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FARMERS VULNERABILITY TO CLIMATE VARIABILITY IN TERMS OF ADAPTIVE CAPACITY IN KOGA WATERSHED, NORTH WESTERN ETHIOPIA

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BAHIR DAR UNIVERSITY

INSTITUTE OF DISASTER RISK MANAGEMENT AND FOOD SECURITY

POST GRADUATE PROGRAM

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M.SC. THESIS,

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A THESIS SUBMITTED TO THE INSTITUTE OF DISASTER RISK MANAGEMENT AND FOOD SECURITY STUDIES,BAHIR DAR UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF THE DEGREE OF MASTER OF SCIENCE (MSC)" IN CLIMATE CHANGE AND DEVELOPMENT"

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Bahir Dar, Ethiopia

THESIS APPROVAL SHEET

As member of the Board of Examiners of the Master of Sciences (M.Sc.) thesis open defense examination, we have read and evaluated this thesis prepared by **Mr., Mengistu Ashebr** entitled **farmers vulnerability to climate variability in terms of adaptive capacity in koga watershed, north western Ethiopia**. We here by certify that, the thesis is accepted for fulfilling the requirements for the award of the degree of Master of Sciences (M.Sc.) in Climate change and Development.

Board of Examiners

_____ _____

Name of External Examiner Signature Date

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Name of Internal Examiner Signature Date

_____ _____

Name of Chair Person Signature Date

DECLARATION

This is to certify that this thesis entitled "**Farmers vulnerability in terms of adaptive capacity to climate variability in koga watershed, north western Ethiopia**" submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in "**Climate Change and Development**" to the Graduate Program of institute of disaster risk and food security studies, in Bahir Dar University by Mr. **Mengistu Ashebr** (ID. No. **BDU0906084pR**) is an authentic work carried out by him under our guidance. The matter embodied in this project work has not been submitted earlier for award of any degree or diploma to the best of our knowledge and belief.

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Signature & date _____

Name of the Supervisors

1) Mintesinot Azene (PhD) (Major Supervisor)

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2) Dessalegn chanie (PhD) (Co-Supervisor)

Signature & date_____

ABSTRACT

Due to anthropogenic and natural factors, climate change and variability is real in Ethiopia. The study analyzed the vulnerability of farmers to climate variability in terms of adaptive capacity in Koga watershed. Livelihood vulnerability index framed within the IPCC vulnerability framework were used to analyze adaptive capacity of 263 household heads in the watershed. Data of rainfall and temperature were complemented from secondary sources. Besides farmer household heads difference in adaptive capacity to climate variability, there difference to perception and adaptation strategies to climate variability were analyzed. Farmers having better socio economic profile were better perceived climate variability problems and implemented adaptation strategies than farmers who had weak socio economic profiles. Woyina dega (midland) farmer household head respondents score highest adaptive capacity score (0.395), than the dega (highland) household head respondents with the adaptive capacity score of 0.298. So, the findings of this study had policy relevance in identifying source and forms of vulnerability. Therefore, narrowing livelihood gaps between dega and woyina dega agro ecology household heads by integrating rural development schemes is needed aimed in order to enhancing adaptive capacity to climate variability .

Key words: Agro ecology, climate variability, vulnerability in terms of adaptive capacity

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ACRONYOMS/ABREVIATIONS

BOA	Bureau of Agriculture
CSA	Central Statistics Agency
DFID	Department for International Development
DHHR	Dega Household Head Respondents
EDRI	Ethiopian Development Research Institute
NMSA	National Metrological Service Agency
FAO	Food and Agricultural Organization
FDRE	Federal Democratic Republic of Ethiopia
GDP	Gross Domestic Product
HH	Household Head
IPCC	International Panel on Climate Change
LDCS	Least Developing Countries
NAPA	National Adaptation Plan for Action
NLFS	National Labor Force Service
NBE	National Bank of Ethiopia
NMSA	National Metrological Service Agency
UNFCCC	United Nation Framework Convention on Climate Change
WDHHR	Woyina Dega Household Head Respondents

CHAPTER ONE

INTRODUCTION

1.1.Background and Justification of The Study

Climate change and variability is one of the major challenges which hinder the development efforts of the world in this era. Even though the impact of climate variability and change on agricultural production is a global concern, the impact is particularly significant in Africa (Kurukulasuriya and Mendelssohn 2007).

Climate variability with increased frequency and intensity of droughts and floods is expected to negatively affect agricultural production and food security (DFID, 2004).The vulnerability of African agriculture to climate variability is attributed to the continent's low adaptive capacity, over-dependence on agricultural sector, marginal climate and existence of many other stressors (Collier *etal.,* 2008).

A region's vulnerability to climate change depends on its adaptive capacity, sensitivity, and exposure to changing climatic patterns. Adaptive capacity describes the ability of a system to adjust to actual or expected climate impacts or to cope with the consequences of climate change. Sensitivity is the degree to which a system is affected whether positively or negatively by extreme weather conditions and associated climatic variations. Exposure refers to the degree to which a system is exposed to climate change and the nature of the climate stimulus (IPCC, 2001).

From the above context of vulnerability ,Ethiopia is one of the African countries which repeatedly heated by the pain of climate variability due to its dependency on rain fed subsistence agriculture, its low adaptive capacity (Temesgen Deressa *et al*, 2008). Ethiopia's agriculture, which is the mainstay of the country's economy constituting more than half the nation's gross domestic product (GDP) and generates more than 85 percent of the foreign exchange earnings ,is mainly rain fed and heavily depend on rainfall. When the rainfall fells, the GDP falls. This dependence makes the country particularly vulnerable to the adverse impacts of climate variability (Ibid).

To reduce the impact of climate variability and enhance food security, enhancing farmer's adaptive capacity and implementing adaptation strategies are urgently required. The process of adaptation options are needed to be location, integrated and flexible.

Climate variability affects to all agricultural sector in a multitude ways. For example, changing weather pattern such as heavy flood and storms makes the agricultural production low and leading to extreme events of poverty and slow down economic development. In general, there is a relationship between climate vulnerability, poverty and food insecurity (FAO, 2011).
Farmers with better knowledge and information on climate variability and agronomic practices able to use adaptation methods to cope up with variability's in climate and other socioeconomic conditions (Nhemachena & Hassan 2008). A better understanding of the local dimensions of climatic variability is also essential to develop appropriate adaptation measures that can mitigate the adverse impact of climate change and variability. Therefore, awareness of the potential benefits from adaptation is an important issue.

Increasing temperature and rainfall variability in different part of Ethiopia were adversely affected agricultural production of the rural household farmers. To minimize the impact of climate variability on farmers', adaptation strategy is vital instrument. The main critical points such as social, economic, technology and environmental trends enable smallholder farmer's to perceive and adapt to climate variability. In addition, knowledge by itself on the adaptation method, adaptive capacity and factor affecting farmer's choice of the adaptation strategies are enhancing efforts directly towards tackling to the impact of climate variability (Temesgen Deressa ,2009).

By understanding all of these facts, effort should focus on finding mechanisms in which farmer's can reduce their vulnerability to climate variability and improve effort to strength farmers' adaptive capacity to climate variability. Generally, it is believed that enhancing the adaptation capacity and implementing the adaptation strategy of farmers on agriculture to climate variability is imperative to reduce the vulnerability of farmers engaging in the agricultural sectors.

1.2.Statement of the Problem

Koga watershed were one of the vulnerable watersheds of Mecha district to climate variability. The vulnerability of this watershed were highly related with poverty (loss of coping or adaptive capacity) (Temesgen, Deressa, 2007, World Bank, 2008).

The following are climate variability extreme effects which insisted the researcher to study the household heads vulnerability to climate variability in koga watershed:
There has been more erratic rainfall in the June to September rainy seasons, bringing drought and reduction in crop yields and plant varieties; the rainfall especially in the later rains towards the end of the year has been reported as coming in more intense and destructive downpours, bringing floods, landslides and soil erosion and have siltation and sedimentation effects on the irrigation dam of koga watershed and farmers.

