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LOCAL-LEVEL ASSESSMENT OF FARMER'S ADAPTIVE CAPACITY TO CLIMATE CHANGE AND VARIABILITY IN LAELAY MYCHEW WOREDA CENTRAL ZONE OF TIGRAY

By:

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May, 2011

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Local-level Assessment of Farmer's Adaptive capacity to Climate Change and Variability in Laelay Mychew Woreda Central Zone of Tigray

A Thesis Submitted to the School of Graduate, Addis Ababa University in Partial Fulfilment of the requirements for the Degree of Masters of Arts in Development Studies

(Environment and Development)

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DEVELOPMENT STUDIES

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Abbreviation and Acronyms

CC	Climate Change
CSA	Central Statics Agency
DFID	Department for International Development of the United Kingdom
EPA	Environmental Protection Authority
FAO	Food and Agriculture Organization
FDG	Focus Group Discussion
FTCs	Farmer's Training Centre
GDP	Gross Domestic Product
GHGs	Green House Gasses
IISD	International Institute for Sustainable Development
ILO	International Labour Organization
IPCC	Intergovernmental Panel for Climate Change
IPCC TAR	Intergovernmental Panel for Climate Change Third Assessment Report
IUCNNR	International Union for Conservation of Nature and Natural Resources
KII	Key Informant Interview
MEDaC	Ministry of Economic Development and Cooperation
NAPA	National Adaptation Program of Action
NMSA	National Meteorological Service Agency
PCA	Principal Component Analysis
SEI	Stockholm Environment Institute
SLF	Sustainable Livelihood Approach
SPSS	Statistical Software for Social Science
UNCED	United Nations Conference on Environment and Development
UNFCCC	United Nations Framework Convention for Climate Change
USAID	United States of America International Development
WLMPF	Woreda Laelay Mychew Plan and Finance Office

Abstract

Despite its negligible emission of greenhouse gases Ethiopia has been affected by the adverse impacts of climate change and variability in different sectors among which the agricultural sector is of a critical focus of this study. This study was conducted with the general objective of analysing the adaptive capacity of farmers to climate change and variability in the two dominant agro ecologies of Laelay Mychew woreda central zone of Tigray based on data collected from 100 household. Descriptive statistics and chi square were used to analyse the trends of temperature, precipitation changes and occurrence of extreme climatic events in the study area over the last there decades as perceived by respondents. Accordingly there is an increasing and decreasing trend of temperature and precipitation respectively, while, drought, flooding and storm have shown increased frequency over the last 30 years. According to the chi square results there was a similar trend in the climate change and variability in both agro ecologies of the study area. The adaptive capacity of farmers to climate change and variability in the study area was analysed by using descriptive statistics, chi square/T-test and principal component analysis. According to the results from the descriptive analysis, farmers in the study area have low level of possession and access to the key livelihood assets. This leads to acceptance of the hypothesis of the study which states that farmers in the study area have low adaptive capacity to climate change and variability. The results from the principal component analysis also demonstrated that farmers in the Dega agro ecology have highest adaptive capacity to climate change and variability. In Hatsebo kebele (Dega) 64%, 36% and 0% of the surveyed households have highest, medium and lowest adaptive capacity to climate change and variability, where as in Welel kebele (kola) 4%, 28% and 68% of the total surveyed household have highest, medium and lowest adaptive capacity to climate change and variability. This difference is statistically significant at 0.01level. Hence, the hypothesis that farmers living in Dega agro ecology have better adaptive capacity to climate change and variability is accepted at less than 0.01 levels. To assess the demographic, socio-economic and farming characteristics that affect farmers adaptive capacity linear correlation was used. Accordingly, Adaptive capacity of farmers to climate change and variability in the study area is strongly affected by household head's age(0.360), size of cultivable land(0.551), type of agricultural practice(0.585) and household's wealth status(0.646) which is significant at 0.01 level. While it is moderately affected by household family size (0.226) and purpose of agricultural practice (0.254) and this is significant at 0.05 levels. So as to enhance the adaptive capacity of farmers in the study area measures such as, effective implementation of health care service, facilitating more supportive and cohesive social environment , better management of natural resources, better access to basic extension services and facilitating infrastructure development, easy access to financial resources, improved early warning systems and awareness creation, and targeting adaptation initiatives towards the lowest adaptive capacity groups and more susceptible areas were recommended.

Key words: Climate change and variability, Adaptive capacity, Agro-ecology

CHAPTER - ONE

1. INRODUCTION

1.1 Background of the Study

Today the issue of climate change has become one of the hottest and debatable agenda globally. It has been presented as a global issue resulting from an increase in greenhouse gas emissions linked to human activities (Brien and Leichenko, 2005). It is recognized as one of the most serious global challenges of the 21st century with multitude effects on basic human support systems such as, agriculture, forests, water resource and the ecosystem in general.

Recent evidence and predictions indicate that climate change is accelerating and will lead to a widespread shift in climatic variables (IPCC, 2007). There will be changes in the mean and variance of rainfall and temperature. Extreme weather events (hurricanes, storms, flood, drought, heat waves e.t.c) are likely to become more common, i.e., increase in frequency, more wide spread spatially and of increased severity (Heltberg et al. 2009). These changes in the mean climate have brought direct negative impacts on agriculture, livelihood assets, water resources nutrition and health status of people. Increased pressure on local coping strategies, social protection measures and the ability to recover from shocks in many instances have lead to resource degradation and scarcity, social tension and conflict (Aklilu and Alebachew, 2009). The most adverse impacts are predicted in the countries of the developing world because of their geographic exposure, already fragile environments, and dominance of climate sensitive sector in their economy and low adaptive capacity (IPCC, 2007).

Despite its negligible emission of greenhouse gases, Ethiopia has been affected by the adverse impacts of climate change and variability. According to the country's first National communication to the UNFCCC climate change evidence is most clearly visible in temperature and precipitation. According to NMSA (2001), the average annual minimum temperature over the country has been increasing by about 0.25 ^{0}C every 10 years, while average annual maximum temperature has been increasing by about 0.1 ^{0}C every decade. Temperature is also projected to rise by 0.5 and 3.6 ^{0}C by 2070, while rain fall is expected to decrease by 5% (NMSA, 2001).

Hence, climate change may have far reaching implications to Ethiopia for many reasons. The country is heavily dependent on rain-fed agriculture which is very sensitive to climate change and significant parts of the country is arid and semi arid and highly prone to drought and desertification (Adgolign, 2006). It has also a fragile highland ecosystem which is currently under stress due to mismanagement and population pressure. Forest, water and biodiversity of the country are also highly susceptible to climate change impacts. Moreover, vector born diseases associated with climatic variation also affect Ethiopia.

In the past decades, the growth rate of agricultural sector in Ethiopia has lingered behind the rate of population growth which made the country to be among the major food aid recipient. Between 1980 and 1997 for instance, the annual population growth was around 3% per annum, where a cereal crop production grew at a rate of only 0.9 per annum, indicating the declining food per capita, increasing food insecurity and worsening poverty (Bewket, 2003). Between 1994 and 2007 the population grew at an annual average of 2.6% and projected to around 120 million by 2025 (Goldenstone, 2007). Owing to the above facts, high sensitivity of Ethiopian agricultural system, and low adaptive capacity of the country, even a slight change in climate will have a huge impact on the farming community and the socio-economic activities of the country. As such, the issue of climate change is therefore a major concern in Ethiopia (NMSA, 2001).

Central to the above fact, empirical studies are essential to guide the policy intervention in the adaptation process of the country's agricultural sector. Some studies have been carried out in the area of climate change and agricultural adaptation nexus in different times by different scholars. Most of the studies focused on the analysis of climate change adaptation strategies, impact of climate change on agriculture and the vulnerability of Ethiopian farmers to the impacts of climate change and variability often at higher level of analysis. However a little has been done regarding the adaptive capacity of farmers' to the possible impacts of climate hazard and variability at lower scale of assessment. This paper therefore is intended to study the adaptive capacity of farmers' to climate change and variability at local level.

1.2 Statement of the Problem

The national program on how Ethiopia can adapt to climate change (NAPA,) states that repeated droughts, storm, hunger and the recent floods are among the most serious problems affecting millions of Ethiopians almost every year. Since climate change is reducing agricultural productivity, accelerating degradation of natural resources, increasing shortage of water and intensifying climate related diseases, it has brought a worst effect on the agricultural sector of the courtly and thereby putting pressure on the lives of the agrarian community.

Deressa et al, (2008) have conducted an integrated vulnerability assessment of seven regional states of Ethiopia. The study found that decline in precipitation and increase in temperature is both damaging Ethiopian agriculture. The result of the study have further pointed out that Tigray Regional State, where Laelay Mychew Woreda is located, is one of the most vulnerable regions to climate change impacts. The authors acknowledged that the study was highly aggregated, hence further study is needed at local levels particularly at district and village levels, one of a gap this study is aimed to fill especially in the aspect of adaptive capacity.

Like many other parts of Ethiopia, the farming community living in Laelay Mychew Woreda Central Zone of Tigray are increasingly becoming vulnerable to the adverse effects of climate change and variability. Vulnerability of a given community to climate change and variability is highly determined by its adaptive capacity and its adaptive capacity is a function of its access and possession of key livelihood asset and resources such as human capital, natural capital, social capital, physical capital and financial capital. The more farmers have better access and ownership of these capitals, they can effectively respond to the adverse effects of climate change and variability.

According to the base line survey 2011, farmers in Laelay Mychew woreda have problems related to low educational level, poor nutrition and poor health status. The level of infrastructural development (access to safe water, electricity, roads, health post e.t.c) is also in its lower stage. Besides the extent to which they can get agricultural extension services and technological facilities (fertilizers, pesticides, improved seeds e.t.c) is constrained by various socio-economic problems. In line with the regional situation most of the kebeles in the woreda have highly degraded natural resources base. Even if there are some patch of forest and fertile land in some kebele, there is still unwise utilization of these resources and intensified natural resource degradation. In addition to this farmers in Laelay Mychew woreda have limited access to financial resources such as savings, credit and formal safety net programmes or other state assistance. This implies that farmers living in the woreda have limited livelihood assets which are the corner stone for agricultural adaptation to climate change and variability, hence low adaptive capacity. All these indicate the existence of problem in access and possession of farmers to the key livelihood assets, which are the key components of their adaptive capacity to climate change and variability. In adequate access and possession of key livelihood assets coupled with low level of awareness farmers to the adverse effect of climate change undermines the adaptive capacity of farmers to climate change and variability. Hence this study is intended to assess farmer's access and possession of the key livelihood assets so as to measure their adaptive capacity to climate change and variability.

1.3 Objective of the Study

The general objective of this study is to assess the adaptive capacity of farmers to climate change and variability in Laelay Mychew woreda central zone of Tigray.

Specific Objectives of the Study

- Identify the general trends of climate change and variability in the study area over the last 30 years as perceived by respondents.
- Determine the adaptive capacity of farmers to climate change and variability in the context of their key livelihood assets, and
- Assess demographic, socio-economic and farm characteristics that affect farmer's adaptive capacity to climate change and variability.

1.4 Research Questions

This study answers the following questions:

- Is there a temperature and precipitation change over the last three couple of decades?
- What was the prevalence of extreme climatic events over the last 30 years as perceived by respondents?
- What is the adaptive capacity of farmer's to climate change and variability in terms of their livelihood asset possession, access and availability?
- Is there a difference in the adaptive capacity of farmers to climate change and variability under 'Dega' and 'Kola' agro ecologies of the study area?
- What are the demographic, socio-economic and farm characteristics related factors affecting the adaptive capacity of farmer's to climate change and variability?

1.5 Significance of the Study

Conducting this study will have the following significances. Firstly, this study provides knowledge by filling some of the gaps regarding key variables that affect adaptive capacity and the relative adaptive capacity of farmers' to climate change and variability. Secondly, it generating policy relevant information which could be used for the targeting of climate change adaptation initiatives and, or the allocation of scarce resources in poverty reduction efforts. Thirdly, the results of the study can also be used by researchers and development practitioners as baseline information for further studies that could be conducted in the study area or related settings

1.6 Scope and Limitation of the Study

Even though it is known that some kebeles in Laelay Mychew have woina dega or combination of dega and kola agro ecology, this study was conducted in only two kebeles of the woreda representing the two dominant agro ecologies of the study area; dega and kola agro-ecological zones due to time and financial limitations. So the result obtained from the study may not be enough to give a broad conclusion about the adaptive capacity of farmer's to climate change and variability in some agro ecologies which slightly differ from the dominant agro ecologies of the study area.

Depending on the sampling procedure adopted for the study, procedure a total of 163 respondents must be the appropriate sample size to statistically represent the 3111 households of the study area. However due to financial and time constraints the researcher takes a sample size of 100 households.

There is no sufficient meteorological data about the historical trends of climate components of the study area. Hence analysis of the trends of climate change and variability of the study area was conducted by summarizing farmer's perception, interviewing more knowledgeable farmers and conducting FGD.

The other limitation of the study area is that even though sustainable livelihood strategy is adopted as a framework for the study, the scope of the study is limited to the assessment of only vulnerability context and livelihood assets in estimating the adaptive capacity of farmers to climate change and variability.

1.7 Organization of the Thesis

The study is organized in five chapters. The introductory part of this study which includes background of the study, statements of the problem, objectives, significance of the study and scope and limitations of the study is provided in chapter one. Chapter two presents the relevant literatures related to climate change, livelihoods, climate change and adaptation, approaches to climate change research and sustainable livelihood approaches and the conceptual frame work of the study. The third chapter covers the research methodology (research design, source of data, sample, sample size, sampling technique, and data collection instruments and data analysis). Chapter four presents and discusses the results of the analysis. Summary, conclusions and implications for policy formulation and mitigation strategies are presented in chapter five.

CHAPTER - TWO

2 LITERATURE REVIEW

2.1 Climate Change, Impacts and Responses

Climate change (CC) refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC, 2007).

Climate change is one of the most pressing global problems of our time. There has been a significant rise in greenhouse gas (GHG) emissions, such as carbon dioxide, methane, nitrous oxide, etc., since the industrial revolution. This increase in emissions has led to a rise in the concentration of GHGs in the atmosphere and subsequently a rise in radiative forcing[1]. Over the 20th century, the increase in global average surface temperature has been of 0.6 ± 0.2°C (IPCC, 2001).

Changes in climate occur as a result of both internal variability within the climate system and external factors (both natural and anthropogenic) independent of the climate system. The influence of external factors on climate can be broadly compared using the concept of radiative forcing. A positive radiative forcing, such as that produced by increasing concentrations of GHGs or black carbon, tends to warm the surface. A negative radiative forcing, which can arise from an increase in some types of aerosols (e.g., sulphur) tends to cool the surface. Natural factors, such as changes in solar output or explosive volcanic activity, can also cause radiative forcing.

The IPCC TAR projected that global mean temperature will increase between 1.4 and 5.8°C over the period 1990 to 2100. For the same set of scenarios, global mean sea level rise was projected to rise by 0.09 to 0.88 meters between 1990 and 2100. Precipitation is projected to increase during the 21st century, but there are regional discrepancies.

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[1] *The relative effectiveness of greenhouse gases to restrict long-wave radiation from escaping back in to space. For a particular greenhouse, radiative forcing is measured as the change in average net radiation (in watts per square meter) at the top of the troposphere, and depends on the wavelength at which the gas absorbs the radiation, the strength of absorption per molecule, and the concentration of the gases.*

Available observational evidence indicated that recent regional changes in climate, particularly increases in temperature, have already affected a diverse set of physical and biological systems in many parts of the world (IPCC 2001). "Examples of observed changes include shrinkage of glaciers, thawing of permafrost, later freezing and earlier break-up of ice on rivers and lakes, lengthening of mid- to high-latitude growing seasons, pole ward and altitudinal shifts of plant and animal ranges, declines of some plant and animal populations, and earlier flowering of trees, emergence on insects, and egg-laying in birds". "Natural systems can be especially vulnerable to climate change because of limited adaptive capacity, and some of these systems may undergo significant and irreversible damage". Many human systems are sensitive to climate change, but the vulnerability of these systems varies with geographic location, time, and social, economic, and environmental conditions.

Projected adverse impacts based on models and other studies include: reduction in potential crop yield in most tropical and sub-tropical regions; decreased water availability for populations in many water-scarce regions, particularly in the sub-tropics; an increase in the number of people exposed to vector-borne and water-borne diseases, and an increase in heat stress mortality; widespread increase in the risk of flooding for many human settlements both from increased heavy precipitation events and sea-level rise; increased energy demand for space cooling due to high summer temperatures.

Projected beneficial impacts include: increased potential crop yields in some regions at mid-latitudes; increased water availability for populations in some water-scarce regions; reduced winter mortality in mid- and high-latitudes; reduced energy demand for space heating due to higher winter temperatures; increased tourism and leisure in some regions.

There are two major responses to climate change: mitigation and adaptation. Mitigation of climate change relates to the reduction of greenhouse gas emissions and the sequestration of GHGs from the atmosphere (e.g., through trees or underground storage). Adaptation to climate change refers to the successful reduction of the adverse effects of climate change and the enhancement of beneficial impacts. This thesis is almost exclusively focused on adaptation responses to climate change, which are elaborated in further detail next.

2.2 Important Concepts and Definitions of Climate Change and Adaptation

Weather describes atmospheric conditions at a particular place in terms of air temperature, pressure, humidity, wind speed, and precipitation.

Climate is often defined as the weather averaged over long period of time (typically, 30 years).

Climate change: A statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Climate variability: Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).

(Climate) Impacts: Consequences of climate change on natural and human systems. Depending on the consideration of adaptation, one can distinguish between potential and residual impacts. Climate impacts are a function of (the change in) the exposure of a system to climatic stimuli and of its sensitivity to these stimuli. Potential impacts are determined in assessments where the exposure of a system changes but its sensitivity is assumed to be unaffected by climate change.

Exposure: The nature and degree to which a system is exposed to significant climatic variations. The exposure of a system (often termed exposure unit) to climate stimuli depends on its location and on the level of global climate change.

Sensitivity is the degree to which a system is affected by, or responsive to, climate changes. The sensitivity of ecological systems to climate change is normally described in terms of physiological tolerances to change and/or variability in physical and chemical conditions (i.e. temperature, pH, etc.). The sensitivity of social systems depends on economic, political, cultural and institutional factors (Fenton et al. 2007). For example, social systems are more likely to be sensitive to climate change if they are highly dependent on a climate vulnerable natural resource (Marshall et al. 2007). These factors can confound (or ameliorate) the economic effect of climate exposure.

Adaptive capacity: describes the ability to respond to challenges through learning, managing risk and impacts, developing new knowledge and devising effective approaches. It requires amongst many other things, the flexibility to experiment and adopt novel solutions (Gunderson 2000). In ecosystems, adaptive capacity is related to genetic diversity, biological diversity, and heterogeneity within landscapes. In social systems, adaptive capacity can be a conscious or inadvertent characteristic, enhanced by the existence of institutions and networks that learn and store knowledge and experience, create flexibility in problem solving, without compromising the ability to cope and adapt to future change Adaptive capacity greatly influences the vulnerability of communities and regions to climate change effects and hazards (Marshall et, al. 2010).

Vulnerability: The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. It is a function of adaptive capacity, sensitivity and exposure.

Mitigation: An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases. It refers to actions that limit the level and rate of climate change. The two basic mitigation options are the reduction of (gross) GHG emissions (e.g. through fuel switching in the energy sector), and the reduction of their concentrations (through enhancing the sink capacity of biological and other systems).

Adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.

2.3 Agricultural Adaptation to Climate Change

Even if the agricultural sector all over the world and especially in developing countries is becoming under continuing stress due to the impacts of climate change and variability, it has the capacity to adapt to climate change and variability provided that technologies, resources and management changes have been undertaken relatively quickly (Mendelssohn, 2000). Throughout human history, societies have adapted to natural climate variability by altering settlement and agricultural patterns and other facets of their economies and lifestyles (Kurukulasuriya and Rosenthal, 2003).

According to many literatures there are two major responses to the impacts of climate change and variability: mitigation and adaptation. Mitigation of climate change relates to the reduction of greenhouse gas emissions and the sequestration of GHGs from the atmosphere (e.g., through trees or underground storage). Adaptation to climate change on the other hand refers to the successful reduction of the adverse effects of climate change and the enhancement of beneficial impacts.

2.3.1 General Typology and Classification of Adaptation

Many climate change researchers have identified different adaptation typologies and presented a number of concepts and frameworks as a benchmark for characterising different types of adaptation based on purpose, timing, duration and location of adaptation activities. This are presented below.

