through strengthening public and households capacities to reduce negative impacts. Public investments on planned adaptations such as irrigation, voluntary resettlement and agricultural extension need to focus not only on methodologies of execution but also social perspectives like promoting perception of smallholder farm households. Family size of the household needs policy intervention in terms of family planning to reduce population pressure on the natural resources such as land, water and environment.

The livelihoods of smallholder farm households are dependent on rain-fed agriculture and highly vulnerable to climate change impacts especially during crop failure from weather conditions. This is because of the absence of adequate saving and insurance facilities at shocking time. Saving for majority of households is difficult from their subsistence life system. Therefore, government should encourage them to save at the time of excess production in good weather time through providing financial centers and awareness creation about savings. In the absence of saving, credit facilities should be accessible to households through relaxing credit policies in such a ways that individual household able to borrow for purchase of improved agricultural inputs to enhance adaptive capacity to climate change.

Crop failure due to climate change is another challenge of the smallholder households of the central rift valley of Ethiopia leads the household government aid dependents. Though insurance does not reduce the real economic damages come from climate change, for instant adverse impact crop failure insurance is required. Therefore, establishment of insurances for crop failure should be encouraged through farmers' cooperative as a sustainable policy alternative instead of providing aids after the problem happened.

Meteorological forecasting is another important and modern option to adjust cropping calendar to reduce yield loss from climate change. The existing meteorological stations in Ethiopia are located at national and regional level. The crop calendar of majority of the farm households depends on their traditional experiences without considering of meteorological forecasting. This is because of the absence of local specific meteorological stations, luck of awareness by farmers and inaccuracy of weather forecasting. Therefore, government should establish local specific meteorological forecasting stations, early warning and awareness creation to allow farmers better prepare against harsh weather conditions.

An autonomous and disaggregated reactive adaptation strategy of farmers should be organized and proactive approaches in line with the Ethiopian government's ambition to build the green economy. This can be possible through organizing smallholder farmers be based on group formation with government, NGOs and other developmental organizations (e.g. farmers' research group, model farmers group etc.).

Government should also support smallholder farm households through providing various adult education and training centers. Education related to climate change should not be limited to agricultural extension but also included in the country's formal education curriculum to promote interactions of the generation and to improve household's decision making regarding climate change.

Providing various sources of household income has vital importance to develop adaptation capacities through creation of off-farm employment opportunities in the rural areas. This can be possible through investment on labor-intensive industries in the near-by areas to improve the livelihoods of the households and sustainability of the environment in bottom-up approaches.

6.3. Further Research Area

The question of what impact of adaptation options to climate change on the livelihoods of smallholder farmers is not yet answered. Hence, future research should focus on identifying the economic impacts of adaptation option with base technology and base climate versus future technologies and changed climate scenarios.

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APPENDIX

Appendix 1: Questionnaire

Household Code: _____________

Household survey questionnaire to assess perception, determinants and impact of adaptation options to climate change in tef and maize in selected agro-ecologies

0. Instructions to the enumerator:

A) Make brief introduction to each farmer before starting any questions

The purpose of the survey is to generate data/information on the impact of climate change and the costs and benefits of adaptation options in tef and maize in selected agro-ecologies.

B) Assure him/her that all his/her words will be kept confidential

C) Circle or fill out the questionnaire as appropriate only using the answer given by the respondent

D) Please ask each question so clearly and patiently until the farmer understands

E) Try not to use technical terms while discussing with farmer and don’t forget the local unit

F) Please recheck the questionnaire for any missed or incorrect information before thanking the respondent for his participation

G) Please thank the farmer for his collaboration

spondent and site identification

N0	Identification	
1.1	Date	
1.2	Enumerators name	
1.3	Time started	
1.4	Time finished:	
1.5	Supervisor name	
1.6	Date of supervision	
1.7	Name of the respondent:	
1.8	Phone no *(If any)*	
1.9	District:	
1.10	Peasant association:	
1.12	Agro-ecological zone (AEZ):	
1.13	Altitude	
1.14	GPS co-ordinates:	Longitude:
		Latitude:

2. Household characteristics and demography

2.1 Relation of respondent with household head

1= HH head, 2=Spouse, 3= Relative, 4= Grown up child (=>18 years), 5= other (specify) _______

2.2 Sex of the household head, 0= Female 1= Male

2.3 Age of HH head: ______________ (years)

2.4 Marital status of HH head: 1. Married, 2. Single 3. Divorced 4.Widowed 5.Other

2.5 Education of HH head _______ class (write class in number if 1-10 or 1. Illiterate, 2. TVET, 3. Diploma 4.Degree and above)