In addition there has been an increase in temperature which disturbs the physiology of crops, the micro-climate, and the soil system on which they grow. Furthermore , the crop and livestock production has been recurrently hit by drought, off seasonal rainfall, early on set and offset of rainfall season, and floods and sedimentation and siltation effect on the irrigation dam of koga irrigation project. Finally, Food insecurity especially in the dega parts of koga watershed due to low adaptive capacity is a major challenge. However due to differences in adaptive capacity and perceptions about climate variability and their responses ,vulnerability of farmers in the two agro ecology of the watershed is not the same .

Researches on the vulnerability of farmers to climate variability and change is plenty (Deressa *et al* ,2008,2009;colliar *et al* 2008, Gbetibouo, 2009,Adger /Kelly 1999,adger *et al* ,2004,belay *et al*.,2012).They analyzed the vulnerability of farmers in all components at small scale that means they analyzed it at regional ,national or watershed level. But assessing the vulnerability of farmers to climate variability at large scale or sub watershed level in terms of adaptive capacity is rare or far between .

This study is differed from other previous works in the following way:
First, this analysis were made at sub watershed scale or it analyzed vulnerability in terms of adaptive capacity at large scale due to the reason that, the study areas rugged topography. An

area where its topography is rugged, it would create difference in adaptive capacity or levels of vulnerability of farmers to climate variability. Second, it were aimed to analyze only farmer's differences in adaptive capacity or socio economic characteristics between dega and woyina dega agro ecology of koga watershed HHR'S from the three characteristics of vulnerability. This is due to that adaptive capacity and adaptive strategies are local specific with special characteristics of farmer household heads. Thirdly, sample Kebeles were selected on by using multi stage sampling techniques. Last but not least the socio economic setup and geographical condition of farmers in koga sub watershed is differing from other national or main watershed level study area analysis.

So studying koga watershed farmers vulnerability to climate variability particularly farmers differences in terms of adaptive capacity using spatial scale of analysis between dega and woyina dega parts is very important. Therefore, the main aim of this study is to address this gap of knowledge by investigating farmer's vulnerability to climate variability in terms of adaptive capacity at large scale or sub watershed level between dega and woyina dega agro ecology of koga watershed.

1.3.Objectives of the study

1.3.1. General Objective

The general objective of this study were to investigate farmer's vulnerability to climate variability in terms of adaptive capacity .

1.3.2. Specific Objectives

The specific objectives are:

- To analyze farmer's perception to climate variability in the Koga watershed;
- To differentiate adaptation strategies being used by farmers between dega and woyina dega agro climatic zones of koga watershed;
- To analyze adaptive capacity of farmers between each agro ecology of koga watershed

1.4. Research Questions

- ✓ How farmers perceive to the variability in precipitation and temperature in koga watershed in the last 5-10 years?
- ✓ What are the major differences between farmers living in dega and woyina dega agro ecology of koga watershed in implementing adaptation strategies to climate variability?
- ✓ What are the major differences in adaptive capacity of farmers to climate variability between agro ecology of koga watershed?

1.5. Scope of the Study

Since it is not possible to cover the whole aspects of the study area with the available time and resources, it is important to limit the study size and the scope of the problem to a manageable size. Hence, the study were focused in west Gojjam zone Amhara Region mecha district, in koga watershed. In particular, this thesis will be limited to four Kebeles of koga watershed.

1.6. Limitation of the study

The main limitations of the study were limited study size and concepts due to lack of resources such as finance and time. In this case according to IPCC (2001) definitions' of vulnerability, to fully understand the vulnerability of farmers in koga watershed to climate variability, all components of it(exposure, sensitivity and adaptive capacity) must be studied . However due to the above reasons this study only investigate koga watershed farmers vulnerability in terms of adaptive capacity. Sensitivities of the study area might be done by other interested researchers .So studying sensitivity is beyond the scope of this study.

1.7. Significance of The Study

The result of this study will be important for farmers, professionals and the government. On this, first it helps governments to know perception of farmers to climate variability in the watershed and to take lessons on farmer’s adaptive capacity. Secondly, since adaptation and vulnerability levels are local specific, it helps governments and farmers, as well as academic communities to know the major factors which leads difference in farmers adaptive capacity to climate variability

and to take lessons and actions in reverse to this problems .Thirdly to identify the major adaptation strategies farmers practiced between dega and woyina dega parts of sub watershed and to take lessons from this. Fourthly Besides analyzing the vulnerability of farmers to climate variability, it enables governments ,farmers and funding agencies to decrease the exposure of the dam and watershed from climate extremes such as flooding through erosion , sedimentation, hydrological drought. This will help to extend the project's irrigation reservoir life to benefit longer the downstream parts of irrigation users.

1.8. Organization of The Study

This study were organized in five chapters. The first chapter gave overview of the background of the study, the statement of the problem and what will expect to be achieved by the end of the study. The chapter that followed presents literature review. In this chapter, previous works on the vulnerability of farmers to climate variability in terms of adaptive capacity and related works was dealt in depth. Chapter three is deals about research methodology. In this chapter, research and sampling methods, data collection instruments, tools and materials, variables used in the analysis and sign of relationships were elaborated in detail. Chapter four provides data analysis and presentation using descriptive statistics, chi square and indicator method. Finally in chapter five conclusions and recommendations are presented.

CHAPTER TWO

LITERATURE REVIEW

2.1.Concepts and Definitions of Vulnerability to Climate Change and Variability

2.1.1. Definitions of Key Terms

Climate change: 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 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 result from natural internal processes within the Climate system (internal variability) or from variations in natural or anthropogenic external Forcing (external variability) (IPCC, 2001b).

Adaptation: the term adaptation, as it is presently used in the global change field, has its origins in natural sciences, particularly evolutionary biology. Although the definition of adaptation in the natural sciences is disputed, the followings are the most commonly used definitions of adaptation and adaptive capacity; IPCC (2007) defines adaptation as "an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or Exploits beneficial opportunities".

Vulnerability: Vulnerability to climate variability means different things to different people. The Intergovernmental Panel on Climate Change describes vulnerability as the degree to which a System is susceptible to, or unable to cope with, adverse effects of climate change, including increased variability and downside risk (IPCC, 2001).

The importance of studying vulnerability to climate change and variability has increased to reverse the adverse impacts of climate extremes it through policy and research. In much of the

literature on adaptation, adaptation is conceptualized on the basis of vulnerability. However, there are large differences in how vulnerability is conceptualized, interpreted and applied because the concept has its roots in different scientific disciplines (Fusel, 2007).

One common distinction has been between impact-oriented research, which interprets vulnerability at the end point of analysis, and research that regards vulnerability at the starting point of analysis; here, vulnerability is regarded as a pre-existing state, driven by a variety of factors that influence the capacity to deal with stress (Eriksen *et al* ,2007; Adger *et al* ,2000). Although research in this second area has greatly increased in recent years, there is still a need for more practical approaches to vulnerability research focusing on the factors that drive or constrain adaptation at a particular place or community (Smit *et al* ,2006).The following section thus gives a brief review of the concepts of vulnerability, adaptation and adaptive capacity and their application in the climate change arena.

Literatures pointed out that the evolution of the concept of vulnerability generally distinguish between several main approaches that have influenced the subsequent evolution of vulnerability research as well as the treatment of vulnerability in the area of climate change: the natural hazard approach, political ecology and political economy approaches to vulnerability, and research related to resilience (Adger, 2006; Füssel, 2007).The natural hazard approach has been described as an exposure model (Cutter *et al* ,2003) due to its focus on the impact of the hazardous event occurring.

Vulnerability is defined as the potential for loss resulting from the combination of the occurrence of the hazard and its magnitude and impact on the exposed unit (Cutter ,1996). However this approach has often been criticized for not sufficiently taking into account the underlying social, economic and political structures that also influence vulnerability (Kasperson et al ,2005). As such, the risk hazard approach has often been applied to physical systems rather than to people (Füssel, 2007). In contrast to the natural hazard approach, political economy and ecology approaches place a strong focus on the social unit by looking at the social, economic and political determinants that make people vulnerable to specific events and by explaining differences in vulnerability between social groupings (c.f. Kasperson et al., 2005).