Autonomous versus planned adaptation

Adaptation responses can be categorized by the level of ownership of the adaptation measure or strategy. Individual level or *autonomous adaptations* are considered to be those that take place in reaction to climatic stimuli (after manifestation of initial impact), that is, as a matter of course and without the directed intervention of any public agency (Smit and Pilifosova, 2001). Autonomous adaptations are widely interpreted to be initiatives by private actors rather than by governments, usually triggered by market or welfare changes induced by actual or anticipated climate change (Leary, 1999). *Policy-driven or planned adaptation* is often interpreted as being the result of a deliberate policy decision on the part of a public agency, based on an awareness that conditions are about to change or have changed, and that action is required to minimize losses or benefit from opportunities (Pittock and Jones, 2000). Thus, autonomous and policy-driven adaptation largely correspond to private and public adaptation, respectively (Smit and Pilifosova, 2001). Private adaptations are those undertaken only for the exclusive benefit of the individual decision maker. The adoption of various measures will be driven purely by self-interest and underlying welfare-maximizing objectives (including profit maximization, output maximization, and so forth) Mendelsohn (2006). While public adaptations are those undertake by the government. In public adaptation the owner and facilitator of adaptation interventions is government not the individual (Kurukulasuriya and Rosenthal, 2003).

As implied in the previous section, autonomous adaptation responses will be evaluated by individual farmers in terms of costs and benefits. It is anticipated that farmers will adapt "efficiently", and that markets alone can encourage efficient adaptation in traded agricultural goods (Mendelsohn, 2006). Yet, in situations where market imperfections exist, such as the absence of information on climate change or land tenure insecurity, climate change will further reduce the capacity of individual farmers to manage risk effectively. Moreover, responses at the individual level tend to be costly to poor producers and often create excessive burdens. As a result, an appropriate balance between public sector efforts and incentives, such as capacity building, creation of risk insurance and private investment, needs to be struck so that the burden can shift away from poor producers.

Reactive (Ex-Post) Versus Anticipatory (Ex-Ante) Adaptations

Reactive adaptation takes place after the initial impacts of climate change have occurred. Whereas Anticipatory adaptation takes place before impacts become apparent or where a change is introduced in response to the onset of impacts that will re-occur and reflect a structural change of state of the system: in climate terms, where new temperature and rainfall patterns emerge. In natural systems, there is no anticipatory adaptation (Bewketu, 2010).

In theory, the literature discusses two types of likely responses to address climate impacts, namely, those that are reactive or, alternatively, anticipatory adaptations. Measures made in anticipation of a coming change are ex-ante. They require that the decision maker be able to predict what is coming. Reactive adaptations consist of coping strategies that agents and institutions are likely to make in response to climate impacts after the fact ***(ex-post)***. These strategies merely require the decision maker to be aware of changes that have occurred (Kurukulasuriya and Rosenthal, 2003).

2.3.2 Classification of Adaptation Measures

There are potentially many adaptation measures that may be adopted in response to climate change. The Second Assessment Report of IPCC Working Group II mentioned or described 228 different adaptation measures (IPCC, 1995). It is useful therefore to classify adaptation measures using an overall framework. A commonly used classification group's adaptation measures into nine categories (Burton et al., 1993).

Bear losses: All other adaptation measures may be compared with the baseline response of "doing nothing" except bearing or accepting the losses. In theory, bearing loss occurs when those affected have no capacity to respond in any other ways (for example, in extremely poor communities) or where the costs of adaptation measures are considered to be high in relation to the risk or the expected damages.

Share losses: This type of adaptation response involves sharing the losses among a wider community. Such actions take place in traditional societies and in the most complex, high-tech societies. In traditional societies, many mechanisms exist to share losses among a wider community, such as extended families and village-level or similar small-scale communities. At the other end of the spectrum, large-scale societies share losses through public relief, rehabilitation, and reconstruction paid for from public funds. Sharing losses can also be achieved through private insurance.

Modify the threat: For some risks, it is possible to exercise a degree of control over the environmental threat itself. When this is a "natural" event such as a flood or a drought, possible measures include flood control works (dams, dikes, levees). For climate change, the major modification possibility is to slow the rate of climate change by reducing greenhouse gas emissions and eventually stabilising greenhouse concentrations in the atmosphere. In the language of the UNFCCC, such measures are referred to as mitigation of climate change and are considered to be in a different category of response from adaptation measures.

Prevent effects: A frequently used set of adaptation measures involves steps to prevent the effects of climate change and variability. An example would be for agriculture: changes in crop management practices such as increased irrigation water, additional fertiliser, and pest and disease control.

Change use: Where the threat of climate change makes the continuation of an economic activity impossible or extremely risky, consideration can be given to changing the use. For example, a farmer may choose to substitute a more drought tolerant crop or switch to varieties with lower moisture. Similarly, crop land may be returned to pasture or forest or other uses may be found such as recreation, wildlife refuges, or national parks.

Change location: A more extreme response is to change the location of economic activities. There is considerable speculation, for example, about relocating major crops and farming regions away from areas of increased aridity and heat to areas that are currently cooler and which may become more attractive for some crops in the future (Rosenzweig and Parry, 1994).

Restoration: The IPCC Technical Guidelines (Carter et. al, 1994) include another category of adaptation called restoration. Restoration aims to restore a system to its original condition following damage or modification due to climate change. From the perspective of adaptation as a continuous process, and as a learning process, the notion of restoration might even be considered as maladaptive, if by restoration is meant a return to a pre-existing state. Successful adaptation is more likely to involve making changes after an event to reduce future vulnerability.

2.4 Livelihoods, Climate Change and Adaptation

It is obvious that the impact of climate change and variability is on the livelihood of vulnerable communities. In their study titled ''Livelihood adaptation to climate variability and change in drought-prone areas of Bangladesh'' Selvaraju et al. (2006), developed a model that clearly demonstrate the relationship between the livelihood of poor agrarian communities and climate change. This is as depicted by the diagram below.

Figure 1 shows how different environmental factors together with risk factors influence household livelihood strategies and decision-making processes over time, taking the role of gender and other vulnerable populations into account. At the centre of the model are the households, where strategies are developed and decisions taken to develop and maintain livelihoods by means of the livelihood portfolio. Looking at the model from a systems perspective, climate change could influence the bio-physical (agriculture), socio-cultural and socio-economic environments of households, impacting resources and assets, including social capital. The resource management strategies and decision-making potential of the local population is also affected. The fact that coping range drops significantly under climate change is one of the reasons that improving adaptive capacity to maintain or improve livelihood security is one of the core aims of this effort.

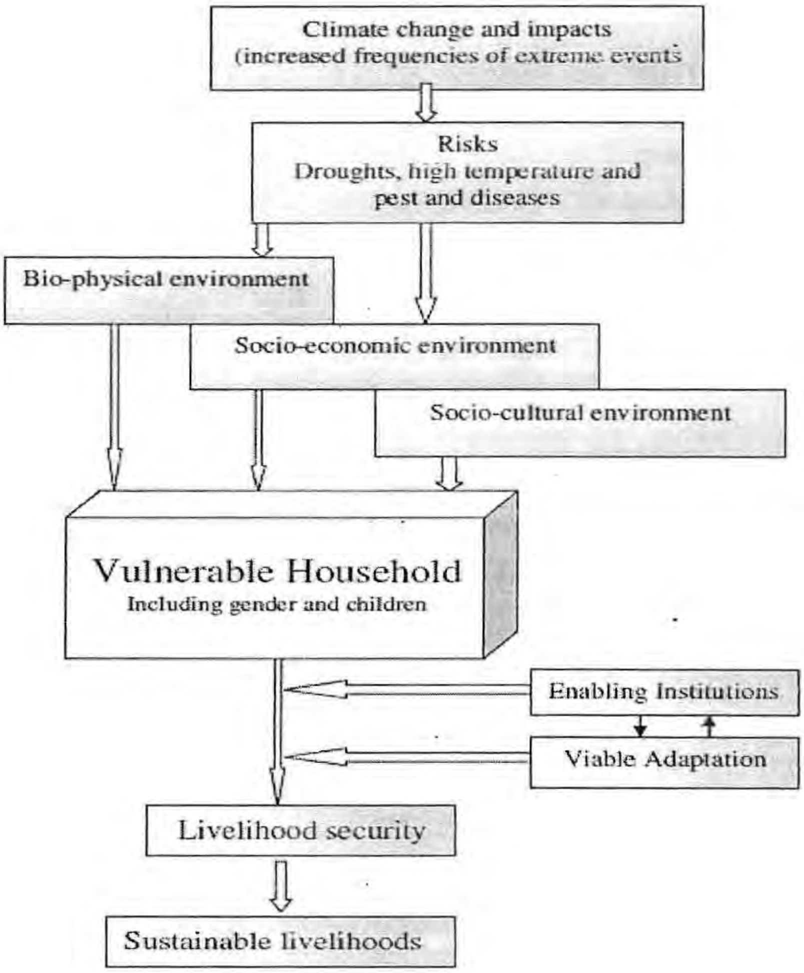

Figure 1: Livelihoods, climate change and adaptation (Source: Sulveraju *et al.*, 2006.)

2.5 Approaches to Climate Change Research

According to Dessai & Hulme (2004), research in the area of climate change impacts and adaptation can be divided into studies employing 'top-down' and 'bottom-up' approaches. The former usually begin with macro-scale conditions based on future projections and then narrow the focus to potential impacts on a particular region or phenomenon. Possible adaptation strategies are assumed and tested for limiting or taking advantage of the projected effects from climate change. But such an outcome is conditional on producers having the capacity to take adaptive actions, a factor that is not always taken into account.

Studies employing a bottom-up approach do focus on adaptive capacity and vulnerability, and tend to be less optimistic about future climate change effects on agricultural sector. This line of inquiry generally has a smaller scale focus, namely the system of interest, and often begins by documenting current adaptive responses to a number of stresses (including weather and climate conditions) as the basis for understanding future capacity to adapt to climate. With its focus on current community capacity, this research adopts the bottom-up approach for understanding climate change impacts and adaptation. Empirical studies in the area of climate change impact, adaptation and vulnerability indicates that, the assessment of a system's adaptive capacity to climate change and variability has been conducted as an integral part of climate change vulnerability assessment, (Smit and Wandel, 2005). There are three major conceptual approaches of vulnerability assessment to climate change which have direct or indirect importance in the understanding of adaptive capacity assessment. These approaches are socio-economic, bio-physical and integrated assessment approaches.

Socioeconomic Approach

The socioeconomic vulnerability assessment approach mainly focuses on the socioeconomic and political status of individuals or social groups or on identifying the adaptive capacity of individuals or communities based on their internal characteristics (Füssel, 2007). A study by Adger and Kelly (1999) is an example of this approach in which environmental factor in a district to coastal lowlands of Vietnam was taken as given, and vulnerability was analyzed based only on variations in socioeconomic attributes of individuals and social groups. However this approach focuses only on the socio-economic aspect of vulnerability.

Biophysical Approach

The biophysical approach assesses the level of damage that a given environmental stress causes on both social and biological systems. For instance, the monetary impact of climate change on agriculture can be measured by modelling the relationships between climatic variables and farm income (Mendelsohn, 1994). Similarly, the yield impacts of climate change can be analyzed by modelling the relationships between crop yields and climatic variables (Olsen, Bocher, and Jensen 2000). This approach also focuses only on the physical dimension of vulnerability.

The Integrated Assessment Approach

The integrated assessment approach combines both socioeconomic and biophysical approaches to determine vulnerability. Füssel (2007) and Füssel and Klein (2006) argued that the IPCC (2001) definition—which conceptualizes vulnerability to climate as a function of adaptive capacity, sensitivity, and exposure— accommodates the integrated approach to vulnerability analysis. According to Füssel and Klein (2006), the biophysical approach corresponds most closely to sensitivity in the IPCC terminology. Adaptive capacity (broader social development) is largely consistent with the socioeconomic approach (Füssel 2007). In this study, adaptive capacity is represented by availability of resource in which a given region possesses and can mobilize it in times of climate change impacts. Such resources are social, human, institutional, economic and natural. Given to their limitation, assessment of these resources cannot be achieved by using either the socio-economic or biophysical approaches; hence the integrated assessment approach will be adopted for this paper.

2.6 Determinants and Scales of Adaptive Capacity Assessment

The forces that influence the ability of the system to adapt are the drivers or determinants of adaptive capacity. Adaptive capacity is context-specific and varies from country to country, from community to community, among social groups and individuals, and over time. Due to this there is not a specific model of assessing the elements and processes of adaptive capacity (Smit and Wandel, 2005). Researchers have been using varied indicators and different scales of analysis in the study of the adaptive capacity of a system by considering the relevance of a given adaptive capacity indicator to the system under consideration. However the logic behind the choice of determinants or indicators of adaptive capacity is similar. That is adaptive capacity is all about the resource of the system that could be used in dealing with the challenge and the institutional ability of mobilizing them (Wall & Marzall, 2006). In light of this fact, varied indicators or determinants of adaptive capacity are established by different researchers which accommodate the overall resource of a given system (Marshall et al, 2010, Wall & Marzall, 2006, Hallie & Lemos, 2005)

Adaptive capacity can be assessed at a range of scales, from the individual, household and community levels of organisation to national assessments (Marshall 2010). The technique most appropriate for a given area will depend on the expertise available, goals and budget (Marshall 2010). The scales of adaptive capacity are not independent or separate: the capacity of a household to cope with climate risks depends to some degree on the enabling environment of the community, and the adaptive capacity of the community is reflective of the resources and processes of the region (Smit and Pilifosova, 2003).

In a study titled ''Measuring Ethioppian farmers' vulnerability to climate change across regional state'' Deressa et al,(2008), applied an integrated assessment approach at a national scale of analysis to identify which of the regions are highly vulnerable to climate change. Since adaptive capacity is one component of vulnerability they assessed it by adopting indicators of adaptive capacity which directly or indirectly measures resource levels of farmers in the study areas. The authors acknowledged that their scale of analysis was highly aggregated (being at national level) and further study is needed at local levels, particularly at district and villages, one of a gap this study is aimed at filing in the aspect of adaptive capacity. In addition to this a combination of indicators modified form the above studies especially that of Wall & Marzall, (2006) and others which fits conditions of the study area will be used. The combination of these indicates will be assessed by placing them in the sustainable livelihood approach (SLA) framework of study.

2.7 Sustainable Livelihood Approach

The sustainable livelihoods idea was first introduced by the Brundtland Commission on Environment and Development as a way of linking socioeconomic and ecological considerations in a cohesive, policy-relevant structure. The 1992 United Nations Conference on Environment and Development (UNCED) expanded the concept, especially in the context of Agenda 21, and advocated for the achievement of sustainable livelihoods as a broad goal for poverty eradication. It stated that sustainable livelihoods could serve as 'an integrating factor that allows policies to address 'development, sustainable resource management, and poverty eradication simultaneously' (Lasse, 2001).

A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living; a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long-term (Chambers and Conway, 1992).The extent to which a livelihood is sustainable is determined by the interaction of several forces and elements. These include vulnerability context, Livelihood assets, transforming structures and processes, livelihood strategies and livelihood outcomes in which these all lead to enhanced adaptive capacity of a system.

2.8 Conceptual Framework

Adaptive capacity describes the ability to respond to challenges through learning, managing risk and impacts, developing new knowledge and devising effective approaches. It requires amongst many other things, socio-economic capacity, the flexibility to experiment and adopt novel solutions (Gunderson, 2000). Hence adaptive capacity of farmers to climate change and variability is directly related to livelihood assets (resource) they possess (Wall & Marzall (2006), and their willingness to mobilize these resources in the face of climate change vulnerability context (Marshall et al, 2010), by adopting flexible livelihood strategies and novel solutions. In this regard the decision and capacity of farmers to adapt to climate change is influenced by various transforming processes and structures existing in their locality.

Due to the above conceptualization of adaptive capacity, the theoretical framework adopted in this paper is sustainable livelihood approach. The sustainable livelihood approach consists the interaction of several elements. These include vulnerability context, Livelihood assets, transforming structures and processes, livelihood strategies and livelihood outcomes in which these all lead to enhanced adaptive capacity of a system.

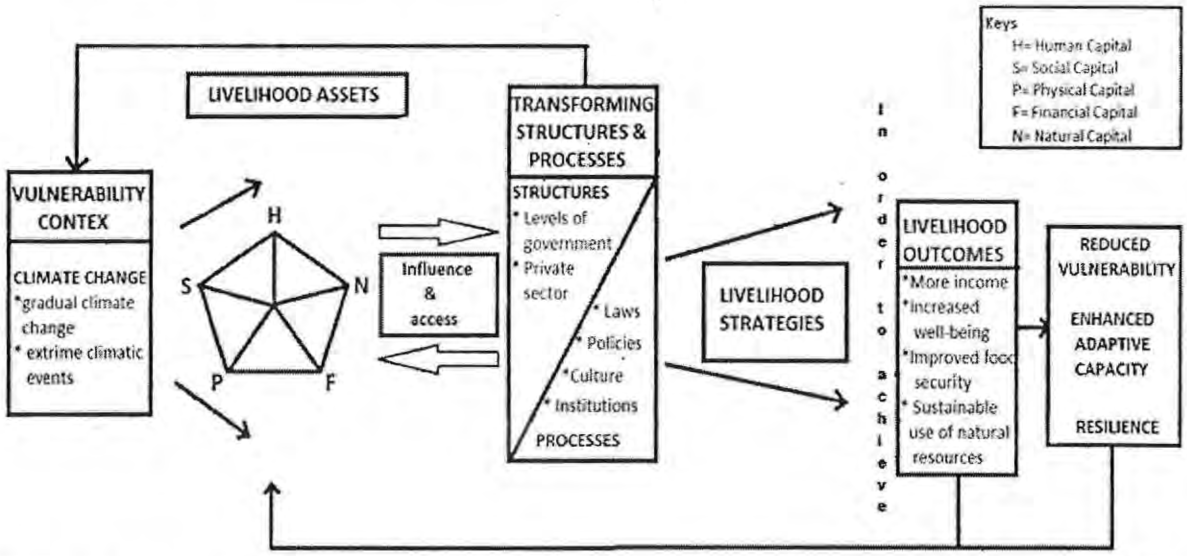

Figure 2: Sustainable Livelihood Approach (adapted from DFID, (1999) with slight modification to suit the purpose of this paper)

The Vulnerability Context is the external environment which affects people's livelihoods due to either trends, shocks and or seasonality – over which people have limited or no control (DFID, 1999). In this paper the vulnerability context is represented by climate change and variability. Climate change and variability is represented by gradual climate changes (precipitation and temperature), and extreme climatic events (prevalence of drought, flooding and storms).

The other component of the sustainable livelihood approach is livelihood assets. Assets refer to the resource base of people. Assets are often represented as a pentagon in the SLF, consisting of the following five categories: natural resources (also called "natural capital"), physical reproducible goods ("physical capital"), monetary resources ("financial capital"), manpower with different skills ("human capital"), social networks of various kinds ("social capital") (FAO and ILO, 2007).

Human capital represents the skills, knowledge, and availability of labour and good health that together enable people to pursue different livelihood strategies and achieve their livelihood objectives and at household level human capital is a factor of the amount and quality of labour available. Here human capitals will be treated based on the assessment of literacy rate, household's family size, percentage of household members who can read and write, number of household members who have additional skill, households average health condition, household's average condition of nutrition, percentage of dependent household members and number of children the household is planning to add. This is due to the assumption that farmers with better knowledge, skill, health and low level of dependants have better adaptive capacity to climate change.

Social capital refers to the resources people draw upon in pursuit of livelihood objectives. Social capital is developed through: networks and connectedness; membership of more formalised groups (governed by mutually-agreed or commonly accepted rules, norms and sanctions); and informal safety nets based upon relationships of trust, reciprocity and exchange. In this paper social capital of farmers is represented by availability and strength of traditional institutions (ekub, edirs, and religious cooperation), kinship financial support (remittance from extended family members and readiness to migrate (resettlement). The underlying principle here is that the more and stronger traditional social institutions the better the adaptive capacity to climate changes. In addition to this when farmers are not willing to resettle and when they are highly attached to their farm occupation they will have low adaptive capacity to climate change.

Natural capital are endowments and resources of a region belonging to the biophysical realm, including forests, air, water, arable land, soil, genetic resources, and environmental services. Natural resources provide the requirements for a substantial resource base to support related economic activity and amenities for enhancing quality of life related to aesthetic appeal and proximity to the natural world (Mendis et al., 2003). For this research water, soil, forest and irrigation potential are taken as indicators for the natural resource assessment of the study area. This is due to the fact that farming communities with better water, soil, irrigation potential and forest can cope up with climate challenges (O'Brien et al. 2004).

Physical capital comprises the basic infrastructure and producer goods needed to support livelihoods. Infrastructure consists of changes to the physical environment that help people to meet their basic needs and to be more productive; producer goods are the tools and equipment that people use to function more productively. The following components of infrastructure represent physical capital in this study: household's housing condition, household's access to road, distance of household's residence from the nearest health post, quality of household cooking fuel, extent of telephone service, ownership of radio, access to market, availability of microfinance institutions and access to agricultural technologies.