2.6 Occupation of HH head: 1= Farming, 2= Employed, 3= Business, 4 = other (specify) _________

Family member by age and educational group

No.	**Age category**	**Total**	**Health**		**Level of education***							
			Active	Inactive	Illiterate	Read & write	Grade 1-8	Above 8-10	10 complete	TVET student/graduate	Diploma	Degree & above
2.7	Number of children up to the age of 14											
2.8	Number of adult females 15-64 years											
2.9	Number of adult males 15-64 years											
2.10	Number of adults beyond 64 years											
2.11	Total family size of the household **(**sum of 2.7, 2.8, 2.9, 2.10**)**											

3. Resource ownership

Total own land area in *timmad* ______________ all the land owned by family /beteseb/.

No.	**Use of the plot during last (2004) Kiremt**	**Plot Size** (Timad)	**Soil quality** 1= Poor 2= Good 3= Very good	**Slope of the plot** 1= Flat 2= Gentle 3= Steep	**Soil type** 1 = Clay, 2 = Loam 3 = Sandy, 4 = Gravel/Stony 5 = Clay-loam 6 = Sandy-loam
3.1.1	Own cultivated				
3.1.2	Owned but share cropped out				
3.1.3	Owned but rented out				
3.1.4	Grazing land				
3.1.5	Left fallow				
3.1.6	Forest (Agro-forestry)				
3.1.7	Home stead area				
3.1.8	Other (specify)				

4. Livestock Enterprise

4.1 Livestock holding and utilization in 2004/05

No.	**Livestock Type**	**Original stock** Meg., 2004	**Stock changes during (Megabit 2004-Yekatit 2005)**						**Number existing now**	**Estimated average price per head now**
			One year ago	Born	Bought	Died	Lost	Sold		
4.1.1	Ox									
4.1.2	Cow									
4.1.3	Calve									
4.1.4	Heifer									
4.1.5	Horse									
4.1.6	Mule									
4.1.7	Camel									
4.1.8	Donkey									
4.1.9	Goat									
4.1.10	Sheep									
4.1.11	Poultry									
4.1.12	Hive (modern)									
4.1.13	Hive (local)									
4.1.14	Other									

4.2. Income from the sales of animal products (Megabit 2004-Yekatit 2005**)**

No.	Type of product	Amount sold	Unit (b)	Ave. price/product
4.2.1	Hides/skins			
4.2.3	Butter/cheese			
4.2.4	Milk/cream			
4.2.5	Dung cakes (kubet)			
4.2.6	Eggs			
4.2.7	Honey			
4.2.8	Other			

(b) Unit, 1 =Kilogram, 2=In number, 3= Liter, 4= 'Chinet', 5= Other (Specify)__________

4.3 Expenditures on livestock for the year (Megabit 2004-Yekatit 2005)

No	Type of expenditure	Cash value (if in kind, give estimated cash value)
4.3.1	Labor for herding	
4.3.2	Feed, including salt	
4.3.3	Veterinary services/medicine	
4.3.4	Transport of animals feed or supplies	
4.3.5	Commission on the sale of animals	
4.3.6	Other (Specify)	

5. Other sources/off-farm incomes (2004/2005)

No.	Type of non-farm income	Average monthly income	Annual income (birr)
5.1	Wage income (daily, monthly etc)		
5.2	Own business income (i.e., total revenue less cost, from all types of own business activities)		
5.3	Transfer (aid) income		
5.4	Remittance		
5.5	Other (if any)		

6. Agricultural implements (amount and costs) last season (2004/2005)

No.	Type of implements	Number of implements				Cost per unit (Birr)=A	Expected years of service=B	Average cost A/B
		Own	Hired	Other	Total			
6.1	Hoe							
6.2	Spade							
6.3	Jamba							
6.4	Shovel							
6.5	MBP							
6.6	Kenber							
6.7	Mofer							
6.8	Water pump							
6.9	Milk churner							
6.10	Crop sheller							
6.11	Sickle							
6.12	Others							

7. **Agricultural inputs and output (**last Kiremt in 2004/05 production)