Vulnerability can also be identified in the climate change literature by bio physical and social vulnerability. Biophysical vulnerability is defined as "a function of the frequency and severity (or probability of occurrence) of a given hazard" and is thus largely consistent with the risk hazard approach of vulnerability (Brooks,2003). Social vulnerability, on the other hand, is regarded as an "inherent property of a system arising from its internal characteristics" (Brooks, 2003).The conceptualization of vulnerability also viewed in terms of social vulnerability to climate change. Social vulnerability is defined as "ability or inability of individuals and social groupings to respond to, in the sense of cope with, recover from or adapt to, any external stress placed on their livelihoods and well-being" (Kelly / Adger, 2000).

The difference between the main approaches can be illustrated with the main questions they address. Whereas the question of the biophysical approach tends to be framed as what can be done to protect the population? Or what is the extent of the climate change problem?, the vulnerability approach tends to focus on what can be done to strengthen people's own capacity to respond and adapt?, Who is vulnerable to climate change and why? And how can vulnerability be reduced? (Erikson / Kelly, 2007, O'Brien et al. 2004,). The resilience approach tends to ask how the system's resilience can be increased.

2.1.2 . Concepts of Adaptation to Climate Variability and Change

Adaptation and mitigation are the two options to reduce the negative impacts of climate change. Mitigation refers to reducing climate change damages by reducing the emissions of greenhouse gasses. Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC ,2001). Even though mitigation targets uprooting the major causes of climate change and offers long run solutions, adaptation is necessary given the current state of the world. Fusel also argues that a high emphasis should be given to adaptation mainly due to the facts that human activities have already affected climate; climate change continues given past trends; the effect of emission reduction or mitigation takes several decades; and adaptation can be undertaken at local or national states as it is less dependent on the actions of others(fussel,2007).

Climate change and variability and its hazard impacts are real (IPCC, 2001).So Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC), which commits countries to mitigate greenhouse gas emissions in order to avoid dangerous anthropogenic changes in climate. Adaptations are considered to assess the degree to which they can moderate or reduce negative impacts of climate change, or realize positive effects, to avoid the danger (Mendelsohn etal, 2010).

UNFCCC gave special concern to adaptation in their agenda by taking the low adaptive capacity of LDCs ,which renders them in need of immediate and urgent support to start adapting to current and projected adverse effects of climate change and variability due to the low adaptive capacity and high dependency on the climate sensitive agriculture sector.

In agriculture, adaptation to climate change takes place at farm, national and global levels. Farm level adaptation depends on: technology (e.g. the availability of different varieties of crops and irrigation); soil types; and the capacity of farmers to detect climate change and undertake necessary actions (Madison, 2006; Kurukulasuriya and Mendelsohn, 2008a; Hassan and Nhemachena, 2008).

2.1.3.Concept of Adaptive Capacity

The concept of adaptive capacity has its roots in evolutionary biology, where it is defined as the ability to become adapted (Gallopín,2006). Similar to the concepts of vulnerability and adaptation there are a large number of different definitions and conceptualizations on adaptive capacity (Smit et. al ,*2006*; Gallopín ,2006). The most common definitions of adaptive capacity are the following:

Adaptive capacity: The potential or capability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of as well as private, planned, individual and institutional mechanisms (Turner et al., 2003). Impact of climate variability and change is increasing from time to time and this causes human and material losses in this world. Hence adaptation intervention is needed to increase the individual or community's adaptive capacity. There is still much debate around the definition and practical applications of the term adaptive capacity. Broadly speaking, adaptive capacity denotes the ability of a system to

adjust, modify or change its characteristics or actions to moderate potential damage, take advantage of opportunities or cope with the consequences of shock or stress (Brooks, 2003).

The impact of climate change is widespread, but its consequences will fall disproportionately on developing countries, and typically will hit the poorest communities within them the hardest (Smith et al., 2003). Generally, these communities also face a host of wider pressures, some of which may be influenced by the impacts of climate change – e.g. Drought, flood, storm, the threat of displacement in conflict, increasing population pressure on land, unequal resource distribution and globalization (O'Brien *et al*., 2004).

So assessing and measuring the vulnerability and adaptive capacity of farmers is crucial to take response measures against climate change and variability impacts .However, direct assessments of adaptive capacity are not feasible, and so it becomes necessary to identify the characteristics or features that influence it. The Intergovernmental Panel on Climate Change (IPCC) identifies economic wealth, technology, information and skills, infrastructure, institutions and equity as the principal determinants of adaptive capacity (IPCC, 2001).Recent assessments argue that social factors, in particular power relations – e.g. 'social capital', governance structures and the role and functions of institutions – have been underplayed in earlier studies (IPCC, 2007).

The relationship between adaptive capacity and vulnerability depends crucially on the timescales and hazards with which we are concerned. The vulnerability, or potential vulnerability, of a system to climate change that is associated with anticipated hazards in the medium- to long-term will depend on that system's ability to adapt appropriately in anticipation of those hazards. However, vulnerability to hazards associated with climate change and variability that may occur in the immediate future will be related to a system's existing short-term coping capacity rather than its ability to pursue long-term adaptation strategies. Vulnerability depends critically on context, and the factors that make a system vulnerable to a hazard depend on the nature of the system and the type of hazard in question (Brooks *et.al*.,2004).

2.2.Frameworks to Assess Adaptive Capacity

In the face of uncertainty, adaptive capacity is a critical system property, for it describes the ability to mobilize scarce resources to anticipate or respond to perceived or current stresses. Adaptive capacity varies between different contexts and systems, and it is not equally distributed

(Adger et al., 2007). Therefore, it is important to identify what builds adaptive capacity or, similarly, what functions as barriers or limits to adaptations (Ibid).In addition to IPCC framework approach the following are frameworks found in literatures to characterize adaptive capacity:

2.2.1.Sustainable Livelihood (SL) framework

Many frameworks have strong links to the Sustainable Livelihoods framework (SL), and have adopted the SL's five 'capitals' (human, economic, social, physical and natural) as direct indicators of adaptive capacity at the community and household levels (Osman Elsha et al., 2005; CARE, 2009; Deressa, 2008)

2.2.2.Local Adaptive Capacity Indicator(LAC) Framework

Based on this framework consists of five distinct yet interrelated characteristics that are conducive to adaptive capacity. These are: the asset base, institutions and entitlements, knowledge and information, innovation, and flexible forward-looking decision-making. These parameters influence and determine the degree to which a community is resilient and responsive to changes in the external environment.

2.2.3.The Asset Base

The ability of a community to cope with and respond to change depends heavily on access to, and control over, key assets (Jones et al 2010). Typically, it is the poorest that are most vulnerable to the impacts of climate change and wider developmental pressures, in large part because of their lack of, or restricted access to, key assets and capitals. Lack of availability and access to appropriate resources may significantly limit the ability of a system to cope with the effects of climate change and wider development pressures.

2.2.4.Institutions and Entitlements

Institutions are the 'rules' that govern belief systems, behavior and organizational structure (Ostrom, 2005). Communities with well-developed social institutions are typically better able to respond to a changing environment than those with less effective institutional arrangements. Given that entitlements to 'elements of adaptive capacity are socially differentiated along the

lines of age, ethnicity, class, religion and gender' (Adger et al., 2007: 730), it is often thought that institutions that ensure equitable opportunities to access resources are likely to promote adaptive capacity within a community. The institutional rules that govern how individuals react in the face of shock and changing trends will also play a large role in adaptive capacity (Dulal etal., 2010).