Financial capital denotes the financial resources that people use to achieve their livelihood objectives. There are two main sources of financial capital: available stocks and regular flows of money. Current amount of household saving in the form of cash and jewellery, amount credit available to the households annually, annual amount of government support, and amount of money the household gets from remittance annually are the indicators used in this study to represent household's financial capital stock.

CHAPTER - THREE

3 RESEARCH METHODOLOGY

3.1 Description of the Study Area

Laelay Mychew Woreda which is located in Central Zone of Tigray Regional State at around 1021 km distance from Addis Ababa is selected as a study area. Laelay Maychew is bordered on the south by Naeder Adet woreda, on the west by Tahtay Mychew woreda, on the north by Mereb Lehe woreda, and on the east by Adwa. The administrative centre of this woreda is Axum town (WLMPF, 2010).

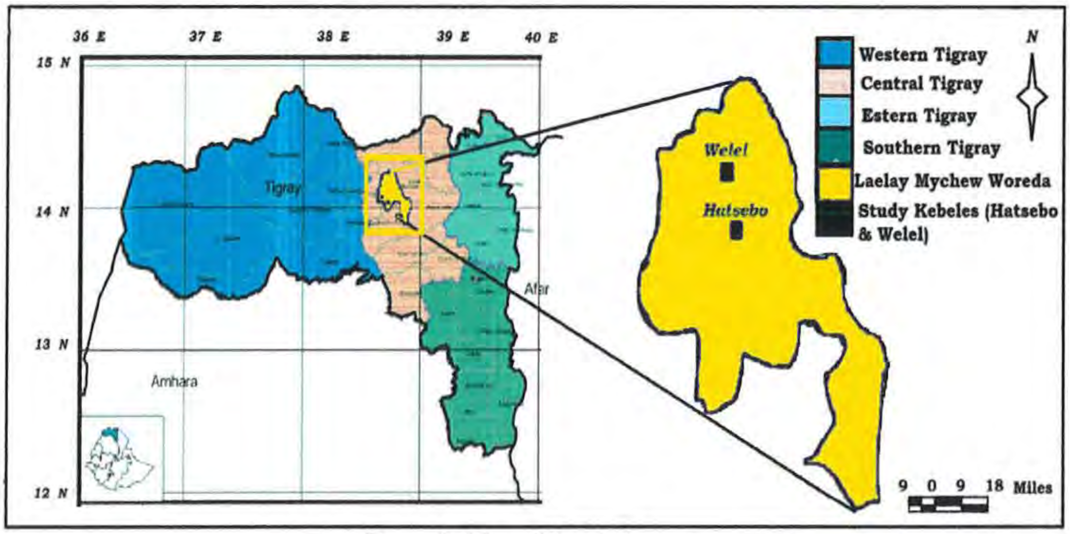

Figure 3: Map of the study area

According to the 2007 National housing and population census, the total population of the Woreda is 78, 495. It is subdivided in to 15 rural Kebeles with predominantly agricultural livelihood (WLMPF, 2010). The Woreda has an estimated total land area of 53,833.39 hectare with an average altitude of 2000m above sea level. Although area possesses dega, woina dega and kola agro ecology or some combination of all, the two dominant agro ecology of the woreda are dega and kola (WLMPF, 2010). The farming system of Laelay Mychew Woreda is mixed crop-livestock production system, and it contains kebeles which are the major Teff growing areas in Tigray (Mehretab, 2009). 78.26% of the farmers both raise crops and livestock, while 21% grow crops only and 0.74% raised livestock alone. Land tenure in this woreda is distributed amongst 82.12% owning their land, 17.43% renting, and 0.44% other forms of tenure (CSA, 2007).

3.2 Research Design

The conceptual and methodological approach to the assessment of farmers' adaptive capacity to climate change and variability in this study is fundamentally viewed as an assessment of access and levels of resource possession underpinned by the concept of sustainable livelihood approach. The resources are of different type such as natural, financial, human, physical, institutional and social. Assessment of access to such requires both quantitative and qualitative data analysis techniques. Socio-economic and biophysical approaches are integrated here in this study to achieve the required objectives and hence the resulting approach is integrated assessment approach.

In order for the study to be effective and practical, the research design needed to have several features. First, the methodology should be simple enough to remain operational. Second, the methodology should permit comparisons both at household and agro-ecology level. Third, the design should not be costly to implement and should have a minimum turnaround time without unduly sacrificing the credibility of results. Consideration of these parameters led to the adoption of the indicator- based cross sectional research design. This method involves (i) identifying a range of indicators that reflect powerfully on farmer's level of adaptive capacity to climate change and variability and for which credible information can be quickly and inexpensively obtained; (ii) designing a survey methodology that facilitates the collection of information on these indicators from households living in the study area and (iii) formulating a single summary index that combines information from the range of indicators and facilitates adaptive capacity comparisons between households at individual and agro-ecological levels.

The development of this indicator-based adaptive capacity assessment research design or tool was accomplished following some methodological steps. Initially extensive literature review and assessment on the general availability and use of adaptive capacity indicators was made which enabled the selection of indicators of analysis. Then a questionnaire and checklists was developed based on the indicators adopted. This was followed by statistical analysis of indicators and development of generic adaptive capacity index.

This study combined purposive sampling, stratified and simple random sampling techniques for selection of the study Woreda, Kebele and households. The quantitative data obtained through structured questionnaires was triangulated with the qualitative data (i.e. FGD, Key informant interview) to support the analysis of the survey.

3.3 Sample Size Determination and Sampling Procedure

From different sampling methods developed by different researchers the one developed by Watson (2001) was used to determine the sample size of the study.

$$n = \frac{\frac{P[1-P]}{\frac{A^2}{Z^2} + \frac{P[1-P]}{N}}}{R}$$

Where: n = Sample size required

N = Number of people in the population (3111 Households)

P = Estimated variance in population, as a decimal (0.3)

A = Precision desired, expressed as a decimal (0.05)

Z = Based on confidence level (1.96)

R = Estimated Response rate, as a decimal (0.95)

The rationale for the adoption of this method is that, it provides sample size value appropriate to different population size given different precision value and degree of variability, to meet the goal of the study. Based o this formula this study assumes a 95% confidence level, identifying a risk of 1 in 20 that actual error is larger than the margin of error (greater than 5%). A five percent margin of error indicates willingness to accept an estimate within +/- 5 of the given value. It also sets the estimated variability of the population at 30% and the expected response rare at 0.95. Depending on this procedure a total of 100 respondents were considered.

Sampling Procedure

For this research multi-stage sampling techniques was employed to select the study kebeles and sample households. Using stratified sampling technique the rural Kebeles were classified in to two clusters based on the agro-ecology of the study area as dega and kola are the two traditional dominant agro ecology of the study area. Totally two Kebeles namely Hatsebo (Dega) and Wele (Kola) were randomly selected to represent each stratum. The complete list of households of the study kebeles being the sampling frame of the study, simple random sampling technique was employed to select the 100 household from these two Kebeles.

3.4 Method of Data Collection

In order to meet the research objectives both primary and secondary data were collected from different sources using different methods as discussed below.

Key Informant Interview

Key informant interview was held with 12 knowledgeable local informants, which among others include 8 development agents 4 from each study Kebele and 4 woreda extension workers. The development agents and extension officers were asked questions related to the livelihood asset possession of farmers and the infrastructural and institutional set up of their respective kebeles/woreda which are directly or indirectly relates to farmer's adaptive capacity to climate change and variability. In addition to this they were also asked about the perception they have to changes of precipitation, temperature and occurrences of extreme climatic events of the study area over the last 30 years.

Focus Group Discussion

In addition to key informant interview focused group discussions were held with two groups of interest to the research work. The first group was composed of farmers with the age of 70 and above. This discussion was held with 20 farmers in four sessions with 5 farmers each. The first two sessions were held in Hatsebo kebele while the other two were held in Wele kebele. The main aim of the FGD is to ensure the soundness of the data collected about changes in precipitation, temperature change and occurrences of extreme climatic events, through household survey. The other focused group discussion held in this study was the one done with female household heads. This was conducted in four sessions of 5 female household heads of each and a total of 20 participants. The first two sessions were held in Hatsebo kebele while the other two are held in Welel kebele. The motive behind this FGD was to see whether there is a difference in the livelihood assets and strategies of farmers between households lead by female and male.

Household Survey

Appropriate questionnaire and checklists were prepared for the survey as well as key informant interview and focus group discussions respectively. Respondents were told what the research is all about in the language that they can understand. Since respondents in this study are speakers of *Tigrigna*, the questionnaire was translated into the language. Doing so was found very important for it enables the respondents to easily understand the questionnaire and express their ideas comfortably. Besides respondents were told that the purpose of the study is only academic and its confidentiality is strictly protected. The collection of household survey data through the questionnaire was conducted by recruiting four enumerators who are selected based on their professional competence and their past experience in data collection for studies conducted on the study area. The enumerators were workers of *Woreda* Office of Agriculture and Rural Development in the study kebeles. Before they started the actual data collection process they attended one day intensive training about the objectives of the research, how to approach a respondent and record responses as well as detailed contents of the questionnaire.

Pilot Per-Test

So as to validate the questionnaire and checklists used pilot testing was undertaken. The pilot testing was carried out in Bet Penteleon *kushet* which is found in Hatsebo kebele. The data collection instruments were administered to 8 farmers living in the *kushet*[2]. To make the pilot testing more sound 4 of the farmers were female household heads as there could be a difference in understanding the central idea of the research instruments due to sex. Having completed the interview and collected the completed questionnaires, critical review was undertaken so as to check whether or not the questionnaire have problems of ambiguity, instruction, wording, sentence construction, time requirement etc. Accordingly, few problems were found in the pilot test. The most critical problem found was that the number of questions in the questionnaire was too much. This was corrected by avoiding some redundancies and grouping of related variables hence it became manageable. In addition to this some wording problems, misplacement of some questionnaire items which have similar concepts and existence of few scientific jargons of the field were found to be a problem to the instrument. So amendment measures were taken based on the feedback from the pilot test.

Field Observation

During field surveys, the researcher a undertook series of field visits with agricultural development agents and woreda kebele officials so as to see the conditions of different infrastructural facilities such as roads, health posts, schools, water supply, communication facilities, farmer's training centres (FTCs) e.t.c and physical and socio-economic changes associated with climate change and farmers adaptive capacity such as trends of erosion, deforestation, conditions of land holding, irrigation activities, changes in life style, access to

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[2] *The lowest administrative unit in Tigray region which is equivalent to the Amharic word 'Got'*

market e.t.c. Furthermore the administration of the questionnaire by the enumerators was controlled by occasional visit and random check of respondent's response.

Document Analysis

Secondary data that are relevant for the research work were gathered from different sources that include published books, journals, reports, prepared by international, federal and regional institutions and unpublished materials available at the woreda administration, woreda agricultural and rural development office, woreda plan and finance office, regional agricultural research centre Axum branch and other related offices and institutions were utilized.

3.5 Method of Data Analysis

In order to meet the general and specific objectives of the study both qualitative and quantities methods of data analysis were used. Descriptive statistic such as percentage, mean, minimum, maximum and standard deviations were used to summarize the collected data. While appropriate inferential statistical techniques such as chi square test, T-test, Pearson's correlation and principal component analysis were used to make inference from the summarized data. The qualitative data from FGD and KI interview were contextually analysed and triangulated with the quantitative data. The summarized data were displayed in diagrams or tables to look for possible relationship between variables. Besides SPSS software package version 15.0 was used to organize, arrange and analyze the data.

Descriptive Statistics

Descriptive statistics (percentages, frequency tables, mean, maximum and minimum etc.) were the methods used to analyze perceived changes of temperature, precipitation, occurrence of extreme climatic events and the key livelihood asset. Findings from the primary and secondary data were compared and contrasted or triangulated with the findings of focus group discussion and key informant interviews.

T-Test and Chi Square

T-test and Chi square test was run to investigate whether there is any statistically significant difference in household demographic, socio economic and farm characteristics between farm households living in Dega and kola agro-ecologies of the study area. Chi square was also run to see if there is any systematic dependency or contingency relationship among variables in respondents living in the two agro ecologies. In addition to this T-test and Chi square test were used to see whether there is a significant statistical difference in access, ownership and availability of the key livelihood assets between farmers living in dega and kola agro ecologies. They were also used to evaluate the difference in the adaptive capacity of farmers to climate change and variability agro ecology wise.

Linear Correlation

Linear correlation was run to identify the demographic, socio-economic and farming characteristics related factors that affect the adaptive capacity of factors to climate change and variability.

Principal Component Analysis

As stated in the research design section this study employs the indicator method which involves a number of correlated variables. Hence principal component analysis is used to reduce the number of variables in to manageable size and to develop the climate change adaptive capacity index of each household.

Principal component analysis (PCA) is a linear dimensionality reduction technique, which identifies orthogonal directions of maximum variance in the original data, and projects the data into a lower-dimensionality space form of a sub-set of the components with highest variance (Deressa et al, 2008).

The principal components method of extraction begins by finding a linear combination of variables (component) that accounts for as much variation in the original variables as possible. It then finds another component that accounts for as much of the remaining variation as possible and is uncorrelated with the previous component, continuing in this way until there are as many components as original variables. Usually, a few components will account for most of the variation, and these components can be used to replace the original variables.

Let $X_1, X_2, X_3 \ldots X_P$ are the original set of p variables under study, and then the first principal component can be defined as:

$$Z_1 = a_{11} X_1 + a_{12}X_2 + a_{13}X_3 + \ldots\ldots\ldots + a_{1p} X_{p,}$$

Where Z_1 is the first principal component and a_i's $_{(i=1,\ 2\ldots\ p)}$ are coefficients of the first principal component as such that variance of Z_1 is as large as possible. The second principal component is defined as:

$$Z_2 = a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + \ldots\ldots\ldots + A_{2P}X_P$$

Where Z_2 is the second principal component and a_i's $_{(i=1,2,\ldots,p)}$ are coefficients of second the second principal component such that Var (Z_2) is as large as possible next to Var (Z_1) and so on.

The aim of using PCA in this study is primarily to construct a composite climate change adaptive capacity index of each household using the first principal component. The adaptive capacity index created through principal component extraction is estimated from standardized indicator values in which every variable is normalized by its mean and standard deviation. Hence the climate change adaptive capacity is also in standardized value. The Standardization is performed automatically by SPSS before running PCA. Suppose $x_{ij}=(x_{ij}-x^*i)/s^*_i$ where x^*_i is the mean of x_{ij} across households s^*_i is its standard deviation.

Once the researcher derived the principal components along with their Eigen values and the factor scores of every variable from the principal component analysis, the adaptive capacity index of every household was calculated. This was done by multiplying the normalized variables with their respective factor score in the first principal component and dividing them by the Eigen value of the first principal components. Since adaptive capacity in this study is considered as access and availability of different types of resources, the adaptive capacity of households is the linear combination of the five types of livelihood assets as specifies and weighted by the first principal component from the PCA. In turn every single type of livelihood assets is a linear combination of its indicator selected by the PCA model. As stated above the first principal component which is expressed as $Z_1 = a_{11} X_1 + a_{12}X_2 + a_{13}X_3+\ldots\ldots\ldots +a_{1p} X_p$, is the index of adaptive capacity of every household and it can be stated as:

$$Z_1 = a_{11} X_1 + a_{12}X_2 + a_{13}X_3+\ldots\ldots\ldots +a_{1p} X_p,$$

$$Z_1 = a_{11} (x_{1j}-x^*_1)/s^*_1 + a_{12} (x_j-x^*_2)/s^*_2+\ldots\ldots\ldots +a_{1p} (x_j-x^*_p)/s^*_{i\,p},$$

Where Z_1 represents the adaptive capacity of a given household, the a_i's are the factor scores and the $(x_{ij}-x^*_i)/s^*_i$'s are the normalized values of each variable. Depending on this conceptualization the following formula is used to calculate the adaptive capacity index of every household.

$$ACI_j=\frac{\sum\left[a_{11}\frac{(x_{1j}-x^*_1)}{s^*_1}+a_{12}\frac{(x_{2j}-x^*_2)}{s^*_2}\ldots\ldots\ldots+a_{1p}\frac{(x_{pj}-x^*_p)}{s^*_p}\right]}{EV_i}$$

Where ACI_j is the overall adaptive capacity index of j household, a_{1i}'s $(i=1,2\ldots p)$ are factor score or loadings of each variables on the principal component, $(x_{1j}-x^*_1)/s^*_1$'s are the normalized variable values of i household on variable on each variable while the EV_i is the Eigen value of the principal component

CHAPTER - FOUR

4 RESULTS AND DISCUSSION

4.1 Characteristics of Sampled Households

This section presents the demographic, socio-economic and farming characteristics of the samples households. Hence it set the perspective in which findings in the subsequent sections should be viewed, because the findings of the study are the manifestations of these characteristics.

4.1.1 Demographic Characteristics

The major demographic characteristics of the samples household collected during the survey are presented in table 1. Accordingly, 21% of the household heads are less than 35 years old, while 74% of the households fall in the age category 33-65 years old and the remaining 5% are beyond 65 years old. In general the minimum and maximum age of household heads in this study is 25 and 78 respectively. There is also a statistically significant age difference among the two agro ecology of the study area at less than 5% level of significance. In the same table, 93 % of the surveyed respondents are males and 7 % are females. Majority of respondents (89%) are married, 8% divorced and 3% single. There is no statistically significant variation in both sex composition and marital status of respondents in the agro-ecologies of the study area.

Table 1: Distribution of respondents by age, sex and marital status

Variable	Kebele of respondents				Total	X^2
	Hatsebo (Dega)		Welel (Kola)			
Age category	Count	%	Count	%		
<35	6	12.0	15	30.0	21	6.114* (df=2, P=0.046)
35 - 65	40	80.0	34	68.0	74	
>65	4	8.0	1	2.0	5	
Total	**50**	**100**	**50**	**100**	**100**	
Sex composition						3.840 (df=1, P=0.112)
Female	6	12.0	1	2.0	7	
Male	44	88.0	49	98.0	93	
Total	**50**	**100**	**50**	**100**	**100**	
Marital status						5.114 (df=2, P=0.078)
Single	1	2.0	2	4.0	3	
Married	42	84.0	47	94.0	89	
Divorced	7	14.0	1	2.0	8	
Total	**50**	**100**	**50**	**100**	**100**	

Source: own field survey, 2011 (Significant at 5% level)*

As far as the family size of surveyed household heads in this study is concerned significant numbers of households (61%) were found to have family greater than 5 members (table, 2).

The average household size of the total sample respondents was found to be 6.1 with standard deviation of 1.972. The size of household is above the national average which is 4.7 and above the regional average which is 4.3 (CSA, 2007). Results of the tested hypothesis for equality of means and frequencies for the two agro ecologies also showed that there is no significant difference.

Table 2: Distribution of respondents by family size

Agro-ecology	**Family size**							
	Category			Mean	St. Dev	Min	Max	X^2
	1-5	**>5**	**total**					
Hatsebo (Dega)	14	36	50	6.32	1.932	1	10	5.086NS (df=2, P=0.2)
Welel (Kola)	25	25	50	5.70	1.982	2	9	
Total	39	61	100	6.01	1.972	1	10	
t-value	1.584 NS (df=98, P=0.116)							

Source: own field survey, 2011

4.1.2 Socio-economic Characteristics

The major socio-economic characteristics of the sampled households is give in table 3.This study classifies respondents educational level in to five categories and accordingly out of the total surveyed households 38% are illiterate,20% can only read and write, 32% completed first cycle, 7% completed secondary cycle and 3% attended college and above.

Table 3: Distribution of respondents by educational level, occupation and wealth status

Variable	**Kebele of respondents**				**Total**	X^2
	Hatsebo (Dega)		**Welel (Kola)**			
Educational level	**Count**	**%**	**Count**	**%**		
Illiterate	24	48.0	14	28.0	38	11.836 NS (df=4, P=0.119)
Read and write only	8	16.0	12	24.0	20	
First cycle	10	20.0	22	44.0	32	
Secondary cycle	6	12.0	1	2.0	7	
Collage and above	2	4.0	1	2.0	3	
Total	**50**	**100**	**50**	**100**	**100**	
Occupation						
Farming only	5	10.0	3	6.0	8	0.543NS (df=1, P=0.45)
Farm and off farm	45	90.0	47	94.0	92	
Total	**50**	**100**	**50**	**100**	**100**	
Wealth status						
Rich	22	44.0	3	6.0	25	26.960** (df=2, P=0.00)
Medium	15	30.0	10	20.0	25	
Poor	13	26.0	37	74.0	50	
Total	**50**	**100**	**50**	**100**	**100**	

*Source: own field survey, 2011 (** Significant at 1% level)*

Table 3, also shows that, 8% of farmers do farming only as a major means of livelihood. While 92% of farmers engaged in off farm activities in addition to their farming activity. Results of the Chi-square test indicate that there is no statistically significant difference in both educational level and occupation of framer's agro ecology wise. As far as the wealth status of the sampled households is concerned, 25%, 25% and 50% were found to be rich, medium and poor respectively. There is a statistically significant wealth disparity in the two agro ecology of the study area. Out of the total samples households living in kola agro ecology 74% are poor, while the proportion of poor people living in the dega part of the study area is only 26%.