7.1 Operation cost of the farmer (2004/05)

No.	Activities	* MI		ML		TI		TL	
		Oxen (donkey)	Man/ day	Oxen (donkey)	Man/day	Oxen (donkey)	Man/day	Oxen (donkey)	Man/day
7.1.1	Land clearing								
7.1.2	Ploughing								
7.1.3	Planting								
7.1.4	Manure spreading								
7.1.5	Fertilizer application								
7.1.6	Shilshalo								
7.1.7	Cultivation								
7.1.8	Weeding								
7.1.9	Herbicide application								
7.1.10	Pesticide application								
7.1.11	Harvesting								
7.1.12	Threshing & winnowing								
7.1.13	Transporting								
7.1.13	Other								

*** MI=** Maize improved variety, **ML=** Maize local variety, **TI**= Teff improved, **TL=** Teff local

7.2 Rain-fed crop (*maize and teff*) production and costs

No.	Type of crop and variety (As plot name)	Size of land (timad)	Date planted	Date harvested	Seeds			Fertilizer				Chemical		Manure	
								Urea		DAP					
					Type of improved seed* (**b**)	Quant (kg)	Value (br/kg)	Quant (kg)	Value (br/kg)	Quant (kg)	Value (br/kg)	Quant (Lit)	Value (br/Lit)	Quant (kg)	Value (br/kg)
7.1.1	Maize (improved)														
7.1.2	Maize (local)														
7.1.3	Teff (improved)														
7.1.4	Teff (local)														

***** Put in bracket according to area you have planted in last kiremt (from large to small)

(b) Maize improved variety: Melkasa one = 1, Melkasa two = 2, Melkasa three = 3, Melkasa four = 4, Melkasa five = 5, Melkasa six = 6,

7.3 Average price of wage and draft animals' per day price in the area

No.	Type	Usual working time hr/day	Value (birr)/day
7.3.1	Man/day		
7.3.2	A pair of oxen/day		

7.3.3 Average price for a donkey's load-unload (chinet) birr/qt: ____________________

7.4. Manure perception and application on crop production

7.3.1 Which fertilizer do you prefer more? 1. Inorganic (Urea & DAP) 2. Manure 3. Indifferent

7.3.2 Reason for use of manure: 1. Easily availability 2. Cheap 3. Effectiveness/yield advantage 4. As option of adaptation to CC impact

7.3.3 Sources of manure for your farm 1. Livestock by-product, 2. Crop residue, 3. Green manure, 4. Other

7.3.4 For which crop do you mostly use manure? (Multiple answers is possible) ________

1. Maize (improved) 2. Maize (local) 3. Teff, 4. Beans 5. Sorghum, 6. Vegetables 7. Other (Specify)

7.3.7 Manure application methods: 1. Compost, 2. Direct, 3. Green manure 4. Rhizobia 5. Other

7.3.8 Your intention to use manure over synthetic fertilizer (Urea and DAP) in the future?

1. Increase manure & fertilize simultaneously 2. Increasing manure and decrease fertilizer 3. Decreasing manure and increasing fertilizer, 4. Decrease both

7.4 Income from crop (teff and maize) production (2004/2005)

Long rainfall (Meher) crops	Area (ha)	Planting date	Amount in(kg)			Average selling price/Qt (for the year)
			Harvested	Stored	Sold	
Maize (improved)						
Maize (local)						
Teff (improved)						
Teff (local)						
Crops by irrigation (if any)						
Maize (improved)						
Maize (local)						
Short rain/belg crops (if any)						
Maize (improved)						
Maize (local)						
Teff (improved)						
Teff (local)						

8. Climate change perception and adaptation

8.1. Please indicate whether climate is changing in your locality for the following two indicators.

8.1.1. How is temperature getting in your area for the last ten years? ___,

1. Increasing 2. Declining 3. No change 4. I don't know

If your answer is (1 or 2) starting from when_, (if answer is 3 or 4, skip this question)

8.1.2. How is rainfall changing in your area for the last ten years? ______

1. Increasing 2. Declining 3. No change 4. I don't know

If your answer is (1 or 2) starting from when____ (if answer is 3 or 4, skip this question)

8.2. How is drought cycle in your area?

1. Once in 3 years, 2. Once in 5 years, 3. Once in ten years 4. Undefined 5. Other

8.3. Your average **maize yield** in quintal/qert or hectare over the last ten years (Year in Eth.C)

8.3.1 (Improved) 2000 --------, 2. 2001 ---------, 3. 2002--------, 4. 2003-------, 5. 2004 -

8.3.2 (Local) 2000 --------, 2. 2001 ---------, 3. 2002--------, 4. 2003-------, 5. 2004 -