2.2.5.Knowledge and Information

Communities are often more likely to cope with change if they have appropriate knowledge about potential future threats, as well as an understanding of how to adapt to them. With this in mind, successful adaptation will require: understanding of likely future change and its complexity, knowledge about adaptation options, the ability to assess options, and the capacity to implement suitable interventions (Frankhauser and Tol, 1997). Knowledge can also play a role in ensuring local empowerment and raising awareness of the needs of particular groups within a community (Ospina and Heeks, 2010). Therefore, the way in which a system generates, collects, analyses and disseminates knowledge is an important determinant of adaptive capacity with obvious links with the institutional context and the governance of knowledge. The following diagram is Conceptual frameworks of the study:

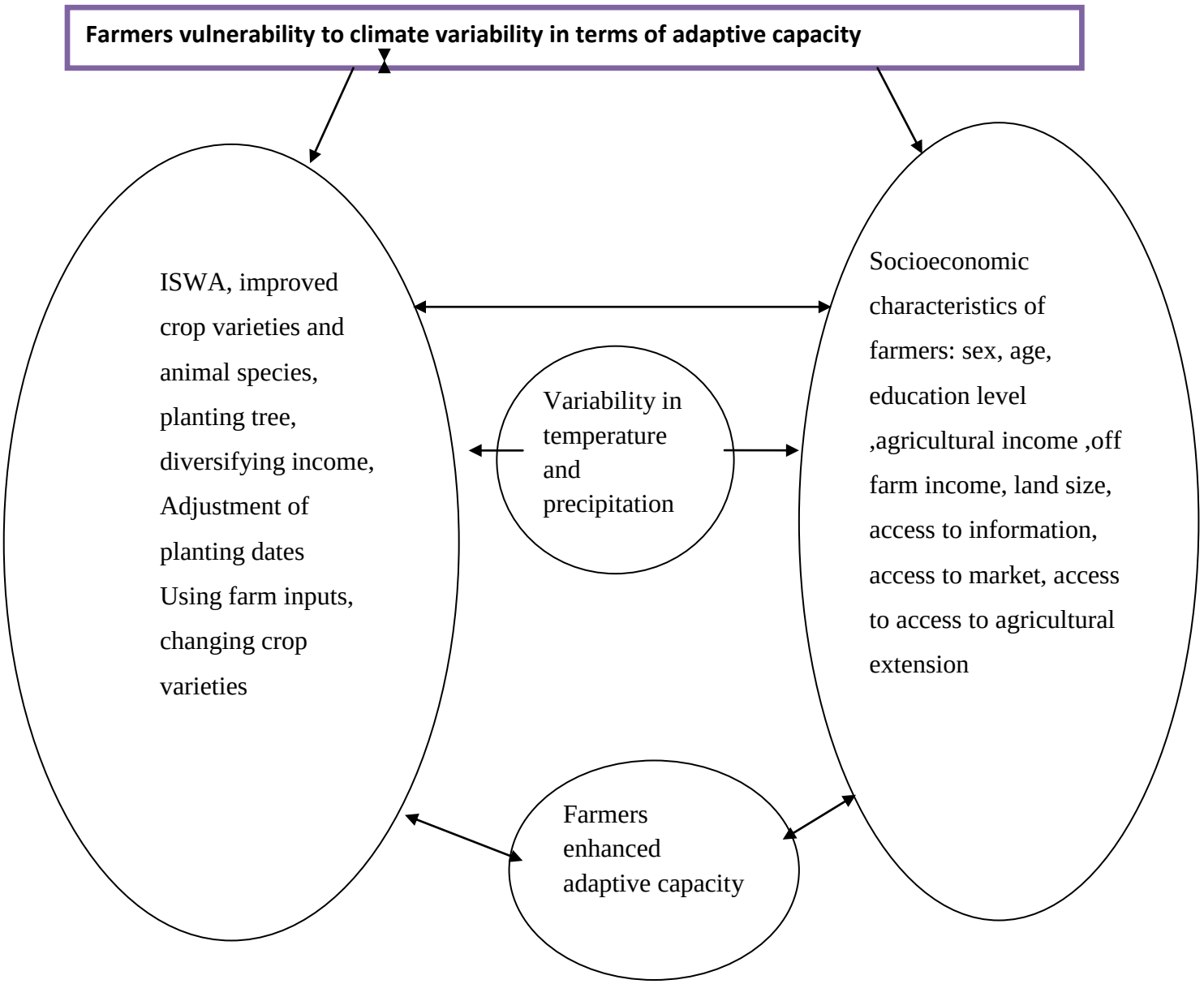

Figure 2. 1.Conceptual frameworks of the study

2.3.Adaptation Strategies to Climate Variability in Ethiopia

Although adaptation strategies are local, to address the immediate adaptation needs Ethiopia identified its national level adaptation options and submitted to UNFCCC. The following are adaptive strategies that Ethiopia identified and practiced depends on local context: planting trees; community based watershed development ; the use of different crop varieties; changing planting dates; and using irrigation, using drought and disease resistance crop and livestock verities ,using agro forestry, of farm employment ,using water wells, diversification, conservation agriculture ,rehabilitation of degraded lands. (NAPA Ethiopia, 2007).

Different strategies are practiced by various farmers, which enhance the farmer's adaptation to climate change. However, adaptation strategies to climate change and variability effects also depend on the socioeconomic characteristics of the farmers. For instance literate farmers may take different adaptive measures compared to those who are illiterate. Moreover, annual family income, farm size, farming experiences, and contact with extension service agents influence the famers' use of adaptive measures to adjust to environmental degradation and severe weather events resultant from climate change effects. Regardless of the strategies applied by any farmer, it is predicted that taking adaptive measures reduces the negative effects of climate change on farm production, household income and farmer livelihoods (Birtukan Atinkut and Abrham Mebrat., 2016).

2.4.Overview of Climate Variability in Ethiopia

Due to the diverse agro ecological zones of Ethiopia, mean annual temperature and rainfall vary widely. Mean annual Rainfall varies from 2000 millimeters high to 250 millimeters lowest and mean annual temperature varies from100^{o}_{c} to about 350^{o}_{c} (Deressa,2010).In Ethiopia, the average annual minimum temperature has increased by about 0.25oc every ten years while the average annual maximum temperature has increased by about 0.1oc(ibid). Additionally, the National Meteorological Services (NMS, 2007) further showed that there was a very high variability of rainfall over the past 50 years. These trends of increasing temperature, decreasing precipitation and the increasing frequency of droughts and floods are predicted to continue in the future in the tropics of Africa where Ethiopia is located (World Bank,2003; IPCC, 2001).National average temperature has increased by 1oc since the 1960s (FDRE, 2015) increasing by 0.37oc per decade. The number of hot days and nights in a year is increasing overtime (World Bank, 2016). On the other hand, the observed trend of mean annual rainfall is not clear (World Bank, 2016). Despite the inter-seasonal and inter-annual rainfall variability, nationally rainfall remained more or less constant in the second half of the twentieth century (FDRE, 2015; NMSA, 2001).

Drought is being recurrent and unpredictable phenomenon (Ali, 2012). For instance, 15 major droughts have stroke Ethiopia since 1950 (Ali,2012). More than half of households in the country experienced at least one major drought shock in 1999-2004 period (Robinson et al., 2013

citing UNDP, 2007). In Ethiopia, rainfall and GDP is directly related .when the rainfall decrease the country's GDP also decreases and vice versa (Temesgen Deressa ,2008).

There is clear agreement in Ethiopia that mean annual temperature will increase (Conway and Schipper, 2011) but disagree on precipitation. Despite ambiguous mean annual rainfall predictions, however, rainfall in the Kiremt (Ethiopian summer or crop growing period) is most likely to decrease (World Bank, 2008). It is pointed that "seasonal predictions suggest significant drop in rainfall during the planting season" (World Bank, 2008:50). The combined effect of increasing temperature, increasing hot days and nights, uncertain rainfall (but likely to decline in Kiremt) will increase the overall Vapor Pressure Deficit (VPD) which in turn leads to higher rates of evaporation and plant transpiration (Admasu *et al*., 2013).

Increasing evapotranspiration eventually decreases soil moisture (Admasu *et al*., 2013) and shortens the length of the growing period for crops and grasses. This poses a challenge to the Ethiopian agriculture which virtually depends on rainfall. Farmers' perception to climate variability is one of the explanatory variables that affect the choice of farmers' adaptation measures. Studies found that farmers' who perceived a change in temperature are more likely to adapt to climate variability by 16 and 14 times greater compared to those who do not perceived a rise in temperature. This possibility is due to the fact that farmers' who perceive the variability in temperature are likely to grow different heat-tolerant crop varieties (Birtukan Atinkut and Abrham Mebrat ,2016).Gbetibouo (2009) found the same result in that farmers' who are aware of changes in climatic conditions have higher chances of taking adaptive measures in response to the observed changes.