The size of land owned by a household lies between 0 and 3.5 hectare with an average farm size of 0.98 hectare (Table, 4). This is equal to the average national arable land holding size per household of which is 0.97ha (CSA, 1994). There is a statistically significant variation in size of land holding per household across the agro ecological zones, where farmers in Hatsebo kebele has better size of land holding.

Table 4: Size of cultivable land

Agro-ecology	**Size of cultivable land holding (ha)**				
	Mean	St. Dev	Min.	Max.	t-value
Hatsebo (Dega)	1.1400	0.56052	.00	3.50	2.935 (df=98, P=0.04)
Welel (Kola)	0.8300	0.49343	.00	2.00	
Total	**.9850**	**.54798**	**.00**	**3.50**	

Source: own field survey, 2011 (Significant at 5% level)*

4.1.3 Farm Characteristics

In table 5, three essential components of the sampled household's farm characteristics are provided. Accordingly, more than half of the respondents (53%) have a long (above 30 years) farming experience, followed by 38% of the surveyed households who have medium(10-30years) farming experience and the rest 9% have a short farming experience ranging from 1-10 years. There is no statistically significance difference between farmers living in dega and kola agro ecology in terms of farming experience.

As far as the type of nature of agriculture practiced by respondent households is concerned, 55% of the respondents reported that they practice a rain fed agriculture only while 45% practiced a mixed type which integrates both rain fed and irrigation. Results of Pearson chi square test indicated that there is a statistically significant difference in the type of agriculture practiced between the two agro ecology. 78% farmers living in the kola Agro ecology of the study woreda found to be dependent on rain fed agriculture only compared to 33 % in the dega agro ecology. This is attributed to the steep and ruggedness of land topography in Welel Kebele (kola).

Table 5: Distribution of respondents by farm experience, type and purpose of agriculture

Variables	Kebele of respondents				Total	X^2
	Hatsebo (Dega)		Welel (Kola)			
Farming experience	**No.**	**%**	**No.**	**%**		
short(1-10 years)	4	8.0	5	10.0	9	0.235 NS (df= 2, P=0.8)
Medium(10-30 years)	20	40.0	18	36.0	38	
Long(above 30 years)	26	52.0	27	54.0	53	
Total	**50**	**100**	**50**	**100**	**100**	
Type of Agriculture						21.374** (df=, P=0.000)
Rain fed	16	32.0	39	78.0	55	
Mixed	34	68.0	11	22.0	45	
Total	**50**	**100**	**50**	**100**	**100**	
Purpose of agriculture						
Subsistence	33	66.0	41	82.0	74	3.326 NS (df=1, P=0.110)
Mixed	17	34.0	9.	18.0	26	
Total	**50**	**100**	**50**	**100**	**100**	

*Source: own field survey, 2011 (** Significant at 1% level)*

Table 5 also indicates the purpose of agricultural activity practiced by respondents and accordingly 74% of respondents do agriculture for subsistence where as the remaining 26% reported to practice agriculture for both subsistence and commercial purposes. Here there is no significant statistical variation in the ago ecologies of the study area.

4.2 Farmers Perception of Climate Change and Variability over the last 30 years

4.2.1 Temperature

About 66% of the respondents reported that there is an increasing trend in the amount of days with highest temperature over the last 30 years. While 22%, 11%, and1% reported decreased, constant and unknown temperature changes trends (Picture, 4). Pearson's chi-square test indicates that there is statistically significant variation in the perception of temperature trends in the two agro ecologies of the study area. Chi square test results (10.788 (df=3, P=0.013)) verified that farmers in the dega agro ecology perceived the change in temperature better than those in kola which statistically significant at 5% level of significance. This can be explained by the fact that farmers in the dega agro ecology (Hatsebo kebele) have experienced cold temperature most of their life, hence they can easily trace the increase in temperature. In addition to this, species such as sheep which are common to kola agro ecology are becoming more common in the dega part which clearly indicates the change in temperature. Whereas farmers in the kola agro ecology have adapted the warmer condition of their locality, and therefore they can't trace the gradual increase in temperature. This argument was further confirmed by the FGD and KI help with participants.

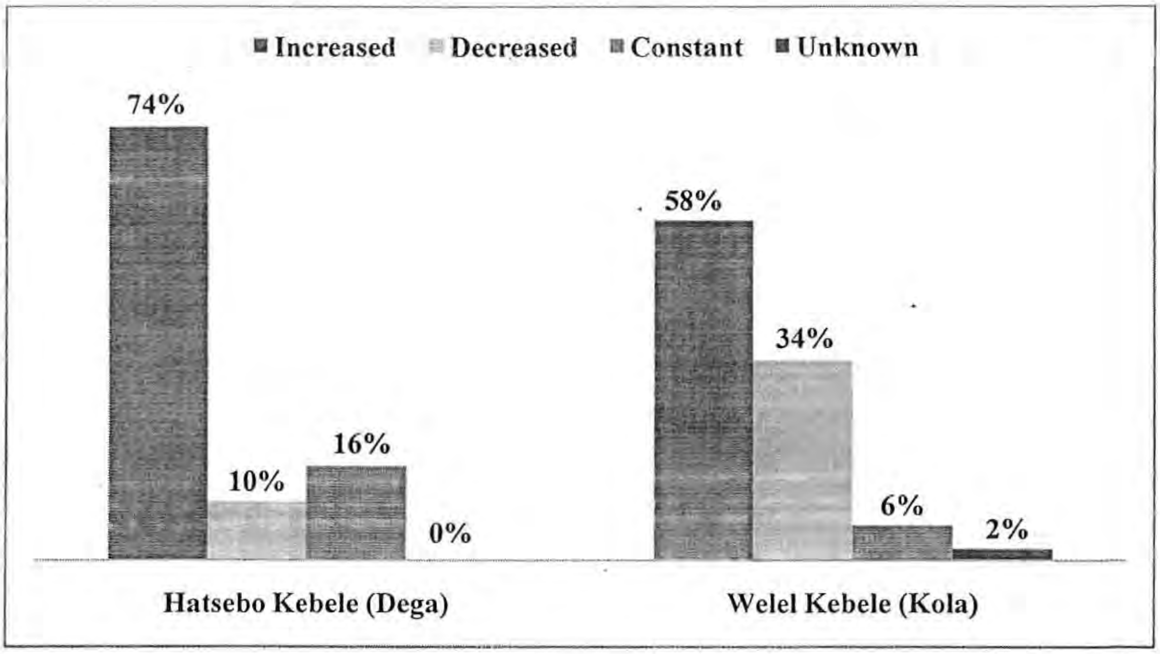

Figure 4: Trends of temperature change over the last 3 decades as perceived by respondents

Source: own field survey, 2011

Changes in the physical structure such as deforestation and erosion, changes in social activities such as clothing, prevalence of new diseases like malaria, and introduction of plants and animals that are new to the area were used as local indicators to trace temperature change by respondents.

Results of FGD and KI confirmed that deforestation, erosion and related environmental degradation are becoming more prevalent. Participants especially those in Hatsebo kebele stated that now there is a need to wear light clothes compared to some years back due to the increasing temperature. According to the participants, the spread of malaria was limited in Hatsebo kebele compared to Welel kebele; however currently it is becoming widely prevalent in Hatsebo kebele. In addition to this, participants of the FGD and KI stated that some cereal crops which are typical of warmer agro ecologies are being introduced to the dega agro ecology. These all as well as the descriptive statistical results are important indicators of the increasing trend of temperature in the study area.

4.2.2 Precipitation

Respondents also stated their observation on the trends of changes in the amount precipitation of their kebele over the past 30 years. As depicted in figure 5, 61% of respondents perceived that there is a decreasing trend of precipitation amount, while 22%, 16% and 1% stated for increasing, constant and unknown trends of precipitation. There is no statistically significant variation in response of respondents about precipitation trends in both agro ecologies.

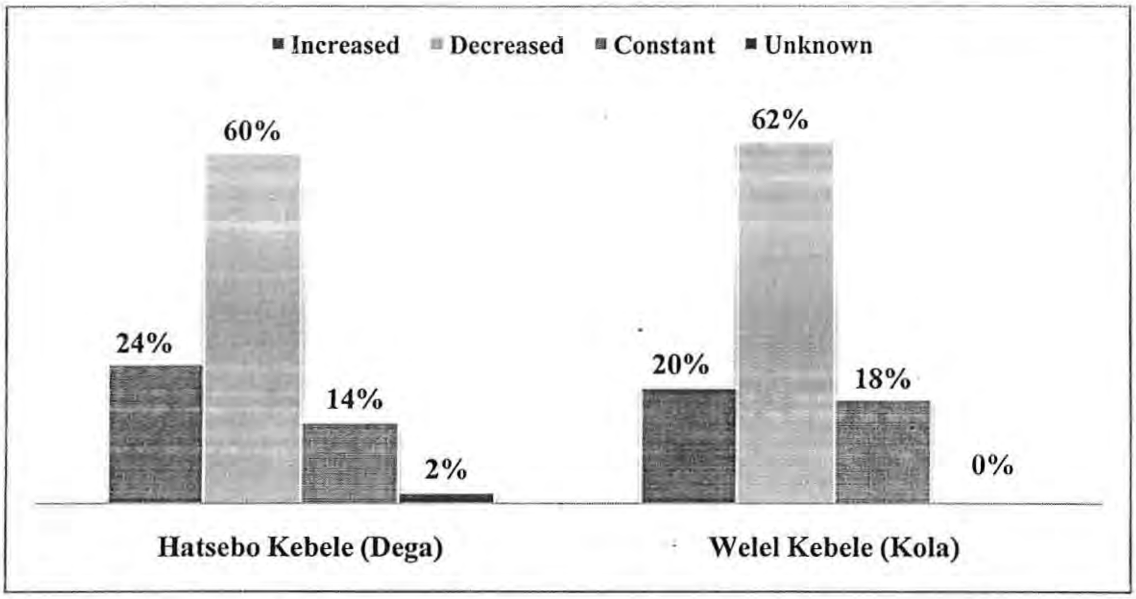

Figure 5: Trends of Precipitation change over the last 3 decades as perceived by respondents

Respondents indicated that they have traced precipitation changes over the required period by local indicators which include loss of plants and animals common to the area, frequency of drought, lack of water availability in water bodies, shortening of growing season and the change in onset of the rainy season. According to the results of FGD and KI, it is becoming difficult to grow cereals which require more rainfall and long growing period due to the decreasing amount of precipitation. They also confirmed that the time gap between consecutive droughts occurred in the course of their life time is becoming short while the beginning of the rainy season is becoming irregular; some time it start earlier and ends in the middle of august and some time it starts late and extends up to the harvesting months, contrary to this it also starts early and stops early. During this time, farmers face damage of their crop due to extended rainfall and problem of shortage of water as a result of the early terminating rainfall. Participants also confirmed that the amount of water reserved in different water bodies sometimes become dried up before the commencement of the rainy season while some times is show a considerable fluctuation after the month of April which caused shortage of drinking water for farmers as well as for their livestock. Depending on the descriptive statistical results of farmer's perception of precipitation change and the discussion results of FGD and KI, there is a decreasing trend in the amount of precipitation in the study area.

4.2.3 Prevalence of Extreme Climatic Events

In addition to the changes in temperature and precipitation respondents also indicated the most commonly prevalent extreme climatic events in their locality. According to table 6, out of the total respondents 66% reported prevalence of drought while 34 % stated for non prevalence of drought. 68% of the surveyed households accounted for prevalence of flooding while 32% goes for absence of flooding. As far as the occurrence of storm is concerned 73% of respondents indicated that there is prevalence of storms which caused series damage on their life. Whereas the remaining 27 reported that there is no significant occurrence of storm in the study area.

Table 6: Prevalence of extreme climatic events over the last 3 decades

Prevalence of extreme climatic event as perceived by respondents	Respondents kebele								Total		X^2
	Hatsebo (Dega)				Wele (Kola)				Yes	No	
	Yes		No		Yes		No				
	count	%	count	%	count	%	count	%			
Drought	22	44	28	56	44	88	6	12	66	34	21.569** (df=1, P=0.000)
Flooding	26	52	24	48	42	84	8	16	68	32	11.765 (df=1, P=0.001
Storm	31	62	19	38	42	84	8	16	73	27	6.139* (df=1, P=0.013)

*Source: own field survey, 2011 (**Significant at 1% level, * Significant at 5% level)*

So as to see the variation of respondents responses on the occurrence of extreme climatic events in the two agro ecologies Pearson's chi square test was run and the result shows a significant difference on the perception of farmers on drought at 1% level. Implying that 88% respondent living in the kola agro ecology reported occurrence of drought and 12% for absence of flooding compared to 44% and 56% of farmers living in the dega agro ecology respectively. In the same token there is statistically significant difference exists in the perception of farmers regarding the prevalence of flooding and storm at 1% and 5% respectively. Out of the total respondents surveyed 84% of farmers in the kola agro ecology reported occurrence of flooding while those who live in the dega agro ecology are 52% and 16% and 48%reported for non occurrence of flooding for the kola and dega ago ecologies respectively. Similarly, 84% and 16% of farmers in the kola agro ecology reported for occurrence and absence of storm respectively. While 62% and 38% of respondents in the dega agro ecology reported for occurrence and absence of storm respectively. The result in table 8 also demonstrates that storm, flooding and drought, is the appropriate sequence of the extreme climatic events according to their relative importance of occurrence in the study area. The argument here is that there is an increasing trend in the occurrences of storm, drought and flooding in the sturdy area.

4.3 Adaptive Capacity of Farmer's to Climate Change and Variability

4.3.1 Key Livelihood Assets

4.3.1.1 Human Capital

A human capital is about the ability of a given household to effectively command and manage labour and it includes health, education, knowledge and skills, capacity to work and capacity to adapt. In this study literacy level, average health condition, average nutrition condition, dependency ration and number of additional children to be born were considered as variables to measure the human capital of households in the study area.

Literacy level

Levels of education and training have a bearing on the capability of the households to adapt to climate change and variability. Educated farm households have better opportunity to get non-farm jobs and they have also better capacity to understand climate related information (Hari et. al, 2010). Moreover families with better literacy level can manage their resources and accept extension services or related adaptation initiatives successfully. As indicated in section 4.1.2 of this study the educational level of the surveyed household is low. Hence, the contribution of the educational level of farmers to the process of adaptation to climate change is limited.

Average household health condition

Good health is vital for everything. As a component of the human capital farmer having good health condition will necessarily have good command of labour as well as effective accomplishment of their farm activities (Howden et. al, 2010). As can be seen in figure 6 only 22% of respondents were found to have better health condition. Significant proportion of respondents (76%) has average health condition while the remaining 2% reported to have health condition below average. As indicated in the table there is no significant difference in the average health condition between the two agro ecologies of the study area.

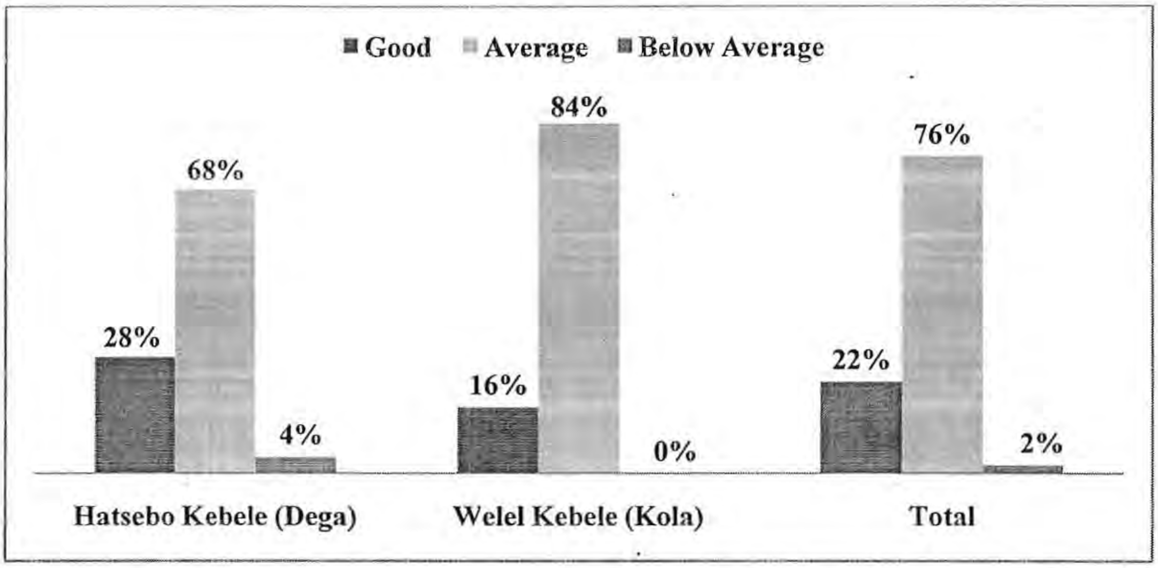

Figure 6: Household's average health condition

Source: own field survey, 2011

This implies that high proportion of farmers in the study area have not good condition of health which will have a negative impact on their adaptive capacity to climate change and variability. Because farmers with poor health status can't pursue other means of income in times of extreme climatic events and they lack general flexibility to effectively invest their labour resource as needed. Hence this will negatively affect their adaptive capacity to climate change and variability.

Household average nutrition condition

Nutrition is essential component in the human capital because it directly or indirectly affects the health and educational level of households. It is when farmers eat balanced diets that they can have good health condition and so that they can effectively invest their labour asset, manages their farming activity and resource they possess (Hari et. al, 2010).) In a way that ensure better adaptive capacity to climate change. In this study nutrition is represented by the household intake frequency of four types of foods. These are meat/chicken/fish, vegetables and pluses, milk and fruits. Respondents were asked to rate their intake frequency of these food items. Their response was summarized in table 7 and accordingly out of the total samples household 9% eat meat/chicken/fish most of the time and 91% eats some time.

The vegetable and pluses item of food is consumed by 7% always, 26% most of the time and 67% sometimes. In case of milk 1%, 10%, and 83% of respondents use it always, mostly and sometimes respectively. As far as the household consumption of fruits is concerned 2% of respondents found to eat always, 7% most of the time, 54% sometimes and the remaining 37% have never consumed at all. The chi square test indicates a statistically significant difference in the consumption of milk and vegetables and pulses between the two agro-ecologies of the study area at alpha .01 and .05 respectively. While 2% and 12% of farmers in Hatsebo kebele use milk at always and mostly bases respectively, there are no farmers who always use milk and only 8% were found to use milk mostly in Welel kebele (Kola). However 92 % of farmers use milk sometimes compare to 74% in Hatsebo kebele. In Hatsebo kebele 12% have never consumed milk at all while all farmers in Welel kebele use milk. Vegetable consumption is slightly better in Hatsebo kebele with 8%, 42% and 50% of farmers in the kebele consuming it at always, mostly and sometimes bases respectively, compared to Wele kebele in which 6%, 10% and 84% of farmers in the kebele use vegetables on always, mostly and sometimes frequency of intake.

Table 7: Household average nutrition condition

Kebele	**Meat/chicken/fish intake frequency**				**Total**	**X^2- Test**
	Always	Mostly	Some times	Never		
Hatsebo	0%	14.0%	86.0%	0%	100%	3.053 NS (df=1, P=0.081)
Wele	0%	4%	96%	0%	100%	
% of Total	0%	9%	91%	0%	100%	
	Vegetable and pulses intake frequency					14.3.2**(df=2, P=0.001)
Hatsebo	8.0%	42.0%	50.0%	0%	100%	
Wele	6.0%	10.0%	84.0%	0%	100%	
% of Total	7.0%	26.0%	67.0%	0%	100%	
	Milk intake frequency					8.376*(df=3, P=0.039)
Hatsebo	2.0%	12.0%	74.0%	.12.0%	100%	
Wele	0%	8.0%	92.0%	0%	100%	
% of Total	1.0%	10.0%	83.0%	0%	100%	
	Fruit intake frequency					6.184 NS (df=3, P=0.103)
Hatsebo	0%	8.0%	64.0%	28.0%	100%	
Wele	4.0%	6.0%	44.0%	46.0%	100%	
% of Total	2.0%	7.0%	54.0%	37.0%	100%	

*Source: own field survey, 2011 (**Significant at 1% level, * Significant at 5% level)*

Generally speaking the consumption of all the food items is very low at always and at mostly frequency of consumption. Significant portion of respondents use the food at sometimes while few respondents consume them at always and mostly cases. This is associated to their low level of income and poverty. Hence the nutrition condition of farmers in the study area is less balanced. This has a direct impact on the health status of farmers. If farmers eat less balanced food they can't have good health if they don't have good health they cannot effectively invest their labour resource in their farm activities and other r non farm income generating activities. Hence they will have low adaptive capacity to climate change and variability

Number of dependants

High percentage of dependants with in a give household reduces the capacity of farmers to adapt to climate change and other related disasters. This is due to the fact that active members of the household will have more burdens to fulfil the need of the dependants. Besides they spend much of their resource in an unproductive activity to take care of the dependants and they cannot invest their labour resource wherever there is demand (Balgis et. al, 2005). As indicated in table 8, the mean number of dependents per household was for both kebeles is 1.37 with standard deviation of 1.228 while .the minimum and maximum number of dependants is 0 and 6 respectively.