8.4 Price trends of maize and input of the area

1. Price of inputs and price of maize increase at the same rate
2. Price of input increased more than that of price of maize
3. Price of maize increased more than that of price of inputs
4. No uniform trends

8.5. How maize production now affected by drought/frost, compared to the same over the last 10 years?

1. Yield per hectare (productivity) is better these days than five years before
2. Yield per hectare (productivity) is better five years back than these days
3. No changes in the production level

8.6. What crop growth stage is most sensitive to the above climate risks (multiple answer is possible)

1. Vegetative/early stage 2. Flowering stage 3. Grain filling 4. Maturity stage 5. At all stages

8.7. How severe have been maize crop failure due to the above noted climate risks over the last 10 years? 1. Total failure 2. Very severe 3. Moderately sever, 4. Not severe

8.8. In the last harvesting year (2004/05), how serious was the maize crop failure due to climate change? 1. Very serious 2. Moderate 3. Less serious 4. No change

8.9. Other than the above noted natural hazards, what are the riskiest climate variables during the growing season in your area? (multiple answer is possible)

1. Late onset (forward shifting) 2. Extended dry spells along crops critical growth stages

3. Early cessation (back shifting)   4. Low seasonal amount /total

5. Shortened length of growing season

8.10. Trend of change in rainy season today, compared to the last five years ________

1. Late start these days, compared to one over the last five years
2. Early start these days, compared to one over the last five years   3. No change

8.11. Trend of cessation (end of rainy season) these days, compared to one over the last five years

1. Early cessation date these days, compared to the last five years
2. Extended cessation data these days, compared to the last five years   3. No change

8.12. Maize planting method? 1. Broadcasting   2. Row planting   3. Both

8.13. The usual maize seed rate (kg/qert or timad) ----------------------------------

8.14. What is the likely yield of maize under the climate changed future dates, given the reality of the current climate at your locality. 1. Declining   2)   No change   3) Increasing

8.15. Key constraints of crop production:1. Drought, 2. Floods, 3. Pests 4. Diseases, 5. Soil fertility

Climate change awareness and adaptation strategies employed by the farm household

8.16. Have you done at least one of the adaptation strategies? (1=yes, 0=No), If yes, tick from the ff.

No.	Climate change and adaptation strategies	Tick (√) the strategy you are practicing
1	I do not know the effect of climate change	
2	Affected but do nothing	
3	Off-farm work	
4	Use of irrigation	
5	Changing crop variety	
6	Change in crop technique/calendar	
7	Soil management and conservation	
8	Credit	
9	Crop diversification	
10	Fertilizer application	
11	Government assistance	
12	Farming in other place	
13	Agro-forestry	
14	Inter-cropping	
15	Application of manure	
16	Just praying	
17	Other	

8.17. What are factors to use these adaptation options?
1. Training, 2. Extension works, 3. Experience 4. My friends/neighborhood 5. Media, 6.Other

8.18. Your general observation and comment on the climate changes (if any)?

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Thank You !!!

Appendix 2 Tests of Multicollinearity (VIF and CC)

Appendix 2a: Collinearity statistics (VIF) for the continous explanatory variables

Variable	Age head	Education	Household size	Land size
Age of head	-	1.834	1.197	1.301
Education head	1.182	-	1.015	1.339
Household size	2.127	1.170	-	1.010
Landholding size	1.302	1.231	1.045	-

Appendix 2b: Contingency Coefficient for discrete explanatory variables

Variable	Sex	Occupations
Sex	1.000	0.014
Occupations		1.000

Appendix 3: Livestock resource

	N	Minimum	Maximum	Mean	Std. Deviation
TLU	233	.00	31.42	4.3088	3.59859
Valid N (listwise)	233				

BIOGRAPHIC SKETCH

The author, Teshome Kumela was born on October 1976 in Dariyan Wonchi district of the South-West Shoa Zone of Oromiya Region, Ethiopia. He attended his primary and elementary education in Chebo Wonchi Junior and Secondary School from 1982 to 1994. He also attended high school education at Woliso Dejazmach Geresu Dhuki Secondary School. He joined Jima university (the then Jima Agricultural College) and was awarded a diploma in General Agriculture.

Since 1996 he has been employed by Ethiopian Institute of Agricultural Research as technical assistant at Jima Agricultural Research Center. He again joined Jima University and awarded B.A. in Economics. He is currently an employee of Jima Agricultural Research Center as Researcher in socioeconomics and agricultural research extension department.