2.5. Effects of Climate Variability on Ethiopian Agriculture

The vulnerability of Ethiopian farmers to climate change and variability is attributed to their dependence on rain-fed agriculture and high poverty. Rain-fed agriculture, which supports the livelihoods of the majority of the population, is highly sensitive to climatic conditions (Conway and Schipper, 2011). Agriculture in Ethiopia employs more than 80% of its labor force, contributes Nine out of ten top export items, and contributes about 45% of GDP (Temesgen Deressa, 2010). Given the dependence of the economy on agriculture and the dependence of the

agricultural sector on climatic conditions, especially rainfall, the macroeconomic performance of the country follows rainfall patterns (Ibid).

Ethiopia has experienced at least five major national droughts since 1980, along with a large number of localized droughts (World Bank, 2008). These cycles of drought create poverty traps for many households, constantly consuming their efforts to build up assets and increase income. About half of all rural households in the country experienced at least one major drought from 1999 to 2004 (Dercon, 2009).

With agriculture highly dependent on rainfall variability and amount, weather in general rules the lives and well-being of many rural Ethiopians. These past experiences in Ethiopia reveal that adaptive capacity in Ethiopian agriculture and economy are insufficient to cope up with environmental changes. Thus, future climate change poses an apparent risk to Ethiopian economy. Literature assessing the biophysical and economic impacts of climate change in Ethiopia. Based on this assessments different major crops varieties yield, quality, productivity and net farm revenue decreased and leads in people looking for food aid to droughts (Madison etal, 2007; Deressa and Hassan, 2009).

In addition to impacts on crop varieties, climate change and variability affects the livestock farming directly and indirectly (Adams et al., 1998). It directly affects mortality, morbidity, reproduction, and physiological performance of livestock and indirectly through its effects on feed quality and quantity, water availability, livestock diseases, and loss of biodiversity. The direct and indirect effects jointly influence the stock of livestock per farm (location) and the livestock species to be reared at each farm (Seo and Mendelssohn, 2008b).

CHAPTER THREE

MATERIALS AND METHODS

3.1.Description of the Study Area

This study was conducted in north western Ethiopia at Koga watershed. It is located between 11^0 10' and 11^0 25' North latitude and 37^0 2' and 37^0 17' East longitude in Lake Tana basin, within the Highland of Ethiopia which is located about 540 km North of the capital city, Addis Ababa .The mean annual rainfall (RF) recorded at Merawi station is 1661 mm, of which 90 % falls in the months May through September. The monthly mean temperature is 25.8^{o}c. The elevation ranges between 1885-3131 masl (meters above sea level), and the slope ranges from nearly flat to very steep. The dry season limits the water availability in the study area.

The Koga watershed lies in the Blue Nile Basin and consists of land drained by the Koga River above its confluence with the Little Nile .The Koga River flows south to northwest with a total length of 49 km to Gilgel (Little) Abay and Lake Tana; its tributaries effectively drain the total catchment area, which is 27,850 ha and lies to the North of the Wezem Mountains (fikiru 2009).

Koga watershed consist of 18 Kebeles . Name of sampled Kebeles and its sample size identified through multi stage sampling .Based on the traditional agro climate classification of Ethiopia ,this watershed is divided into dega (highland) and woyina dega (midland) agro climatic zones. The dega agro climatic zones of the watershed is rain fed with little accessibility to small scale irrigation whereas woyina dega agro climatic zones of the watershed is located in irrigated plains except few Kebeles which is not accessible to use irrigation water through canals. Farmers living in the watershed are increasingly vulnerable to climate variability and its impacts due to the low adaptive capacity of farmers. Mountainous and hilly topography, a low degree of vegetation cover and gully erosion, lack of infrastructure, education, access to training and farm inputs, increasing population pressure are the major causes to the low adaptive capacity of farmers in the watershed.

By understanding the vulnerability of farmers in the watershed ,the government of Ethiopia introduced different adaptation strategies in the area .Among the adaptation practices adopted in

the watershed soil and water conservation ,using improved crop and livestock varieties, crop diversification ,planting tree, diversifying income, adjustment of planting dates, using manure and using irrigation are among the few .But koga watershed farmers adaptive capacity vary between two agro climatic zones of the watershed due to several factors.

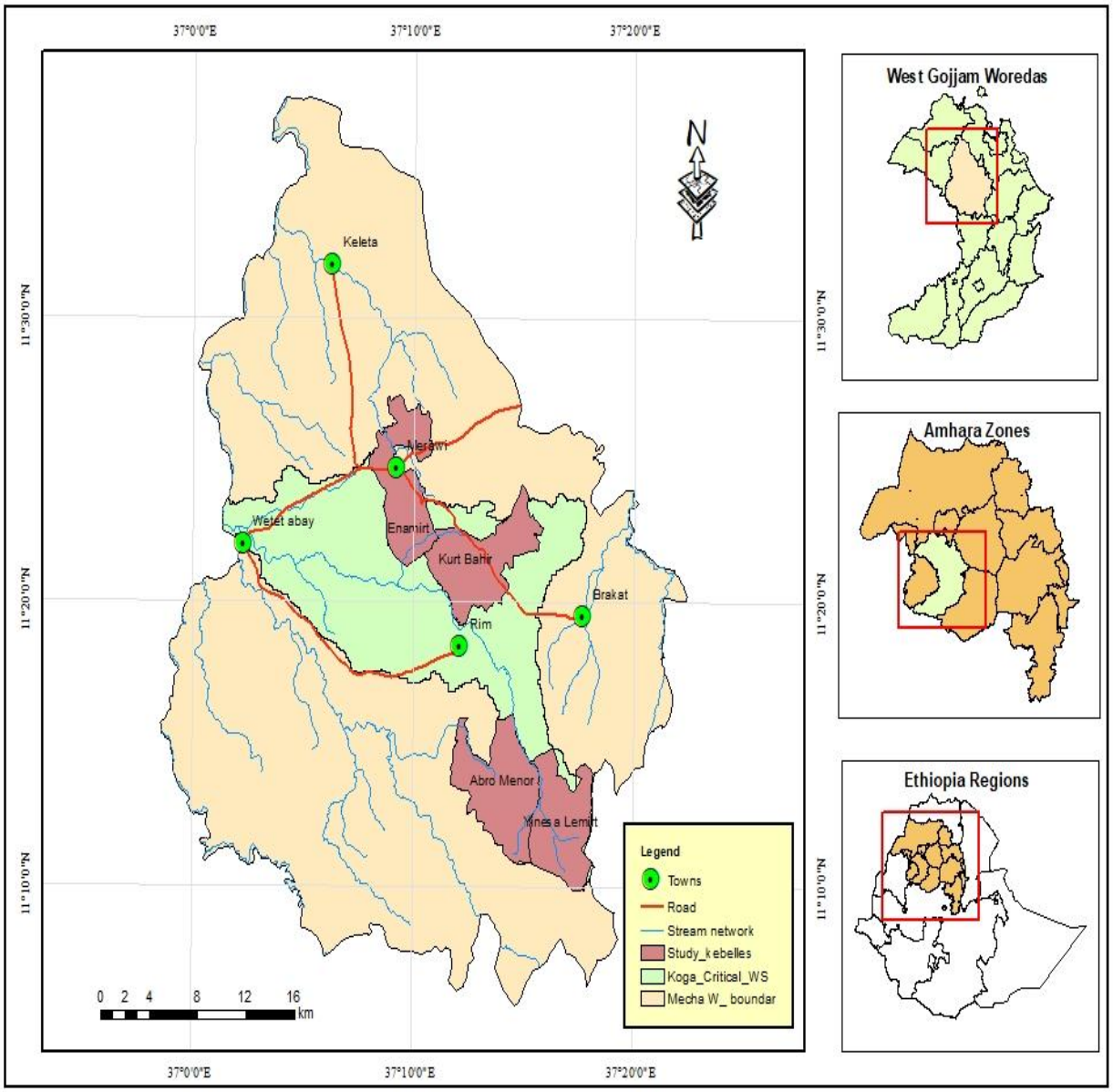

Figure 3. 1 Location Map of study area

3.2.Research Design

Research design is important because it provides a structure or framework for collecting and analyzing information for the research. As indicated the aim of the study were to analyze the farmers vulnerability to climate variability

in terms of adaptive capacity in koga watershed, north western Ethiopia. To achieve this goal both qualitative and quantitative research design were used for the study. To address the stated objective qualitative data and quantitative data were collected.