A T-Test for the equality of mean was run and there is no statistically significant difference in number of dependents per household between the dega and kola agro-ecologies of the study area. On average every household has less that1.5 dependents and this figure indicates that there are few dependents per each household. This implies that farmers in the study area can peruse different strategies to cope up with climate change and variability such as off farm activity, migration in search for work and resettlement because they have less number of dependents in their household. In addition to this they will have less expenditures and better income as there are more active members of the household who can earn living.

Table 8: Number of dependant per household

Ago ecology zone	**Number of dependant household members**				
	Mean	**Std. Dev**	**Min**	**Max**	**t-value**
Hatsebo	1.560	1.527	0	6	1.558 NS (df=98, P=0.122)
Welel	1.180	0.800	0	4	
Total	1.370	1.228	0	6	

Source: own field survey, 2011

4.3.1.2 Social Capital

Social capital is developed through: networks and connectedness; membership of more formalised groups (governed by mutually-agreed or commonly accepted rules, norms and sanctions); and informal safety nets based upon relationships of trust, reciprocity and exchange (Park et. al, 2009).In this study social capital is conceptualized as the social support which could be readily available to members of the community who are in trouble due to extreme climatic event. To assess the strength of social capital in the study area, respondents were asked to state the amount of financial support they could get from their local social associations and networks of relations.

Availability of support from relatives, friends and extended family member in times of extreme climatic events

The underlying assumption here is that farmers who can get high amount of support from their relatives, friends or extended family members will have better adaptive capacity to climate change and variability (Hari et. al, 2010).

To measure this dimension for social capital in the study area respondents were asked to state the amount of support they can get form their relatives, friends of extended family members. As indicated in table 9, 30% of the surveyed households can get a support greater or equal 50% and above percent of the destructed amount of their properties while 38% of the can get support but less than 50% of the hypothetically destructed property. The remaining 32% cannot get any kind of support from their families. This implies that farm households in the study area fall proportionally in to the category of better support, low support and no supports at all with slight increase in less support followed by no support at all. The chi square test indicates that there if a difference in the amount of available support from close relatives and friends at alpha 0.1 agro-ecology wise. According to the test farmers in Welel kebele have better support from the irrelative, friends and extends family members. According to the information gathered through FGD this due to the reason that the farmers in the kola agro ecology are far from the town of Axum so that they have less exposure the individualistic life style which restricts social connectedness and encourages individualism. While farmers living in Hatsebo kebele are close to the town of Axum and hence they are influences by the individualistic lifestyle so that hindered their close social interdependence. Even though this is the fact participants of the FGD in both kebeles stated that there is a decreasing trend in the interconnectedness of the local society compare to the some years back. This can contribute to the low adaptive capacity of farmers to climate change and variability.

Table 9: Percentage of available support from relatives, friends and extended family members

Variable	**Respondents kebele**		**Percentage of available support**			**Total**
			>50%	<50%	No support	
Suppose any climatic hazard say drought or flooding destructed all your properties, how much percentage of the destructed property could you get from your relatives, friends or extended family members in the form of support?	Hatsebo	Count	13	14	23	50
		% with in	26%	28%	46%	100%
		% of total	43.3%	36.8	71.9	50%
	Welel	Count	17	24	9	50
		% with in	34%	48%	18%	100%
		% of total	56.7%	63.2	28.1%	50%
	Total	Count	30	38	32	100
		% with in	30%	38%	32%	100%
		% of total	100%	100%	100%	100%
X^2	9.290* (df=2, P=0.010)					

*Source: own field survey, 2011 (**Significant at 1% level).*

Percentage of available support from social institutions like Equb, idr and mahber in time of extreme climatic events

Apart from the inter individual, family or relative level of social support households can get support from socially established institutions like in the case of this study Equb, end and mahber (Adger, 2003). As indicated in table 12, 68% of respondents stated that there are social institutions in their locality where as the rest 32% reported for absence of these institutions.

The calculated chi square test demonstrated a statistically significant difference between the availability of social institution in the two agro ecologies of the study area at alpha 0.5. 82% of respondents in Hatsebo kebele indicated availability of social institutions compares to 52% in Welel kebele. Results in table 10 also indicate that, 65.9% and 66.7%of the surveyed households are members of the social institutions in Hatsebo kebele and Well respectively. Despite the considerable difference in the agro ecologies a good deal of households has access to the social support system provided from social institutions such as Equb, idr or mahber. This implies that there is favourable social institutional support which could contribute to the adaptive capacity of farmers to climate change and Variability. Discussion results from FGD show that even though there is good social support system from the social institution now days the role of these institutions is decreasing from time to time. According to the suggestion of the participant it is due to the growing individualistic life style.

Table 10: Percentage of available support from social institution

Respondents kebele		Are there Equb, idr or mahber in your locality?			If yes are you a member of these social institutions?		
		Yes	**No**	**Total**	**Yes**	**No**	**Total**
Hatsebo	Count	41	9	50	27	14	41
	% with in	82.0%	18.0%	100.0%	65.9%	34.1%	100.0%
	% of total	60.3%	28.0	50.0%	60.0%	60.7	41%
Welel	Count	27	23	50	18	9	27
	% with in	54.0%	46.0%	100.0%	66.7	33.3	100.0%
	% of total	39.7	71.9	50%	40.0%	39.1%	41.0%
Total	Count	68	32	100	45	23	68
	% with in	68%	32%	100%	66.2%	33.8.%	100.0%
	% of total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
X^2 – Test		9.007* (df=1, P=0.05)			9.01(df=1, P=0.101)		

Source: own field survey, 2011 (Significant at 5% level)*

4.3.1.3 Natural Capitals

Natural capital consists of land, water and biological resources such as biodiversity (Balgis et. al, 2005). The actual natural resources available to an individual farm household reflects the characteristics of the local resource base and the extent to which the household is able to gain access to these resources, which in turn reflects issues of ownership and entitlements as well as the availability of technologies that make it possible to use the resource potentials (IISD, IUCNNR and SEI, 2003).In this study natural capital of farmers in the study area is the reflection of their land holding size, fertility, slope and irrigation potential, access to water and the size of forest cove they posses.

Land holding size

As indicates in section 4.1.2, Even though it is similar to the national average of land holding the figure by itself is not enough for the livelihood of farmers. Because the current trend of household size is increasing and such size of land cannot support the growing number of household members in the future. Field observation as well as focused group discussion with respondents confirmed that, even now days the land holding size of farmers in the study area is becoming highly fragmented in to small farm plots since they are distributing their actual land to their family members when they get married.

Land soil Fertility

Soil fertility is essential component of the cultivable land of farmers (Hari et. al, 2010). Farmers were asked to state the fertility level of their land as very fertile, fertile, less fertile and poor depending on local criteria and the results were as depicted in the table below. Table 11 indicate that, 2%, 51%, 36% and 5% of the surveyed household have very fertile, fertile, less fertile and poor level of land fertility respectively. This implies that more than half of the respondents have land which could be productive if cultivated well. While the land of 41% of respondent households fall under less fertile and poor fertility level. The remaining 6% are farmers without land. The figure indicates the proportion of farmers who can have low adaptive capacity to climate change and variability as a result of their land's fertility is not minimal.

Hence even if the proportion of farmers holding futile land is more than half a considerable numbers of households have less fertile land. This will affect their productivity and thereby their adaptive capacity to climate change and variability. To see whether there is a difference in land fertility of household's land, Chi square test was conducted and the result demonstrates a statistically significant difference at 1% level of confidence. The land fertility of Hatsebo Kebele (Dega) is more fertile than that of Wele Kebele (Kola). In Hatsebo Kebele the land of 4% of the farmers is very fertile while the land of 90% of the respondents is fertile and only 6% of respondents in the Kebele have less fertile land. In Wele Kebele none of the respondents have fertile land. Out of the sampled house in the Kebele only 12% of respondents have fertile land, 66% have less fertile land and 10% have land with poor fertility. In this Kebele 6 household were also found to have no land at all. This shows that farmers in Hatsebo kebele have better land fertility than those in Welel so does their adaptive capacity to climate change and variability.

Table 11: Soil fertility level of household's land

Respondents kebele		Soil fertility level of household's land				Total
		Very fertile	Fertile	Less fertile	Poor	
Hatsebo	Count	2	45	3	0	50
	% with in	4%	90%	6%	0%	100%
	% of total	2%	45%	3%	0%	50%
	Count	0	6	33	5	44[a]
Welel	% with in	0%	12%	66%	10%	88%[a]
	% of total	0%	6%	33%	5%	44%[a]
Total	Count	2	51	36	5	94[a]
	% with in	2%	51%	36%	5%	94%[a]
	% of total	100%	100%	100%	100%	94%[a]
X^2	67.824* (df=4, P=0.000)					

Source: own field survey, 2011(Significant at 5% level, [a] there are 6 households with 0 hectare land holding)*

Slope of land

The slope of a land has a paramount effect on the agricultural activity of a give household. Households whose land is steep can be easily susceptible to risks of climate change such as flooding, soil erosion and the like. In addition to this steep sloped land is not suitable for intensified agricultural activities such as irrigation which is one of the adaptation mechanisms to climate change and variability. In this study farmers were asked to rate the slope of their land in to three categories steep, gentile and plain.

According to table 12, out of the total surveyed households 20%, 37% and 37% of respondents reported that the slope of their land is plain, gentle and steep respectively with 6 household having no land at all. Which indicates higher proportion of respondents land is in the category of gentle and steep slope. More interesting is the result of chi-square test which reflected a significant variation in the slope of household's land at 1% confidence level. Out of the total surveyed households in Welel kebele, only 2% have plain sloped land are compared to Hatsebo kebele in which 38% of respondents have pain slopped land. Only 12% of the households in Welel kebele have a land with gentle slope where as 50% of respondents in Hatsebo kebele have gentle sloped land. Moreover most of farmers in Welel kebele (62%)

have a steep slopped land in Hatsebo kebele however only 12% of the surveyed household have a steep sloped land. This clearly indicates that the general slope of Welel kebele is steeper that of Hatsebo kebele. This was further confirmed by the researcher's field observation. Hence, farmers in Welel kebele have land resource easily susceptible to environmental hazards such as erosion, flooding etc than the land of farmers in Hatsebo kebele. Besides, their land is not suitable for irrigation and other agricultural development related activities due to its steepness. This will negatively affect the adaptive capacity of farmers of the study area to climate change and variability. Such negative effect will be more prevalent in Welel kebele.

Table 12: Average slope of household's land

Respondents kebele		**Average slope of household's land**			**Total**
		Plain	**Gentile**	**Steep**	
Hatsebo	Count	19	25	6	50
	% with in	38%	50%	12%	100%
	% of total	19%	25%	6%	50%
Welel	Count	1	12	31	44[a]
	% with in	2%	24%	62%	88%[a]
	% of total	1%	12%	31%	%[a]
Total	Count	20	37	37	94[a]
	% with in	20%	37%	37%	94%[a]
	% of total	100%	100%	100%	100%
X^2	43.659**(df=3, P=0.000)				

Source: own field survey, 2011 (***Significant at 1% level,* [a] there are 6 households with 0 hectare land holding)

Water availability and accessibility

Water is one of the vital components of natural resources. The importance of water for the farming community is unquestionable (Indur, 2008). To assess the availability of water in the study area focused group discussion was held on both kebeles. In the discussion participants were asked whether the water bodies in the study area last with available water from the rainy season to rainy season. Accordingly farmers in Welel kebele stated that the water bodies in the study area show a considerable reduction after the month of April and in some years they becomes dried up. During this time they faced problem of water shortage for themselves and their livestock. Contrary to these farmers in Hatsebo kebele discussed that there is no shortage of water through the year except in times extreme climatic events such as drought. In addition to this farmers in Hatsebo stated that water could be easily obtained by digging few meters inside the soil while farmers in Welel explained that they have to dig more than 12-15 meters inside the land to get water. This shows that there is a considerable difference in the availability of water in the two agro-ecologies. This can hinder the irrigation potential of farmers in Wele kebele and so does to their adaptive capacity to climate change and variability. The result of discussion were triangulates with the key informant interviews with the extension workers and development agents working in both kebeles. The interviews also demonstrated similar results.

Forest cover

The forest resources play an essential role in the ecological balance of a given ecosystem. If a significant portion of a household's is covered with forest there will be less erosion, enhanced infiltration and water percolation. This in turn increases the productivity of households' land. In addition to this it maintains a healthy system by creating smooth environment to different elements of biodiversity (Venema et. al, 1997). In this study the amount of forest cover in each surveyed household was collected as reported by the respondents.

As depicted in table 13, the mean size of forest cove in a households land was found to be 0.119 hectare with standard deviation of 0.22 the maximum and minimum forest cover size are 0 and 1.25 hectare respectively. There is no statistically significant difference in the amount of forest cover in both agro-ecologies of the study area. From the results in the table it can be seen that there is low forest cove in the study area which reduces soil quality and enhances erosion frequency in farmers' land. Hence farmers will be easily susceptible to climate change related hazards. Such a condition reduces the adaptive capacity of farmers to climate change and variability.

Table 13: Size of forest cover in household's land

Ago ecology zone	Size of forest cover in household's land				
	Mean	St. Dev	Min	Max	t-value
Hatsebo	0.146	0.316	0.00	1.250	1.041 NS (df=98, P=0.301)
Welel	0.091	0.205	0.00	1.250	
Total	0.119	0.266	0.00	1.250	

Source: own field survey, 2011

4.3.1.4 Physical Capitals

Physical capital comprises the basic infrastructure and producer goods needed to support livelihoods. Infrastructure consists of changes to the physical environment that help people to meet their basic needs and to be more productive; producer goods are the tools and equipment that people use to function more productively. Infrastructures can include: affordable transport; secure shelter and buildings; adequate water supply and sanitation; clean, affordable and energy; and access to information and communications (Park et. al, 2009, Indur, 2008). Adequate availability and standard quality of these components of physical capital enhances the adaptive capacity of local peoples to climate change and variability.

Hence in this study assessment of physical capital for the study area was conducted on the basis of selected indicators and it is presented as below.

Livestock ownership

As in Regmi (2007), in this study also the number of livestock owned by a given farm household is considered as an important component of physical capital, which acts as a store of wealth and buffer against bad times in this case climate change and variability.

As illustrated in table 14, Cattle, goat, sheep, donkey, mule, horse, bee colony and camel are the major types of livestock in the study area. The average cattle per household for the sampled household was found to be 3.64 with a standard deviation of 2.158 both the minimum and maximum cattle owned being 0 and 11 respectively. The maximum and minimum number of goats owned per household is 0 and 35 respectively while the average ownership is 4.67 at a standard deviation of 6.337. For the sampled households the mean number of sheep owned is 2.55 with a standard deviation of 4.00. The minimum and maximum number of sheep owned is 0 and 35 respectively.

Table 14: Number of livestock owned

Livestock type	Kebele	Min	Max	Mean	Std.dev	T-value
Cattle	Hatsebo	0	6	3.0200	1.74368	-2.986** (df=98, P=0.004)
	Welel	0	11	4.2600	2.36307	
	Total	0	11	3.640	2.158	
Goat	Hatsebo	0	6	0.84	1.765	-7.569** (df=98, P=0.000)
	Welel	0	35	8.50	6.935	
	Total	0	35	4.670	6.337	
Sheep	Hatsebo	0	18	3.92	4.575	3.628** (df=98, P=0.000)
	Welel	0	15	1.18	2.753	
	Total	0	18	2.550	4.001	
Donkey	Hatsebo	0	3	0.98	0.714	1.129 (df=98, P=0.262)
	Welel	0	2	0.84	0.510	
	Total	0	3	0.910	0.621	
Mule	Hatsebo	0	1	0.020	0.143	-0.564 (df=97, P=0.574)
	Welel	0	1	0.04	0.198	
	Total	0	1	0.030	0.172	
Horse	Hatsebo	0	0	0.000	0.000	
	Welel	0	0	0.000	0.000	
	Total	0	0	0.000	0.000	
Bee colony	Hatsebo	0	11	1.550	3.470	1.071 (df=97, P=0.287)
	Welel	0	11	0.920	2.284	
	Total	0	11	1.230	2.934	
Camel	Hatsebo	0	0	0	0	
	Welel	0	1	0.190	0.394	
	Total	0	1	0.190	0.394	

*Source: own field survey, 2011 (**Significant at 1% level)*

A statistically significant difference in the number of cattle, goat and sheep owned was identified through the t-test of means at 5%, 1% and 1% respectively. According the test respondents in Wele kebele have better possession of cattle and goats while those in Hatsebo kebele have better possession of sheep. This is due to the agro ecological suitability of kola to goat and dega to sheep. As far as donkey, mule and camel are concerned the average number of ownership is 0.91, 0.03 and 0.39 respectively while the minimum possession per household is 0 the maximum possession is 3, 1 and 1 respectively. No households were found to report to own horse in both kebeles.

The other important livestock variety assessed is bee colony. The average number of bee colony per household was found to be 1.23 with a standard deviation of 2.93 and the minimum and maximum is 0 and11 respectively. There is no statistically significant variation in the ownership of donkey, mule, and camel and bee colony.

Agricultural technology

Agricultural technology enhances the productivity and adaptive capacity of farmer's to climate change and other related hazards. Even though agricultural technologies can include many things in this study it is represented by farmer's access to fertilizer, pesticides and improved seeds. The distance travelled by a given household to get these technological inputs was used as a proxy to access.

Table 15: Distance travelled to get agricultural inputs

Respondents kebele		**Distance travelled to get agricultural inputs**			**Total**	**X^2**
		≤4 Km	**5-9Km**	**≥10Km**		
Hatsebo	Count	37	13	0	50	63.721**(df=2, P=0.000)
	% with in	74.0%	26.0%	0.0%	100.0%	
	% of total	100.0%	30.2%	0.0%	50.0%	
Welel	Count	0	30	20	50	
	% with in	0.0%	60.0%	40.0%	100.0%	
	% of total	0.0%	69.8%	100.0%	50.0%	
Total	Count	37	43	20	100	
	% with in	37.0%	43.0%	20.0%	100.0%	
	% of total	100.0%	100.0%	100.0%	100.0%	

*Source: own field survey, 2011 (**Significant at 1% level)*

Deressa et. al (2008), used the criteria that farmers within 1-4Km of the centre of provision of the above agricultural in puts are less vulnerable to climate change and variability in terms of technology. This concept is adapted in this study and as can be seen in table 15, only 37% of the surveyed house hold are within the range of 1-4Km from the centre of provision fertilizers, pesticide and improved seeds. While 34% and 20% are 5-9Km and ≥10Kms away from the centre of provision of these agricultural inputs. This indicates that a great deal of farmers have limited access to the agricultural technologies and this will necessarily bear a negative effect on their adaptive capacity to climate change and variability; due to the fact that they can't get the technological inputs whenever they need as a result of the distance barrier. Chi square test result also indicates that there is a statistically significant difference in access to the agricultural technologies in the two agro ecologies of the study area at alpha 0.01, in which no farmer from Welel kebele is within the range of 1-4Km of the supply centre of the agricultural technologies, hence farmers in Hatsebo kebele have better adaptive capacity to climate change and variability.

Ownership of radio

This day's information is a great power. Farm households should get information related to climate change and variability, market and other data which are essential to their day to day life. When farmers get timely, credible and indispensible information they can adjust according to the changes in climate or market related changes (Wall & Marzall, 2006). Hence the ownership of electronic devices such as radio is central to this argument. Households having radio can follow up current information by updating and keeping track of events. This will enhance their adaptive capacity to destructive changes like climate change and variability.