3.3.Data type and Sources

Both primary and secondary data collected by employing quantitative and qualitative data collection methods. Primary data was collected using methods like questionnaires, focus group discussion and direct personal observation. On the other hand the following are the major secondary sources of data that were used in the study: books, periodicals and seminar paper, and research reports, project reports, websites and official reports such as metrological data reports. This data were collected from NMSA, BOA, and from farmers.

3.4. Methods of Data Collection

Data collection techniques are techniques which are used to collect primary and secondary data needed for the study .So to collect data based on the framework of this study; the following major data collection techniques were employed:

3.4.1.Questionnaires

Questionnaires were used as a primary instrument to collect primary data from the selected sample households from three Kebeles. The investigator were prepared close and open ended types of question for the sample of respondents. Based on this tool categorical and continuous data's were collected from farmers. The questionnaires consist of different types which are related to the topics of research. The questionnaires prepared to the randomly selected household heads or representatives by a team of assistance recruited and trained for the purpose with close

supervision by the investigator. Since farmers in the study area speak Amharic language, the questionnaires that were initially prepared in English were translated to Amharic language.

3.4.2.Focus Group Discussion

Focus group discussions were carried out to know the knowledge and view of farmers about climate variability and extremes, to identify and to give priorities of the major adaptive capacity indicators and adaptation strategies practiced in the watershed. Focus group was comprised of respondents, representing varying interests. They were model farmers, elders, district and kebele administrators, agricultural leaders and vulnerable groups like female headed households, landless youths. These focus group participants were discussed on questions prepared earlier by the researcher on each sample Kebeles and agro ecology based on the issue of perceptions of farmers to climate variability, household head respondents difference in adaptation strategy and difference in adaptive capacities of them.

3.4.3.Field Observation

Direct field observation was held to visit the vulnerability of farmers with due concern to their adaptive capacity. Socioeconomic and biophysical feature of the study area were observed. Thus the investigators opinion is based on his visit of the study area were included in the analysis by using check lists.

3.5.Sample Size and Sampling Technique

Sampling technique is used to select the representative sample from the total population under the study universe. This study was used multi stage sampling method. Koga watershed consists of 18 Kebeles. Based on the traditional classifications of Ethiopia's climate, the study area stratified in to two agro climatic zones of the watershed.

This study purposively selected four Kebeles from dega (highland) and woyina dega (midland) agro climatic zones based on the agro climatic zones and homogeneity of sampled Kebeles socio economic characteristics. So two Kebeles are in each agro climatic zones of the watershed were selected by using the above sampling techniques. Selected sampled Kebeles are yinesa lemirt and Abro Menor from dega agro ecology and Enamirt and Qurt Bahir from woyina dega agro

ecology of watershed with the population of male =1271, female=214 total 1485, male =1380, female 229 total 1609, male 658, female =69 total 727, male=1169, female=131 total 1300 respectively. The sample households from each Kebeles were selected by systematic random sampling method. The reason of this preference is the ability of systematic sampling to ensure the extension of sample to the whole population. List of household head respondents were obtained from kebele administration office. In addition to these this research was used and selected eight respondents for FGD reports in each Kebeles.

Sample sizes were determined by appropriates formula for this study: Yemane (1967:886) provides a simplified formula to calculate the sample size n=N/1+N [e^2] Where n - sample size, N - total households (= 22,155), and e - desired level of precision (in case, e= 6%) e^2 - the variance of an attribute in the population instruments of data collection. Based on this formula the total population size of koga watershed is 22, 155, the sample frame is 5121, and the sampling size is 263. Then the sampled households were easily identified through proportional sampling methods .The sample households in sampled Kebeles as shows in table 1,Yinesa Lemirt, Abro Menor ,Enamirt and Qurt Bahir consists of 76,83,67 and 37 households respectively .So the total sampled households of the study area would be 263 households. Since farmers are speaking Amharic language, discussion points for group discussion, questions used for interview were prepared first in English language and then was converted in to Amharic.

*Table 3. 1.*Sample Kebeles and sample size

No	Sample Kebeles for study	Agro ecology	Household size	Sample size
1	Yinesa lemirt	Dega(highland)	1485	76
2	Abro menor	Dega(highland	1609	83
3	Qurt bahir	Woyina dega(midland)	1300	68
4	Enamirt	Woyina dega(midland)	727	36
	Total Sample Size			263

3.6.Method of Data Analysis

This section provides an overview of the methodology used in addressing each of the objectives of this study. To reiterate, this study were analyzed (i) whether farmers in koga watershed recognize climate variability, (ii) to identify adaptation measures farmers being used between dega and woyina dega agro climatic zones of this watershed, and (iii) finally analyzing adaptive capacity of farmers to climate variability between two agro climatic zones of koga watershed. In order to analyze whether small holder farmers in koga watershed recognize climate variability or not, they were asked whether they have observed climate variability or not in recent past 10 years compared with 1990s (i.e. between the 1990s' and the 2000s') both in terms of the means and variances of precipitation and temperature.

3.6.1.Descriptive Statistics

Descriptive statistic (means, frequency, crosstabs, percentage, count, and chi-square) was used to characterize farmer perceptions on variability to temperature and precipitation as well as various adaptation measures being used by farmers.

To analyze farmers' perception and adaptation strategies, descriptive statistics based on summary counts and percentages of the questionnaire structure were used. For climate variability perception, further comparison was made by undertaking linear trend analysis of monthly means of temperature and rainfall of 13 years of record obtained from Merawi Meteorological station. SPSS version number 20 was the tool of analysis.

To analyze perceptions and views of farmers as well as adaptation measures being used by farmers in both agro ecologies in the study area, descriptive statistics (Pearson chi square test) was employed. Tools such as SPSS version 20 and spread sheet micro soft excel computer program were used to analyze perception of farmers and their knowledge about climate variability. Tables, figures and narratives were employed to strengthen the findings of descriptive statistics and indicator methods of analysis.

To analyze difference in adaptive strategies being used by farmers to climate variability between DHHR and WDHHR of koga watershed, Pearson chi square statistics was employed through SPSS version 20 software. Pearson chi- square statistics is used to analyze the relationship of two categorical variables with two or more responses by comparing counts and percentages that was found in different category.

3.6.2.Indicator Method

This study was adopted LVI-IPCC method to quantify and analyze level of vulnerability in terms of adaptive capacity between dega and woyina dega agro ecologies of koga watershed (Hahn, 2009, Belay semani, 2016). The LVI-IPCC approach focuses on quantifying the strength of current socio economic livelihood systems as well as the capacity of communities to alter these strategies in response to climate-related variability problems. The LVI method has the advantage of using primary data instead of depending on secondary data (Hahn, 2009).

To quantify the level of vulnerability in terms of adaptive capacity in each agro-ecology, indicators or sub-components as shown below in table 3. 2, developed based on a review of the literature, researchers observation on socio economic and geographical set up, and livelihood practices of the study area. This data were collected to quantify vulnerability levels (in terms of adaptive capacity) between dega and woyina dega agro ecology of koga watershed based on questioner survey.

The Adaptive capacity index (ACI) developed from LVI includes six sub components that were categorized by Socio-economic Profile, Livelihood Strategies and infrastructure. Each is comprised of selected indicators that were practiced in the study area.

The LVI uses a balanced weighted average approach (Sullivan Et al., 2002) where each sub-component contributes equally to the overall index even though each major component is comprised of a different number of sub-components. So the choice of indices was undertaken based on a review of the literature and adjusting to the context of koga watershed farmers socio economic and geographical set up.

Because of each of the sub-components is measured on a different Scale, it was first necessary to standardize each as an index. The equation used for this conversion was adapted from that used in the human development index to calculate the life expectancy index, which is the ratio of the

difference of the actual life Expectancy and a pre-selected minimum, and the range of predetermined maximum and minimum life expectancy (UNDP, 2007).

$$Index_{sA} = {}_{SA\text{-}min\ /Smax}\text{-}s_{min} \quad (1)$$

Where s is the original sub-component for agro ecology A, and s min and s max are the minimum and maximum values, respectively, for each Sub-component determined using data from both agro ecologies. For Example, the 'average on farm income that were a farmer gained as a subcomponent ranged from 5400 minimum to 31,500 maximum values surveyed. These minimum and maximum values were used to transform this indicator into a standardized index .So it could be integrated into the on farm income component of the ACI. For variables that Measure frequencies such as the 'percent of households reporting perception levels in their Community,' the minimum value was set at 0 and the maximum at 100.

The maximum and minimum values were also transformed following this logic and Eq. (1) used to standardize these sub-components.

After each was standardized, the sub-components were averaged using equation (2) to calculate the value of each major component:

$$M_d = \sum^{n}_{i=1} index_{sdi/n} \quad (2)$$

Where Md = one of the six major components for agro ecology a [Socio-economic Profile (SEP), Livelihood Strategies (LS) and infrastructure (INF).Index sdi represents the sub-components, indexed by i, that make up each major Component, and n is the number of sub-components in each major component.

Once values for each of the seven major components for agro ecology were calculated, they were averaged using Eq. (3) to obtain

The agro ecology-level LVI (ACI):

$$LVIa = \sum^{6}_{i=1} Wmi\ Mai\ /\ \sum^{6}_{i=1} \quad (3)$$

Where LVIa, the Livelihood Vulnerability Index for agro ecology a, equals the weighted average of the six sub components. The weights of each sub component, Wmi, are determined by the number of Sub-components that make up each major component and are included to ensure that all sub-components contribute equally to the overall LVI (Sullivan *et al*., 2002). In related

researches the LVI is scaled from 0 (least vulnerable) to 0.5 (most vulnerable). But this study was only focused on the single components of vulnerability that is adaptive capacity. So, the more agro ecology in level of adaptive capacity is the less its vulnerability and vice versa (Temesgen Derressa et al, 2008).

Table 3. 2. vulnerability index components

Adaptive capacity capitals	Major components	Sub indicator	unit of Measurement	Hypothesis
Financial Capital	Wealth	Farm size of the HHs (inverse)	Hectare	The more the wealthy Status the more the adaptive capacity
		Number of Livestock unit (inverse)	Livestock No	
		on farm income	Ethiopian Birr	
		off farm income	Ethiopian birr	
		access to credit	count/percentage	
Human capital	Community	Sex of HH heads	count	The more the information the more the adaptive capacity
		Education level	literacy rate	
		Radio owner ship	count/percentage	
		Availability of extension skill/training	count	
Livelihood strategy		Average agricultural income.	birr	The higher the agricultural livelihoods diversity, the lesser the vulnerability
		Livelihood diversity	count	
		Percent of HHs dependent on agriculture as major source of income	Count/Percentage	
		Percent of HHs dependent on non-farm activities as source of income	Count/Percentage	
Social capital	Socio demographic	Dependency ratio	percentage	The higher the dependence ratio the higher, the vulnerability
		female headed household	percentage	

	Average family members in the households access to communication devices as well as climate information	percentage	The higher climate information, the lower vulnerability
Infrastructure	distance from household head home to market	count/percentage	The nearer distance households home to market, the more adaptive capacity and vice versa

CHAPTER FOUR RESULTS AND DISCUSSIONS

4.1.Socio Economic Characteristics of The Study Area

Based on Table 3.3 shows below, a total of 263 farm households participated in the study and of those studied 79.5 % were male and 20.5 % were female. In terms of agro ecology 60.5 % farmer respondents were found in dega agro climatic zone. Whereas, the remaining 39.5 % farmer respondents found in woyina dega agro ecological zone. In addition in terms of age category, 49 % majority of respondents are within the active working age group of 30–49, while 38.5% of respondents are within adult age group of 50-65.While 10.3 % respondents were above 65 years of age. In terms of marital status 79.5% of farmer respondents were married and the remainder was divorced and widowed. Furthermore as Table 4.3 shows below, education status were low with respondents 30.8 % were able to read and write while 69.2 % of the respondents being note literate. Based on education level of household head respondents approximately 16 % were able read and write, and about 6.1% attended traditional orthodox church school and the rest 6.5% and 2.3% attended cycle of (1-4 level) and elementary (grade 5-8) schooling respectively.

*Table4. 1.*socio economic characteristics of the study population

Characteristics	**Category**		**Dega**	**Woyina daga**	**Total**
Gender	Male headed household heads		46.8	32.7	79.5
	Female headed household heads		13.7	6.8	20.5
Age	30-49		58.5	49	
	50-65		32.7	38.5	
	>65		8.8	12.5	
Marital status	Married		77.4	82.7	
	Divorced		11.9	8.7	
	Widowed		10.7	8.7	
Education	Literate	Read and write	11.9	22.1	
		Church school	5.7	5.8	
		1-4	4.4	9.6	
		Grade5-8	0	5.8	
	Not literate		78	55.8	

4.2.Temperature Trends of The Study Area

Based on the results for the 12 year annual maximum and minimum temperature recorded data (i.e. 2005-2017) as shown in Figure 4.2 below, reveals that annual mean maximum temperature is showing an increasing trend by 0.026 ^{O}C. In addition 2008,2012 and 2015 were the highest year in which maximum temperature were recorded compared among sample years in the study area with mean annual temperature of 28,28.12 and 28.1^{O}C respectively .On the contrary, 2011 and 2012 were years which were recorded minimum mean annual temperature with 14.12 ^{O}C ,and 14.41 ^{O}C compared with other sample years.

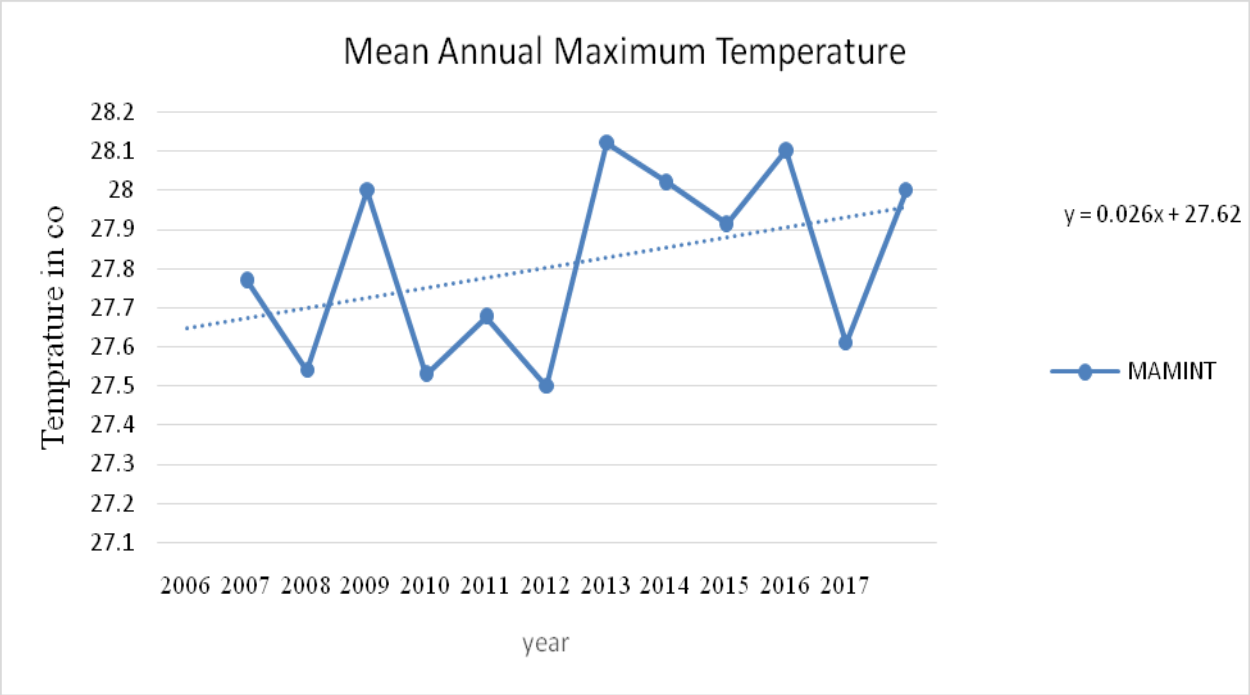

Figure 4. 1.Mean annual maximum temperature

As indicated in the appendix Table 2.2, and in the Figure 4.3 below, maximum and minimum range of temperature, mean, standard deviation and coefficient of variation were analyzed and interpreted. Based on these findings, the study area recorded monthly mean maximum temperature in the month of March and April with 31 ^{0}C and 30 ^{0}C respectively. Whereas, high standard deviation of monthly mean temperature were recorded on the month of February and

March with 3.17 ^{0}C and 1.46 ^{0}c respectively. In addition in April and July were recorded high coefficient of variation of temperature with 10.3 % and 4.7 % respectively.