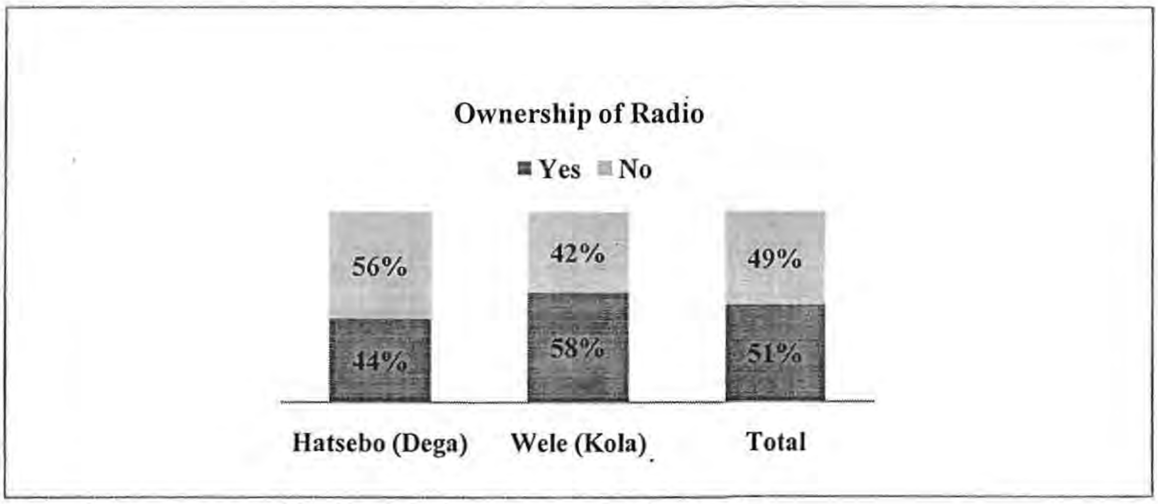

Figure 7: Ownership of Radio

Source: own field survey, 2011

Picture 7, indicates that only 49% of the respondents in both kebele have radio while more than half (51%) are with no radio. This indicates that a great deal of farmers have no adequate access to information regarding climate change and other pertinent issue to the agricultural sector. This is a bottleneck to the adaptation process of farmers to climate change and variability. Because, if farmers have no adequate information regarding weather and climate condition of their locality and other important issues (marketing, politics etc.), they cannot take necessary adjustments to changes in climate, market situation, politics etc. Hence they become vulnerable to the impacts of climate change and variability. There is no significance difference in the ownership of radio in the two agro ecologies of the study area.

Access to telephone service

Availability of telephone facilitates quick exchange of information between farm households and any focus of their interest. Through it they can get information regarding climate change, production, supply and demand of agricultural products (market) etc. In addition to that farmers can get support in times of hardship from their relatives or else where they can by communicating through telephone (Deressa et. al, 2008).

Table 16 indicates that, 50% of the surveyed household have access to telephone service. This implies that farmer in the study area have low level of telephone service due to poverty and lack of adequate telecommunication service. Hence they will have low adaptive capacity to climate change and variability. This result is line with the findings of the FGD and KI. Participants of the FGD and KI stated that they were unable to get telephone service due to lack of the infrastructure and poverty. According to participants' lack of telephone service have impacted their life by limiting their access to market information and by undermining the possibility of getting support from their relative who are living in some other areas. The results show a statistically significant difference in the two kebeles at alpha less than 0.01 levels. In Hatsebo kebele, 66% of respondents have access to telephone service compared to Welel kebele which are 34%. Hence farmers in Hatsebo kebele have better access to information and there by better adaptive capacity to climate change and variability.

Table 16: Access to telephone service

Respondents kebele		**Telephone service**		**Total**	**X^2**
		Yes	**No**		
Hatsebo	Count	33	17	50	10.240** (df=1, P=0.001)
	% with in	66.0%	34.0%	100.0%	
	% of total	66.0%	34.0%	50.0%	
Welel	Count	17	33	50	
	% with in	34.0%	66.0%	100.0%	
	% of total	34.0%	66.0%	50.0%	
Total	Count	50	50	100	
	% with in	50.0%	50.0%	100.0%	
	% of total	100.0%	100.0%	100.0%	

*Source: own field survey, 2011 (**Significant at 1% level)*

Access to health care service

Climate change and other hazards often cause a number of complications to the health status of the farm households. Due to climate change disease outbreak such as malaria could happen or farmers could be injured due to flooding. Hence availability of health care service in their locality is essential to cure their health problem (Deressa et. al, 2008). In addition to this, farming communities should be able to periodically check their health condition so that they can effectively accomplish their farm activities and they can productively manage their labour resource.

Like for the other infrastructures this study used distance travelled to get the nearest health post was used as proxy for access to health care service. Table 17 indicates that, the residence of more than half of the respondents (62%) is locates with in a distance of 1-4Km of the nearest health post. The residence of 36% of the respondents is found within 5-9Km distance of the nearest health post. Only 2% of the respondents' residence is 10 or more Km far away from the nearest health post. Hence a good deal of the respondents has easy access of health care service whenever they need.

Table 17: Distance travelled to the nearest health post

Respondents kebele		Distance travelled to the nearest health post			Total
		≤4 Km	5-9Km	≥10Km	
Hatsebo	Count	43	7	0	50
	% with in	86.0%	14.0%	0.0%	100.0%
	% of total	69.4%	19.4%	0.0%	50.0%
Welel	Count	19	29	2	50
	% with in	38.0%	58.0%	4.0%	100.0%
	% of total	30.6%	80.6%	100.0%	50.0%
Total	Count	62	36	2	100
	% with in	62.0%	36.0%	2.0%	100.0%
	% of total	100.0%	100.0%	100.0%	100.0%
X^2	24.735** (df=2, P=0.000)				

*Source: own field survey, 2011 (**Significant at 1% level.*

Chi square results however indicates that there is a statistically significant difference in the distance of respondents residence from the nearest health post in the two agro ecologies of the study area at alpha 0.01. In Hatsebo kebele the residence of 86% of respondents is within 1-4Km of the nearest health post while only 38% of the total surveyed households in Welel kebele live within this range of distance. The remaining 14% of respondents in Hatsebo kebele are found 5-9 Km distance from the nearest health post, in Welel kebele significant percentage of respondents (58%) live within this range of distance. And all those that live within 10 and above Km far from the nearest health post are from Wele kebele. This reflects that farmers living in Hatsebo kebele have better access to the nearest available health post.

According to this, farmer in Welel kebele will have low adaptive capacity to disease and injuries related to climate change and variability or other health problems.

Access to road

Road infrastructure plays an important role in the life of farming community. If there are sufficient and standard roads available for a give farm community, farmers can easily produce, distribute and market their products. In addition to this road network facilitates effective distribution of aids and materials in times of hardship from disaster prevention and preparedness offices or related institutions (DFID, 1999). In this study two aspects of road infrastructure were used to assess respondent's access to road. The type of road and distance travelled to reach to the nearest available road.

Table 18 indicates that, few percentage (38%) of respondents have access to all weather road. The rest 62% of respondents use seasonal roads which only serve in the dry season. When this figure is disaggregated in to level of agro ecologies 72% of the respondents in Hatsebo kebele have access to all weather road compared to only 2% in Welel kebele. This shows that most respondents in Hatsebo kebele have access to better quality road than those living in Welel kebele.

Table 18: Access to road

Respondents kebele		Type of road			Distance to nearest road			Total
		All weather	Seasonal	Total	≤4 Km	5-9Km	≥10Km	
Hatsebo	Count	36	14	50	46	3	1	50
	% with in	72.0%	28.0%	100.0%	92.0%	6.0%	2.0%	100.0%
	% of total	94.7%	22.6%	50.0%	78.0%	17.6%	4.2%	50.0%
Welel	Count	2	48	50	13	14	23	50
	% with in	4.0%	96.0%	100.0%	26.0%	28.0%	46.0%	100.0%
	% of total	5.3%	77.4%	50.0%	22.0%	82.4%	95.8%	50.0%
Total	Count	38	62	100	59	17	24	100
	% with in	38.0%	62.0%	100.0%	59.0%	17.0%	24.0%	100.0%
	% of total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
X^2 – Test		49.006 **(df=1, P=0.000)			45.742** (df=2, P=0.000)			

*Source: own field survey, 2011 (**Significant at 1% level)*

The difference is statistically significant difference at an alpha 0.01. In terms of the distance of respondent's residence to the nearest road 59%, 17% and 24% of the surveyed households are found at a distance of ≤4Km, 5-9 Km and ≥10Km respectively. This also indicates that more than half of the surveyed households are found within ≤4Km from the nearest available road. However there is a statistically significant difference in distance of respondents residence from the nearest available road at an alpha of 0.001. In Hatsebo kebele 92%, 6% and 2% of the surveyed households are found at a distance of ≤4Km, 5-9 Km and ≥10Km respectively. In Welel kebele on the other hand 26%, 28% and 46% of the surveyed households are found at a distance of ≤4Km, 5-9 Km and ≥10Km respectively. This indicates that significant proportion of respondents in Hatsebo kebele live in short distance from the nearest road while the reverse is true for those in Wele kebele.

Generally farmers in the study area have good access to road infrastructure which facilitates their production, distribution and marketing of their agricultural products or communication. This in turn enhances their adaptive capacity to climate change and variability. The result also demonstrates that farmers in Hatsebo kebele have better access to road and thereby better adaptive capacity to climate change and variability than farmers in Welel kebele.

Market

Availability of market in which farmers could trade their necessities is essential for farmers to adapt to different hazards and shocks. In times of extreme climatic events for instance farmers could buy foods or other related basic requirements by using their savings or by selling their livestock and/or properties in the market. Hence they will adapt to that extreme climatic event which could be either drought or flooding (Hari et. al, 2010).

In this study market is considered like the other infrastructures and its availability is measured in terms of its distance from the respondent's residence. Accordingly table 19 indicates that, 42%, 34% and 24% of the respondents are found in a distance of ≤4Km, 5-9 Km and ≥10Km respectively from the nearest market. This reflects that the percentages of respondents with good access to market are few and hence market availability is highly limited due to the distance of household's residence.

Table 19: Access to market

Respondents kebele		**Distance from the nearest market**			**Total**
		≤4 Km	**5-9Km**	**≥10Km**	
Hatsebo	Count	42	8	0	**50**
	% with in	84.0%	16.0%	0.0%	**100.0%**
	% of total	100.0%	23.5%	0.0%	50.0%
Welel	Count	0	26	24	50
	% with in	.0%	52.0%	48.0%	100.0%
	% of total	.0%	76.5%	100.0%	50.0%
Total	Count	42	34	24	100
	% with in	42.0%	34.0%	24.0%	100.0%
	% of total	100.0%	100.0%	100.0%	100.0%
X^2	75.529** (df=2, P=0.000)				

*Source: own field survey, 2011 (**Significant at 1% level)*

The chi square results demonstrated a significant difference in the availability of market in the two kebeles in which 84%, 16% and 0% of respondents in Hatsebo kebele are found at a distance of ≤4Km, 5-9 Km and ≥10Km respectively, while 0%, 52% and 48% of respondents in Wele kebele are found at a distance of ≤4Km, 5-9 Km and ≥10Km respectively. Hence farmers in Hatsebo kebele have better availability of market than those in Welel due to the relative distance from the market.

Generally however farmers in the study area have low adaptive capacity to shocks such as drought and famine due to the limited access to market. But most of farmers in Hatsebo kebele have better access to market, so that they will also have better adaptive capacity to climate change and variability.

Micro finance institutions

Availability microfinance institution in a given locality of farm community plays a key role in supporting efforts of climate change adaptation. Farmers can get financial resources in the form of loans or other different forms so as to diversify their range of livelihood strategies. If farmers diversify their livelihood strategies they will develop autonomy from excessive dependence on rain fed agriculture hence they will probably have better adaptive capacity to climate change and variability (Hammill et. al, 2008).

In this study farmers were asked whether there is microfinance institution in their locality and their response is summarized in table 20. Accordingly out of the total surveyed households 98% stated that they have access to micro institutions. This is an indication of the adequate availability of micro finance institution in the study area. Therefore there is sufficient enabling environment to build strong adaptive capacity to climate change and variability by diversifying the limited livelihood strategies of farmers in the study area through the financial resources available to farm households in the microfinance institutions. There is no statistical difference in availability of microfinance institutions in the agro-ecology of the study area.

Table 20: Access to microfinance institution

Respondents kebele		**Availability of microfinance institution**		**Total**
		Yes	No	
Hatsebo	Count	48	2	50
	% with in	96.0%	4.0%	100.0%
	% of total	49.0%	100.0%	50.0%
Welel	Count	50	0	50
	% with in	100.0%	0.0%	100.0%
	% of total	51.0%	0.0%	50.0%
Total	Count	98	2	100
	% with in	98.0%	2.0%	100.0%
	% of total	100.0%	100.0%	100.0%
X^2	2.041 (df=1, P=0.153)			

Source: own field survey, 2011

4.3.1.5 Financial Capitals

Financial capital denotes the financial resources that people use to achieve their livelihood objectives. There are two main sources of financial capital which contribute to consumption and production: available stocks and regular flows of money. The notion of financial capital has been included in livelihood analysis to reflect the importance of the availability of cash or equivalent in enabling people to adopt different livelihood strategies. In this study available stock is represented by households' amount of saving in the form of cash and jewellery and regular flow of money is represented by credit availability, government support and remittance. All these are source of finance to the household which could be utilized in times of hazard (DFID, 1999).

Table 21 indicates household's current amount of saving, credit availability per year, amount of government support and annual amount of remittance available. Accordingly the average amount of current saving per household was found to be 36959.6. The maximum amount of saving per household is 128000.00 Birr and the minimum is 15000.00. Even though the mean saving is good the standard deviation is 25, 290.88 which indicate a widespread variation in current amount of household saving stock. Farmers in Hatsebo kebele have higher amount of current amount of saving than those in Welel kebele which is significant at less than 0.01 levels.

The average amount of credit that a given household can get is 7610.0000 birr with standard deviation of 4160.15 birr the maximum and minimum amount of credit available being 13000.00 birr and 0.00 birr respectively. In terms of credit availability also farmers in Hatsebo kebele are better off than farmers in Welel kebele at less than 0.01 levels of significance.

Farm households in the study area get government support in the form of safety net, food aid, pension etc and according to the results from the survey data the average financial amount of money that a given household can get from government as a support is 884.5050 birr with standard deviation of 1011.72216 birr. The standard deviation is more than the average which demonstrates low level of government support. The maximum and minimum amount of government support per household per year is 4200.00 birr and 0 birr respectively. In case of government support again respondents in Hatsebo get the maximum amount of government support but the average amount of government support is higher in Welel kebele. The difference is significant at 0.01 levels.

As far as the amount of remittance a household can get per year is concerned, the average amount of remittance for the surveyed households is 332.00 birr with a standard deviation of 876.73407 birr while the maximum and minimum amount of remittance per household per year is 4000.00 birr. From one can understand that the amount of remittance available for the surveyed household is very low. Despite the low amount of remittance farmers in Hatsebo kebele get better remittance than those living in Wele at less than 0.01 levels of significance.

Table 21: Household financial capital stock

Financial sources	Kebele	Min	Max	Mean	Std.dev	T-value
Current saving	Hatsebo	1500.00	128000.00	44217.30	26480.93	2.982** (df=98, P=0.004)
	Welel	4540.00	101800.00	29702.08	21990.35	
	Total	1500.00	128000.00	36959.69	25290.88	
Availability of credit per year	Hatsebo	0.00	13000.00	7610.00	4320.44	5.403** (df=98, P=0.000)
	Welel	0.00	10000.00	3644.00	2876.73	
	Total	0.00	13000.00	5627.00	4160.15	
Government support per year	Hatsebo	0.00	4200.00	461.01	881.88	-4.591** (df=98, P=0.000)
	Welel	0.00	4000.00	1308.00	961.42	
	Total	0.00	4200.00	884.51	1011.72	
Remittance per year	Hatsebo	0.00	4000.00	604.00	1105.45	3.249** (df=98, P=0.002)
	Welel	0.00	3000.00	60.00	424.26407	
	Total	0.00	4000.00	332.00	876.73407	

*Source: own field survey, 2011 (**Significant at 1% level)*

4.3.2 Results from the Principal Component Analysis

As explained above PCA was run on the indicators using SPSS version 15. Results from the PCA of the data set on adaptive capacity indicators revealed seven components with Eigen values greater than 1. These seven components explain 65.7% of the total variation in the data set. The first principal component explained 22.7% of the whole variance and 34.6% of the amount of variance explained by the seven principal components (see appendix 1 table 4). Based on the earlier logic for the use of PCA in constructing indices, the first principal components, which explained the highest amount of variance in the data set is considered. The factor scores of the first principal component for each variable categorized by the type of livelihood asset are giving in table 22.

The appropriateness or good of fit of the model produced by the principal component analysis was tested by against the commonly agreed criteria's. Primarily the principal components should at least explain 50% 0f the total variance in the data (Carla et. al, 2003), and the results of the PCA fulfils this requirement which is 65.7% (see appendix 1 table 4). Moreover the anti-image correlation matrix (sampling adequacy) of each variable is expected to be greater $\geq|0.5|$; the result of this analysis range from 0.504-0.852, which in indicates the relevance of the model (see appendix 1 table 2). In addition to this the overall sampling adequacy (Kaiser-Meyer-Olkin Measure of Sampling Adequacy) of the whole data is 0.746 which is significantly beyond the minimum requirement of 0.5 (see appendix 1 table 3)

The o test on the appropriateness of the model to the data is done through the assessment of the commonalities. Communalities indicate the amount of variance in each variable that is accounted for. They are of two types, initial and extraction commonalities. Initial communalities are estimates of the variance in each variable accounted for by all components or factors. For principal components extraction, this is always equal to 1.0 for correlation analyses. Extraction communalities are estimates of the variance in each variable accounted for by the components. The value of the extraction commonalties should at least be 0.5, if the extracted components are to represent the variables well. The extraction commonalities for this study range from 0.520 - 0.828 (see appendix 1 table 1), indicating that the extracted component represent the original data well.

Table 22: Factor scores of the first principal component

Category of indicator	Adaptive capacity indicator	Factor score
Human capital	Literacy level	**0.357**
	Average health condition	**0.275**
	Average nutrition condition	**0.762**
	Household level dependency ratio	**-0.018**
	Number of additional children to be born	**-0.623**
Social capital	Availability of support from relatives, friends or members of family	**0.141**
	Availability of support from social institution (Equb, idr or mahber)	**0.267**
	willingness to resettle and migrate in case of extreme	**-0.585**
Natural capital	Water availability and accessibility	**0.238**
	Size of cultivated land	**0.551**
	General condition of land (Fertility and slope)	**0.749**
	Irrigation potential	**0.681**
	Size of forest	**0.152**
Physical capital	Ownership of livestock	**0.196**
	Dwelling condition	**-0.002**
	Access to road	**0.770**
	Distance to the nearest health post	**0.372**
	Extent of telephone service	**0.499**
	Ownership of radio	**0.506**
Financial capital	Current amount of saving in the form of cash and jewellery	**0.573**
	Credit availability	**0.456**
	Annual amount of government support	**-0.392**
	Remittance	**0.498**
	Eigen value	**5.228**
	Percentage of variance in the whole data	**22.730**
	Percentage of variance with in the principal components	**34.608**

The above factor scores are then used to construct the index of adaptive capacity to climate change and variability of each household using of the following formula which is clearly described in chapter three.

$$ACI_j = \frac{\sum\left[a_{11}\frac{(x_{1j} - x^*_1)}{s^*_1} + a_{12}\frac{(x_{2j} - x^*_2)}{s^*_2} \ldots\ldots + a_{1p}\frac{(x_{pj} - x^*_p)}{s^*_p}\right]}{EV_i}$$

(0.357) (Literacy level) + (0.275) (health condition) + (0.762) (nutrition condition) + (-0.018) (Dependency ratio) + (-0.623) (Children to be born) + (0.141) (availability of support from nearby relatives) + (0.267) (availability of support from social institutions) + (-0.585) (willingness to resettlement/migration) + (0.238) (water availability and accessibility) +(0.551) (size of cultivable land) + (0.749) (fertility and slope of land) + (0.681) (irrigation potential) + (0.152) (size of forest cover) + (0.196) (ownership of livestock) + (-0.002) (dwelling condition) +(0.770) (access to road) + (0.372) (distance to nearest health post) + (0.499) (Telephone service) + (0.506) (ownership of radio) + (0.573)(Current saving) + (0.456)(credit availability) + (-0.392)(government support) + (0.498) (remittance).

After multiplying the normalized variables values of each household by the factor loading/score (as in the above), the result is divided by the Eigen value of the principal component that is 5.228. Then this will be the adaptive capacity index of the household. For instance the adaptive capacity index value of the first household in the sample survey from Hatsebo kebele is calculated as:

$$\frac{\left(\begin{array}{l}(0.357*0.65) + (0.275*-0.04) + (0.762*1.00) + (-0.018*-1.16) + (-0.623*-0.43) + (0.141*-1.05) + (0.267*-0.55) + (-\\ 0.585*-0.90) + (0.238*.68) + (0.551*0.94) + (0.749*1.20) + (0.681*1.12) + (0.152*3.31) + (0.196*0.48) + (-0.002*-\\ 0.37) + (0.770*0.23) + (0.372*0.66) + (0.499*-1.17) + (0.506*1.02) + (0.573*-0.18) + (0.456*-0.63) + (-0.392*-0.63)\\ + (0.498*-0.38)\end{array}\right)}{5.228}$$

Adaptive capacity index of respondent $_{01}$ = **<u>0.852</u>**

The adaptive capacity index of all the samples households was calculated following similar procedure. The values of the household adaptive capacity index for the study area ranges from -1.769 to 2.383. This is graphically depicted in figure there blow. Figure 8 indicates that significant parts of the values from the index are well below zero and slightly skewed towards the negative values in the normal distribution. This result was used to further analyse the adaptive capacity of farmers in relation to their agro-ecology and to create the adaptive capacity group of farmers to climate change and variability.

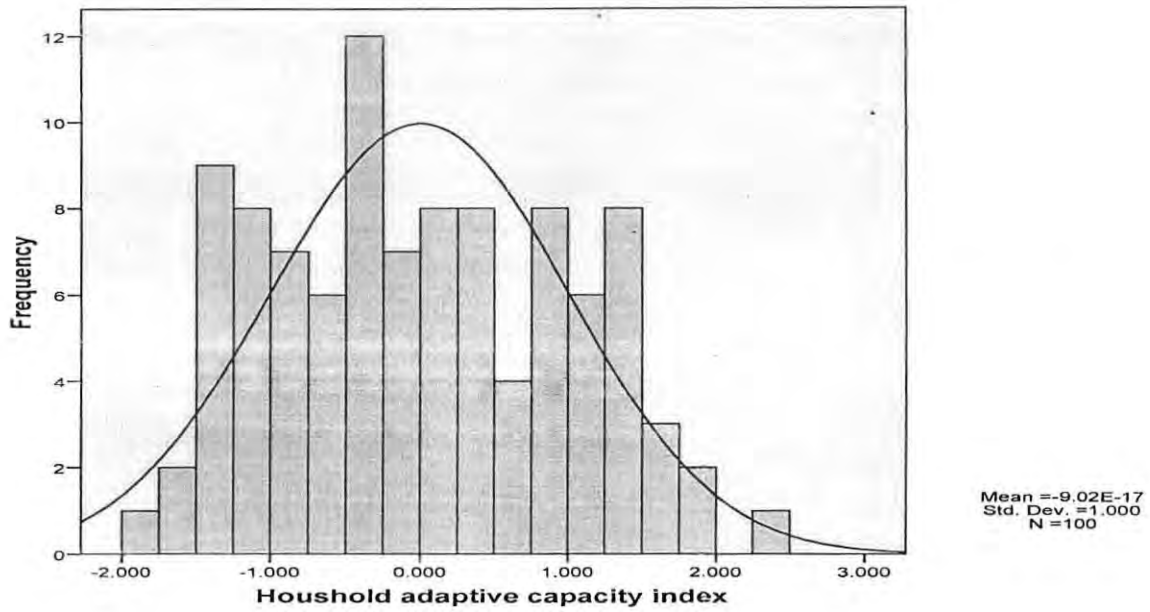

Figure 8: Household adaptive capacity index

4.3.2.1 Adaptive Capacity Groups of Households

The construction of the adaptive capacity index assigns adaptive capacity-ranking score to each household. The lower the score, the less adaptive the household relative to all others with higher scores. First, however, the share of the local population likely to fall into the lowest adaptive capacity group must be decided. Hence this study uses a cut-off of 33 percent to define the less adaptive group within the local population. This decision is based on the usefulness of categorizing local populations into terciles that can be broadly interpreted to represent the lowest, middle and higher-ranked groups of households based on their relative adaptive capacity (Carla et. al, 2003).

The adaptive capacity index scores of each household were classified in to three groups of approximately 33%, of the total surveyed household by calculating the percentile group of the adaptive capacity scores. The frequency table was produces to check the appropriateness of the distribution. According to figure 9, the first percentile group accounts for 33% of the total surveyed households while the second and third percentile groups accounts for 34% and 33% of the total surveyed households in the study area respectively.

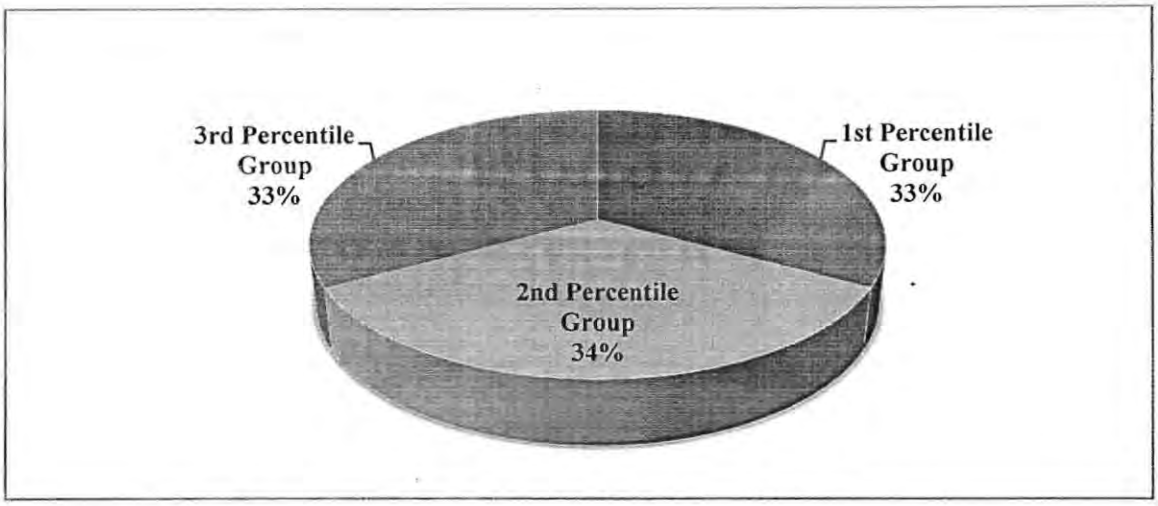

Figure 9: Percentile group of household adaptive capacity index

After classifying the whole distribution in to three percentile groups the researcher identified the upper and lower limits of each percentile groups so as to define the adaptive capacity groups. To achieve this descriptive analysis was run on the distribution of the second percentile group.

Table 23: Descriptive statistics of the second percentile group

Household adaptive capacity index score of the second percentile group	N	Min	Max	Mean	St.Dev
	34	-0.488	0.438	-0.055	0.295

Table 23 indicates the descriptive statistical summary of the adaptive capacity index score of the households falling in the second percentile group. Accordingly the numbers of respondents falling in the second percentile group are 34. The lower bound of the second percentile group is -0.488 and its upper bound is 0.438. Depending on the descriptive results of the second percentile group the upper and lower limits of the rest two percentile groups were produced and the relative adaptive capacity group was assigned for all the three percentile groups.

Table 24: Adaptive capacity groups

Adaptive capacity group	Lower and upper limits of adaptive capacity index score	Percentage (%)
Lowest	Less than -0.488	33
Medium	-0.488 up to 0.438	34
Highest	Greater than 0.438	33
Total		100

As indicated in table 24, respondents who fall in the lowest adaptive capacity group are those who have an adaptive capacity index score of less than -0.488, while the respondents who have medium adaptive capacity to climate change and variability are those who have scores of adaptive capacity index ranging from -0.488 to 0.438 and the farmers with higher adaptive capacity to climate change and variability are those who have scored beyond 0.438 in the adaptive capacity index.

4.3.2.2 Farmer's Relative Adaptive Capacity to Climate Change and Variability by agro-ecology

Table 10 indicates the relative adaptive capacity of farmers to climate change and variability by agro ecology based on each households adaptive capacity index score which is calculated using principal component analysis.

In order to see whether there is a statistically significant difference between the adaptive capacity of farmers in the kola and dega agro ecologies of the study area, chi square test was run and the result was 60.971 which is statistically significant at less 0.01 level. In Hatsebo kebele 64%, 36% and 0% of the surveyed households have highest, medium and lowest adaptive capacity to climate change and variability. In case of Welel kebele which is characterized by kola agro ecology 4%, 28% and 68% of the total surveyed household have highest, medium and lowest adaptive capacity to climate change and variability. This implies that farmers living in Hatsebo kebele have better adaptive capacity to climate change and variability compared to farmers living in Welel kebele.

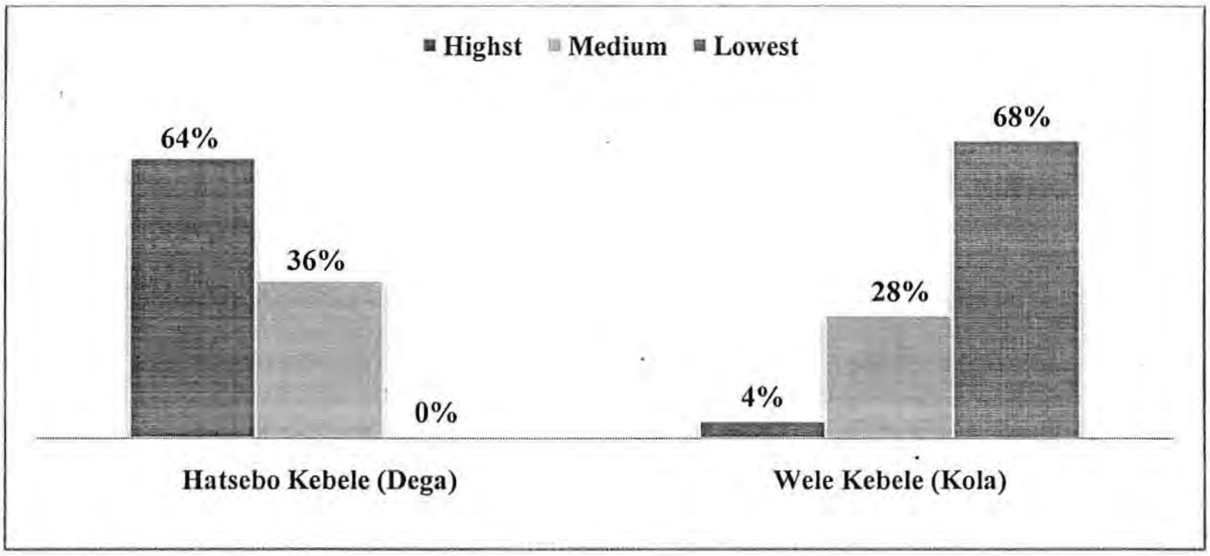

Figure 10: Relative adaptive capacity of farmers to climate change and variability by agro ecology

Source: own field survey, 2011

4.4 Demographic, Socio-economic and Farm Characteristics of Households that affect Adaptive Capacity of Farmers to Climate Change and variability

Even though the analysis of farmer's adaptive capacity to climate change and variability is largely assessment of farmer's socio-economic capabilities, all the socio-economic, demographic and farm characteristics doesn't have equal effect on the adaptive capacity of farmer's to climate change and variability. Hence linear correlation was run between the demographic, socio-economic and farm characteristics of households and their adaptive capacity index score in order to identify the most significant demographic, socio-economic and farm characteristics of households that affect their adaptive capacity to climate change and variability.

Variables and hypothesized relationships

Demographic factors were represented by household head age, sex, and family size. In case of socio-economic factors household heads educational level, occupational diversity and wealth status were considered while size of cultivable land, type of agricultural practice, purpose of agriculture and household heads farming experience make up the variables used to assess the farm characteristics of surveyed households.

Household head's age: In this study age is classified in to three categories 1= <35 years old, 2= 53-65 years old and 3= >65 years old. The underlying assumption hers is that farmers with higher age categories have better adaptive capacity to climate change and variability due to the rich experience they acquired in farming activities.

Household head's sex: A dummy variable for sex of household head, where 1 denotes men headed households and 0 otherwise. It is hypothesized that the probability of participating in off farm activities, in resettlement and migration for male headed households is significantly higher than that of female headed households.

Family size: Donates the number of family members in a given household. For the matter of comparison it is classifies in to two categories households with <5 members and household with members >5. The categories were assigned the value of 1 and 2 respectively. It was hypothesized that households with large members have low adaptive capacity to climate change and variability.

Household heads educational level: A discrete variable which represents number of years of formal schooling attained by the head of the household. It takes the value of 0, 1,2,3, and 4 for illiterate, read and write only, first cycle, secondary school and college and above. The hypothesized relationship is that farmers with higher educational level will have better adaptive capacity to climate change and variability.

Occupational diversity: a discrete variable which donates the diversity of household's occupation. It takes the value 1 if the household is engaged only in farm activity and 2 if the household is engaged in additional nonfarm activities. Since they are not dependant on agricultural income only, it is expected that farmers with diversified occupations will have higher adaptive capacity to climate change and variability.

Wealth status: represents the socio-economic status of the household in the local community where it is found. It is discrete variable which takes the value of 1, 2 and 3 for poor, medium and rich respectively. The assumption is that rich farmers will have high adaptive capacity to climate change and variability and the opposite is true for the poor ones.

Size of cultivable land: is a continuous variable which represents size of cultivable land owned by a single household. The expectation here is that households with large farmland have better adaptive capacity to climate change and variability

Type of agricultural practice: is a discrete which represents the type of agriculture practiced by the household. It takes the value of 1, 2 and 3 for rained, irrigation and mixed respectively. It is assumed that farmers practicing a mixed type of agriculture will have better adaptive capacity to climate change and variability.

Purpose of agriculture: this variable is also discrete which donates the purpose of doing agriculture for the household under consideration. The purpose could be subsistence, commercial or mixed and it takes the value of 1, 2 and 3 respectively. The hypothesized assumption here is that farmers who practice agriculture for subsistence only have low adaptive capacity to climate change and variability where as those who practice agriculture for the purpose of both market and substance or those who practice agriculture for mixed purpose have better adaptive capacity to climate change and variability.

Household heads farming experience: represents the number of years in which a given household head engaged in agriculture. It is a discrete variable which takes the value of 1, 2 and 3 for short (1-10 years), medium (10-30 years) and long (above 30 years) farming experiences respectively. The underlying assumption here is that farmers with long farm experience will have better adaptive capacity to climate change and variability.

Results of the Linear Correlation

Linear correlation was run between these three categories of variables and the adaptive capacity index score of every respondent household. The results were summarized in table 25. Accordingly the Pearson correlation coefficient of household heads age, size of cultivable land, type of agricultural practice, and wealth status with the adaptive capacity index score of households is found to be 0.360, 0.551, 0.585 and 0.646 respectively. The correlation of all these variables is significant at a level of 0.01. As can be seen from the correlation coefficients of the variables the direction of relationship of all the variables with the adaptive capacity index score is positive. The result therefore indicates that household heads with higher age category have better adaptive capacity to climate change and variability because with age farmers acquire more knowledge, wealth and diversity of livelihood strategies. This is supported by strong correlation between household heads age with household farm experience and wealth status. In addition to this farmers with large size of farm land, mixed type of agriculture and farmers who are categorized as rich in terms of their wealth status were found to have higher adaptive capacity to climate change and variability. The relationship of these variables with the adaptive capacity index score as explained by the linear correlation is similar to the in advance hypothesized relationship.

Table 25 also indicates that Pearson correlation coefficient for family size and purpose of agriculture is 0.226 and 0.254 respectively which are all significant at 0.05 levels. The relationship between the variables and the adaptive capacity index score is also positive. This implies that households with family members more than 5 and farmers who practice agriculture for both subsistence and commercial purposes have better adaptive capacity to climate change and variability. The correlation results for purpose of agriculture were found as expected while family size was found to be contrary to the prior assumption. The Pearson correlation coefficient for household head's Sex, farm experience, occupation, and household head's educational level are -0.129, 0.028, -0.110 and -0.015 respectively. All the correlations are not significant at 0.01 and 0.05 levels.

Generally household heads age, size of cultivable land, type of agricultural practice, and wealth status are the most determinant factors affecting the adaptive capacity of farmers in the study area followed by family size and purpose of agriculture. However the adaptive capacity of farmers to climate change and variability in the study area is not affected by household head's Sex, farm experience, occupation, and household head's educational level.

Table 25: Pearson's correlation coefficient between the demographic, socio-economic and farm characteristics and adaptive capacity index score of farmers

Variables		Adaptive capacity index score
Adaptive capacity index score	Pearson correlation	1
	Sig. (2-tailed)	-
Age	Pearson correlation	0.360(**)
	Sig. (2-tailed)	0.000
Sex	Pearson correlation	-0.129
	Sig. (2-tailed)	0.200
Family size	Pearson correlation	0.226(*)
	Sig. (2-tailed)	0.024
Farming experience	Pearson correlation	0.028
	Sig. (2-tailed)	0.779
Occupation diversity	Pearson correlation	-0.110
	Sig. (2-tailed)	0.274
Educational level	Pearson correlation	-0.015
	Sig. (2-tailed)	0.882
Size of cultivable land	Pearson correlation	0.551(**)
	Sig. (2-tailed)	0.000
Type of agricultural practice	Pearson correlation	0.585(**)
	Sig. (2-tailed)	0.000
Purpose of agriculture	Pearson correlation	0.254(*)
	Sig. (2-tailed)	0.011
Wealth status	Pearson correlation	0.646(**)
	Sig. (2-tailed)	0.000

*Source: own field survey, 2011 (**Significant at 1% level, *Significant at 5% level)*

CHAPTER - FIVE

5 CONCLUSION AND POLICY IMPLICATION

5.1 Conclusions

Based on the findings of the study the following conclusions were made:

- According to the perception of farmers there is a shift in the components of the climate of the study area in which temperature is increasing and precipitation is decreasing; while there is an increasing frequency of storm, drought and flooding compares from time to time. This indication of climate change and variability in the study area.
- Farmers in the study area have low level of possession and access to the key livelihood assets. Except for soil fertility level, availability of water, road, health post, and radio and microfinance institutions. Even for these variables results indicate that there is a huge gap to be filled. This leads to acceptance of the hypothesis of the study which states that farmers in the study area have low adaptive capacity to climate change and variability.
- Farmers in the Dega agro ecology have better possession and access to the key livelihood assets and highest adaptive capacity to climate change and variability. The hypothesis that farmers living in Dega agro ecology have better adaptive capacity to climate change and variability is accepted at less than 0.01 levels.
- Adaptive capacity of farmers to climate change and variability in the study area is strongly affected by household head's age, size of cultivable land, type of agricultural practice and household's wealth status while it is moderately affected by household family size and purpose of agricultural practice.

5.2 Policy implications

According to the findings of this study there is a direct relationship between the levels of farmer's access and /or ownership of the key livelihood assets (human capital, social capital, natural capital, physical capital and financial capital) and their adaptive capacity to climate change and variability. The limited access and /or ownership farmers have to the key livelihood assets, the lowest be their adaptive capacity to climate change and variability and vice versa. Hence the following policy relevant recommendations were made based on the findings of the study to enhance the adaptive capacity of farmers in the study area to climate change and variability.

☞ **Effective implementation of health care service**

Government should ensure effective implementation of health extension services, environmental and personal hygiene and sanitation. This contributes to the improvement of farmer's human capital, hence they can effectively adapt during extreme climatic events by productively investing their labour resource.

☞ **Facilitating more supportive and cohesive social environment**

With the intent to improve the social capital efforts should be made to strengthen the social networks, associations and institutions such as Equb, idr, mahber, family/relative or friendship based financial flows by improving their internal functional structure in terms of leadership, management and extent of external link. To achieve this, already established social institutions should be provided with training and technical support that enhances their internal structure in terms of leadership, management and facility. This in turn facilitates the creation of social institutions characterized by good governance and self reliance, so that farmers could get appropriate and fair support during extreme climatic events.

☞ **Better management of natural resources**

To improve the current condition of natural capital of the study area in general and soil, water and forest resources in particular, natural resources conservation & development activities such as erosion control, tree planting, integrated watershed management, and participatory forest management should be implemented effectively. However government policy intervention should go beyond this and reach the extent of reforming institutions implementing the above adaptation strategies and using taxation, pricing and legal enforcement mechanisms to decrease inappropriate demand of local peoples on environmental resources.

☞ **Better access to basic extension services and facilitating infrastructure development**

In view of improving the physical capital stock of the study area there is urgent need to promote farmer's access to all weather roads, health post, and market at an acceptable distance from their residence. Moreover it is essential to improve availability and accessibility of agricultural technologies (fertilizers, improved seed, pesticides and related equipments) to farmers of the study area. Priority should also be given to improve farmer's ownership of telephone, radio, as well as livestock.

☞ **Easy access to financial resources**

Even though there are microfinance institution, procedure of obtaining financial services is somehow complex. Hence barriers of getting financial service such as collateral should be simplified. In case farmers can't afford the lowest possible requirement of obtaining financial service, government should provide them with formal safely nets, food aid, food for work or other forms of financial support hence the financial capital stock of farmers in the study area could be improved.

☞ **Improved early warning systems and awareness creation**

Pertinent to the lack of organized climate and weather data in the study area greater sense of urgency and interest is needed from policy-makers and the government to ensure adequate and consistent funding of national weather recording systems, and early warning systems for climate-related shocks at lower level of administrative unit such as kebele. If farmers are aware of the climatic condition of their locality they can make well informed decisions about their planting dates, selling their livestock, migrating or resettling in other areas. Besides, availability of well organized climatic data is essential for further studies in the study area.
Climate change adaptations require well planned stakeholder involvement; hence creating awareness among farmers, development agents, and other concerned bodies about vulnerability to climate change and variability is one of the areas needing the most immediate attention. In order to do so, concerted effort should be made by the Government as well as NGOs and international organizations.

☞ **Targeting adaptation initiatives towards the lowest adaptive capacity groups and more susceptible areas**

Findings of the study indicated that farmers living in the Dega agro ecology have better adaptive capacity to climate change and variability than those living in kola agro ecology; hence adaptation interventions should place more priority on farmers living in the kola agro ecology. While the adaptive capacity of farmers in the dega agro ecology is at the same time enhanced. In addition to this strategies such as transforming the agricultural practice of the study area to widespread application of irrigation technology and high market orientation, facilitating wealth accumulation of farmers and controlling of land fragmentation should be give high priority.

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Appendixes

Appendix 1: Principal component analysis model validation

Table1: Communalities

Adaptive capacity indicator	Initial	Extraction
Literacy level	1.000	0.557
Average health condition	1.000	0.739
Average nutrition condition	1.000	0.828
Household level dependency ratio	1.000	0.636
Number of additional children to be born	1.000	0.609
Availability of support from relatives, friends or members of family	1.000	0.667
Availability of support from social institution (Equb, idr or mahber)	1.000	0.610
willingness to resettle and migrate in case of extreme	1.000	0.650
Water availability and accessibility	1.000	0.520
Size of cultivated land	1.000	0.666
General condition of land (Fertility and slope)	1.000	0.723
Irrigation potential	1.000	0.628
Size of forest	1.000	0.600
Ownership of livestock	1.000	0.608
Dwelling condition	1.000	0.687
Access to road	1.000	0.779
Distance to the nearest health post	1.000	0.672
Extent of telephone service	1.000	0.618
Ownership of radio	1.000	0.772
Current amount of saving in the form of cash and jewellery	1.000	0.692
Credit availability	1.000	0.689
Annual amount of government support	1.000	0.619
Remittance	1.000	0.536

Table 2: Anti-image Correlation

Variables	Sampling adequacy
Literacy level	0.686
Average health condition	0.657
Average nutrition condition	0.764
Household level dependency ratio	0.575
Number of additional children to be born	0.845
Availability of support from relatives, friends or members of family	0.561
Availability of support from social institution (Equb, idr or mahber)	0.654
willingness to resettle and migrate in case of extreme	0.796
Water availability and accessibility	0.586
Size of cultivated land	0.795
General condition of land (Fertility and slope)	0.852
Irrigation potential	0.825
Size of forest	0.617
Ownership of livestock	0.504
Dwelling condition	0.539
Access to road	0.794

Distance to the nearest health post	0.783
Extent of telephone service	0.777
Ownership of radio	0.724
Current amount of saving in the form of cash and jewellery	0.795
Credit availability	0.756
Annual amount of government support	0.673
Remittance	0.732

Table 3: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.746
Bartlett's Test of Sphericity	Approx. Chi-Square	795.008
	df	253
	Sig.	0.000

Table 4: Total Variance Explained

Components	Initial Eigen values			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.228	22.730	22.730	5.228	22.730	22.730
2	2.429	10.561	33.291	2.429	10.561	33.291
3	2.017	8.768	42.059	2.017	8.768	42.059
4	1.621	7.049	49.108	1.621	7.049	49.108
5	1.420	6.174	55.283	1.420	6.174	55.283
6	1.302	5.663	60.946	1.302	5.663	60.946
7	1.089	4.733	65.678	1.089	4.733	65.678
8	.932	4.052	69.730			
9	.817	3.551	73.280			
10	.758	3.297	76.577			
11	.693	3.013	79.590			
12	.637	2.770	82.360			
13	.547	2.377	84.737			
14	.539	2.343	87.081			
15	.520	2.261	89.341			
16	.473	2.055	91.396			
17	.384	1.671	93.067			
18	.371	1.614	94.681			
19	.333	1.447	96.128			
20	.284	1.236	97.364			
21	.275	1.195	98.558			
22	.193	.837	99.396			
23	.139	.604	100.000			

Extraction Method: Principal Component Analysis.

Table 5: Component matrix[a]

Variables	Components						
	1	2	3	4	5	6	7
Literacy level	0.357	.146	-.151	.456	.228	-.003	.355
Average health condition	0.275	-.402	.137	.246	-.146	-.301	.557
Average nutrition condition	0.762	-.453	.032	.099	-.131	.108	.048
Household level dependency ratio	-0.018	-.184	-.691	-.239	.259	-.010	-.009
Number of additional children to be born	-0.623	.224	-.121	.158	.102	-.302	-.171
Availability of support from relatives, friends or members of family	0.141	.633	-.013	.299	.385	.090	.032
Availability of support from social institution (Equb, idr or mahber)	0.267	.586	-.190	.234	-.293	-.067	-.120
willingness to resettle and migrate in case of extreme	-0.585	-.084	.257	.278	.385	-.070	.063
Water availability and accessibility	.238	.098	.182	-.398	-.080	.455	.220
Size of cultivated land	.551	.119	.317	-.188	.366	-.005	-.281
General condition of land (Fertility and slope)	.749	-.272	.123	.103	-.010	.146	-.203
Irrigation potential	.681	.091	.212	-.125	.034	-.277	-.133
Size of forest	.152	-.033	.647	-.295	-.219	-.104	-.103
Ownership of livestock	.196	.357	-.118	-.610	.159	.070	.163
Dwelling condition	-.002	.133	.464	.095	.357	.487	.283
Access to road	.770	-.126	-.223	.222	-.166	.206	.024
Distance to the nearest health post	.372	-.326	.324	.324	.232	-.097	-.393
Extent of telephone service	.499	.542	-.077	.124	-.196	.106	.064
Ownership of radio	.506	.558	.060	.049	-.335	-.295	.029
Current amount of saving in the form of cash and jewellery	.573	.094	-.272	-.283	.402	-.192	-.052
Credit availability	.456	-.228	-.493	.184	.090	.313	-.213
Annual amount of government support	-.392	.364	.166	.254	-.136	.396	-.255
Remittance	.498	.184	.169	.035	.331	-.302	.156

Extraction Method: Principal Component Analysis.
a 7 components extracted.

Appendix 2: Questionnaire and checklists

Questionnaire

Household Survey for the Assessment of Farmer's Adaptive Capacity to Climate Change and Variability in Laelay Mychew Woreda Central Zone of Tigray

Part I. General Information

Respondent ID

Zone ____________ Woreda ______________ Kebele __________________

Village ______________________ Agro ecology __________________________

1. Household head characteristics
   1.1 Household head's Age_______
   1.2 Household head's Gender a) Female b) Male
   1.3 Marital status 1 = married 2= single 3 = divorced 4= widowed
   1.4 Farming experience 1. Short (0-10 yrs) 2. Medium (10-30yrs) 3. High (30 + years)
   1.5 Household size _______
2. Household (HH) members characteristics

No.	HH member's name (start with the HH head and continue starting with the oldest HH member)	Relationship to the HH head[a]	Sex	Age	Level of education	Occupation[c]	
						Primary	secondary
1							
2							
3							
4							
5							
6							
7							
8							
9							

Key for question No. 2

a) 1=Head 2=Wife/husband 3=Son/Daughter 4=Son/Daughter in law 5=Father/Mother 6= Father/Mother in law 7= Grandchild 8=other relative 9=Non-family / Non-relative

***b)* 1=Illiterate 2=Read and write 3=Primary level 4=Secondary level 5= Tertiary**

***c)* 1=Crop production 2=livestock rearing 3=Mixed farming 4= government employee 5=other, specify________________________**

3. How much money do you earn per year in Ethiopian birr (ETB) (approximately)? _____
4. If you liquidate all of your private properties, how much capital (in terms of monetary value) will you have? ___________
5. With this total capital, in which socio-economic group do you put yourself? 1. Rich 2. Medium 3. Poor

6. What type of agriculture do you practice? 1. Rain-fed 2. Irrigated 3. Mixed
7. Why do you do farming? 1. Subsistence 2. profit making(business) 3.both

Part II. Vulnerability context

8. Is today's weather the same as the weather conditions that was 20 years ago? 1. Yes 2. No
9. What do you say about the trend of hot days over the last 20 years?
   1.Increase 2. Decreased 3. Constant 5. I don't know
10. Which local indicators do you use to evaluate the temperature trend in the area?

1=Prevalence of familiar human and animal diseases (e.g. malaria) 2=Introduction of plant and animal species that were not in the area (e.g. goat in highland not common)

3=Observation of physical structures and societal clothing styles changes (disappearance of dry up of rivers, streams, lakes, dressing light cloths)

4= Habitat shift towards higher locations

5= Other (specify)

11. What do you say about the trend of precipitation over the last 20 years?
    1. Increased 2. Not changed 3. Decrease 4. I don't know 5.Other (specify)
12. Which local indicator do you use to evaluate today's rainfall pattern?
    1=Loss of some plant and animal species
    2=Increased drought and flood frequency
    3=Growing period shortened
    4=Rainfall come early or lately
    5=Decline of soil productivity/fertility
    6=Decline of agriculture yields
    7=Decreased available water
    8=other (specify)
13. Have you encountered any climate related disasters from 1970 E.C?
    1. Yes 2. No.
14. If yes, indicate the occurrence of the following extreme events along with their trend over the last 20yrs

Types of stress	Occurrence		Trend over the last 20 years			
	Yes	No	Increased	Decreased	No change	Unknown
Drought						
Flood						
Wind storm						

15. Did these stresses bring you damage on your resources? 1= Yes 2= No
16. If yes indicate the damage you have faced among the following
    1= property damage including public infrastructures
    2= reduction in all agricultural production
    3= prevalence of diseases
    4=disturbance of social networks and relationships (edir, ekub etc)
    5= lack of financial resource such as saving, credit and remittance form relatives
    6= land slide, erosion and forest reduction

7= others specify

Part III. Livelihood Assets

17. What the literacy level of your family?(to be referred from question No.2)

18. Do you have any skill other than farming in your household which help you to engage in other activities? 1= Yes 2=No

19. If Yes specify____

20. How do you define the state of your personal health?

1= Good 2= Average 3=below average

21. What is the general health condition of your family?

1= Good 2= Average 3=below average

22. What is the most prevalent disease in your family?

1= Malaria 2=eye 3= yellow fever 4= abdominal 5= Cardiac problem 7= there is no disease 8=other (specify)

23. What is your usual food intake or diet?

a) Meat/chicken/fish 1=daily 2= often 3=sometimes 4=not at all
b) Vegetables/pluses 1= daily 2= often 3=sometimes 4=not at all
c) Milk 1= daily 2= often 3=sometimes 4=not at all
d) Fruits 1= daily 2= often 3=sometimes 4=not at all

24. How many dependents (household members with no labour or money contribution to the household due to age or permanent sickness) are there in the household?

a) Adult male_______ Adult female______
b) Children_________ Elderly __________

25. Do you want to have more children? 1=Yes 2=No

26. If Yes how much? 1= 1 2=2 3=3 4=As many as I can give

27. Suppose you have faced a hazard that devastates your properties, do you think you can get financial, material and moral support? 1= Yes 2=No

28. If yes how much financial and material support could you get?

1=100% of what is required 2= 75% of what is required
3= 50% of what is required 4= 25 % of what is required
5= Less than 25% 6= No support at all

29. Are there local traditional institutions such as mahber, ekub and edir in your village? 1= Yes 2= No

30. If 'Yes' are you a member of the ekubs and edirs found in your locality? 1=yes 2=no

31. Suppose a drought is prevailed in your locality, would you migrate or resettle to the most of opportunities elsewhere? 1= yes 2= No

32. If 'No' what is your reason?

1= the kinship I have with People here mean a lot to me
2= because I have no experience of resettlement and migration
3= because migration and resettlement cannot save me from the risk

33. Do you own land? 1. Yes 2. No

34. If your answer to the above question is yes, how much in ha?

1. Cultivated area: _______ 2. Grass and woodland/forest: ______
3. parcels/homestead: _________

35. How do you state the general trend of the woodland/forest in your land?

1= increasing 2=decreasing 3= constant 4=I can't perceive it

36. In which category do you classify the soil of your land on the basis of its fertility?

1=Infertile 2=Less fertile 3=Fertile 4=highly fertile

37. How sloppy is your farm? 1, plain 2, Medium 3, very steep

38. Is your land suitable for irrigation? 1=yes 2= No

39. If yes how much of your total land is suitable for irrigation?

1=100% 2=75% 3=50% 4=25% 5=below25% 6

40. What is the type of house you live?

1= a house made up of cement 2= a house made up of mud and stone

41. How many rooms are there in your house? 1= 1 2=2 3=3 4= >3

42. Do you have the following services in your house?

1=Electricity 3= piped water 3=toilet

43. Do you rare domestic animals? 1= yes 2=No

If your answer to question no 41 is yes, indicate the type, number/ size/ and use of the animal you owned in the following table

No	Type	Number(Size)	Use	Total value in birr
1	Oxen			
2	Cow			
3	Heifer			
4	Bull			
5	Calves			
6	Goat			
7	Sheep			
8	Donkey			
9	Mule			
10	Horse			
11	Bee colony			
12	Poultry			
13	Other			

44. How do you see the trend of livestock ownership in your household for last 10 years?

1= Increasing 2=Decreasing

3= Constant 4= I don't know

45. Do you have road that connect you with nearby towns or cities?

1=Yes, always usable 2=Yes, sometimes usable

46. If yes how long would it take you to reach the road?

1= ≤4Km 2=5-9Km 3=≥10km

47. Do you have health posts at your village? 1=Yes 2=No.

48. How far from your residence? 1= ≤4Km 2= 5-9 km 3= above 10km

49. What is the source of water you use for your household consumption?

1= piped 2= river 3=dug hole 4= other specify

50. How far from your residence is the source of water?

1= 1-4Km 2= 5-9 km 3= ≤10km

51. Do you have electricity service provision in your locality?1.yes 2.No

52. If your answer to the above question is yes, what is the source of the power? 1=water 2=sun 3=bio fuel 4=wind

53. If your answer to question 47 is 'no' what is the source of energy in your household? 1= Animal dung 2=fuel wood (charcoal) 3= bio gas

54. Do you have access to telephone service? 1. Yes 2. No

55. If yes, what kind of service?

1=Fixed line (home) 2=Fixed line (tele centres) 3=Wireless services

56. Do you have postal service? 1= Yes 2=No

57. If yes how far is from your residence? 1= ≤4Km 2= 5-9 km 3= ≥10km

58. Do you have radio? 1=yes 2=No

59. If yes do you get climate change related information form it? 1=yes 2=no

60. What power do you use for farming?

1=Family labour 2=Shared labour 3=Animal traction 4=Tractor

61. Do you have access to agricultural technologies? 1=Yes 2=No.

62. If yes indicate your access to the agricultural services listed in the table below.

No.	Agricultural technology	Access		Distance travelled to get the service		
		yes	No	≤4Km	5-9 km	≥10km
1	Pesticides and insecticides					
2	Fertilizers					
3	Improved seed					
4	Farm machinery and tools					

63. Is there farmers training centre in your locality? 1= Yes 2=No

64. How far is from your residence? 1= ≤4Km 2=5-9Km 3=≥10km

65. Would you tell your household source of cash income and its amount (in Birr)?

Major Area	Types of Activities	Yes	No
Farm Activity	Selling of crop productions		
	Selling of livestock and their products		
	Selling of fruits, roots and vegetables		
Off-farm Activity	Labour wage		
	Engaging in fetching water		
	Selling of fuel woods		
	Selling of grasses		
	Selling of timbers and wooden poles		
Non-farm activity	Mat, basket and spinning		
	Bamboo work		
	Weaving		
	Tannery		
	Blacksmithing		
	Tela and *Areki*		
	Cooking egg, *kolo* and *kita*		
	Consumer goods (salt, soap, kerosene, etc)		
	Other(specify)		

66. Indicate the amount of money you save per year in the following forms

1= cash ________ birr 2=livestock ________ birr 3=jewellery ________

67. Do you have access to adequate credit? 1. Yes 2. No?

68. If yes how much birr per year could you get credit? _________

69. Do you get any financial support from the state? 1=Yes 2=No

70. If yes indicate the amount of money you get from the state annually?

1= pension _____birr 2= safety net ______birr 3=food aid _______birr

4= other specify____

71. Do you get remittance? 1= Yes 2=No

72. If yes, how much money per year do you get from remittance? _____________

73. How do you see the trend of average income level in your household for last 10 years?

No.	Financial resources	Trend			
		Increasing	Decreasing	Constant	Unknown
1	Earned income				
2	Saved stock				
3	Inflow of money				
4	Credit				

74. Do you have market access nearby? 1=Yes 2=No

75. If your answer is yes, how far is it? 1= ≤4Km 2=5-9Km 3=≥10km

76. Suppose you have faced climate change related hazard and you want to buy your basic necessities, do you think you can get what you need in the market? 1= Yes 2=No

77. Are there micro finance institutions in your locality? 1= Yes 2= No

78. If yes to what kind of micro finance institutions do you have access?

1= public2= private 3=both

Checklists to Guide Key Informant Interviews

Village _______________Woreda _________________ kebele________________

I. Elderly Groups from the Community

1. How long have you been here?
2. How do you characterize the weather of this area (temperature and precipitation)?
3. Have you observed any change in temperature or rain fall?
4. If you perceived the change in climate, what is your local indicator?
5. What change do you observe in rivers, aquifers and other water bodies?
6. What change do you observe in forest coverage?
7. In your life, What climate hazards have you seen or have you heard from your family?(erratic rain, drought, flood)
8. If you say yes what climate related impact did you observe (heard)?
9. How do you see the general level of education, health and skill of the society? Is it getting better or not?
10. Is there a strong social and institutional relationship (kinship, equb, edir, mahber etc) in your village?
11. Do you have adequate access to public infrastructures like road, electricity, health posts, and water supply? How do you see the service?
12. What do you say about the Natural resources of your village (fertile soil, woodland/ forest, potential irrigable land) etc

13. Do you think farmers have diversified their livelihood strategies to improve their living?
14. If yes what are the most common activities being persued by farmers?
    a) Microfinance institutions
    b) Local market

II. Agriculture and Rural Development Office Officials, Development Agents and Other Experts

Name____________________ Position______________________ kebele ________

1. What is the agro-ecology of your kebele(s)?
2. Is there any form of Climate change in your district or Kebele(s)?
3. Is there any Change rainfall pattern in the kebele/woreda?
4. What change have you observed in temperature and rain fall?
5. Do you think that there is a shift in cropping calendar? How?
6. What changes have you observed in crop type? Do you observe crops and livestock's that were not familiar in the area?
7. Which group do you think is more affected? Why
8. How do you state the livelihood asset base (human, financial, physical, social and natural capital) of farmers in your Woreda?
9. Do you think farmers in this Woreda/ kebele have better livelihood strategies that combine the livelihood asset they have in a way the help the offset natural hazards like climate change and variability?
    a) Microfinance institutions
    b) Local market

Checklists to Guide Focused Group Discussion

Guiding question

1. Have you heard about climate change and variability?
2. Who did tell you? Have you heard from Radio? Or from extension workers?
3. Do you think the weather condition is changing? If you say yes how? Explain
4. Without having instrument to measure the change how do you explain by local indicators?
5. Do you observe a change in the rain fall pattern and temperature condition? Which one is increasing? Or Decreasing?
6. Have you observed any climate extremes (floods and drought) in your locality? How many times occurred since 30 years ago?
7. Do you observe any shift in cropping calendar?
8. Let us say that there will be a drought or any climate related hazard in the near future, do you think you have:

a) Educated, skilled, healthy and self-reliant human source to engage in non agricultural activities
b) Strong social relationships such as kinships other social institutions(edir, ekub member etc.) that provide you with the necessary requirements
c) Private assets such as better house with sufficient utilities, livestock, and access to public infrastructures like road, electricity, health posts, water supply
d) Natural resources (fertile soil, woodland/forest, potential irrigable land)
e) Financial resource in the form of saved stock, earned income and inflow of money

9. Who are the most affected in the society by climate change and variability? Male headed households? Female headed households? How they affected by the change? Any other
10. How societies support each other? Those with relatives?
11. What is the role of equb, eddir and mahiber in supporting those vulnerable households?
12. Are there micro finances that you can draw money to purchase agricultural technology?
13. Have you diversified your livelihood beyond farm occupation? If yes how? What outcomes have you got form diversifying your livelihood?

Declaration

I the under signed declared that, this thesis is my original work and has not been presented for a degree in any other university, and that all sources of material used for the thesis have been duly acknowledged.

Declared by:

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