On the other hand, in May and June were recorded minimum temperature with 13.84 ^{0}C and 13.1^{0}C respectively. In terms of standard deviation of mean minimum temperature, February and January were recorded highest standard deviation of annual mean minimum temperature with 3.9 ^{0}C and 3.6 ^{0}C .In addition January and February were recorded highest coefficient of variation on temperature with 47.6 % and 42.7 % respectively.

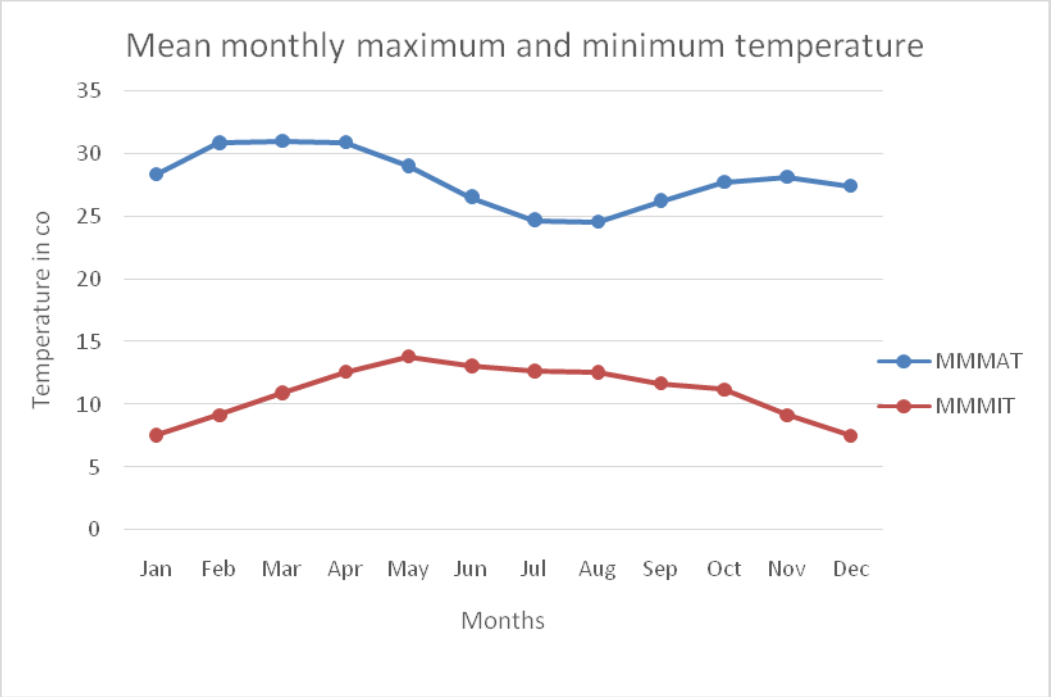

figure 4. 2.Trend of mean monthly maximum and minimum temperature

As indicated in the appendix Table 2 and 2.1, maximum and minimum annual range of temperature, mean, standard deviation and coefficient of variation were analyzed. Based on these findings, the study area recorded mean monthly maximum temperature in March and April with 31 ^{0}C and 30 ^{0}C respectively. Whereas, high standard deviation of mean monthly temperature were recorded in February and March with 3.17 ^{0}C and 1.46 ^{0}C respectively. In addition in April and July were recorded high variation of temperature with 10.3 % and 4.7 % respectively.

On the other hand, in May and June were recorded monthly minimum temperature with 13.84 ^{0}c and 13.1^{0}c respectively. In terms of standard deviation of monthly minimum temperature, February and January were recorded highest with 3.9 ^{0}c and 3.6 ^{0}c respectively .In addition from January to February recorded highest coefficient of variation in temperature with 47.6 % and 42.7 % respectively.

4.3. Rainfall Trends of The Study Area

Based on the results of metrological data that were collected and analyzed in the study area as indicated in the appendix Table 2.2 and in Figure 4.1.5, shows below, maximum mean annual rainfall were recorded in 2008 with rainfall amount of 1638.1mm. whereas, minimum mean annual rainfall were recorded in 2012 and 2017 with the rain fall amount of 1628.2 and 1681 mm respectively.

Generally, as shows in Figure 4.4. below, the estimated results for the 12 years recorded rainfall data reveals that the annual average rainfall is showing a decreasing trend of (-31.27mm) from year to year compared with sampled years.

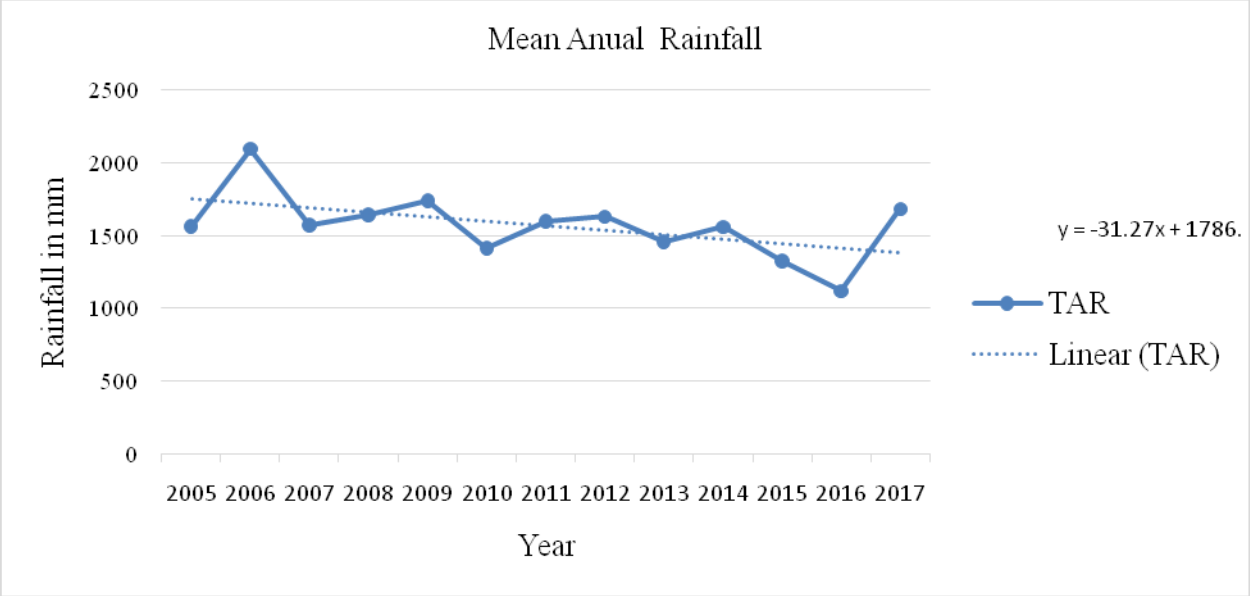

Figure 4. 3.Annual rainfall amount trends of the study area

In terms of trends in monthly rainfall amount variability as indicated in the figure 4.5. shows below, as well as in the appendix 2.2, monthly maximum and minimum, mean, standard deviation and coefficient of variation of rainfall were analyzed and interpreted as follows:

Metrological data results of the study area revealed that mean maximum rainfall of July and June were 300 and 368.49 mm respectively. In terms of standard deviations, June, July and August were recorded highest standard deviations of rainfall than other months with 91, 132, 143 mm. In addition on June, July and August were recorded highest range of rainfall amount with 455, 432, 537.9 mm respectively. Furthermore, on the month of December and February were recorded highest coefficient of variation in rainfall with rainfall amount of 214 % and 229.7 %.

Generally, as shown in figure 4.5. Below, mean monthly rainfall shows a decreasing trend. However, from the month of June to August were recorded a maximum rainfall amount compared with other months.

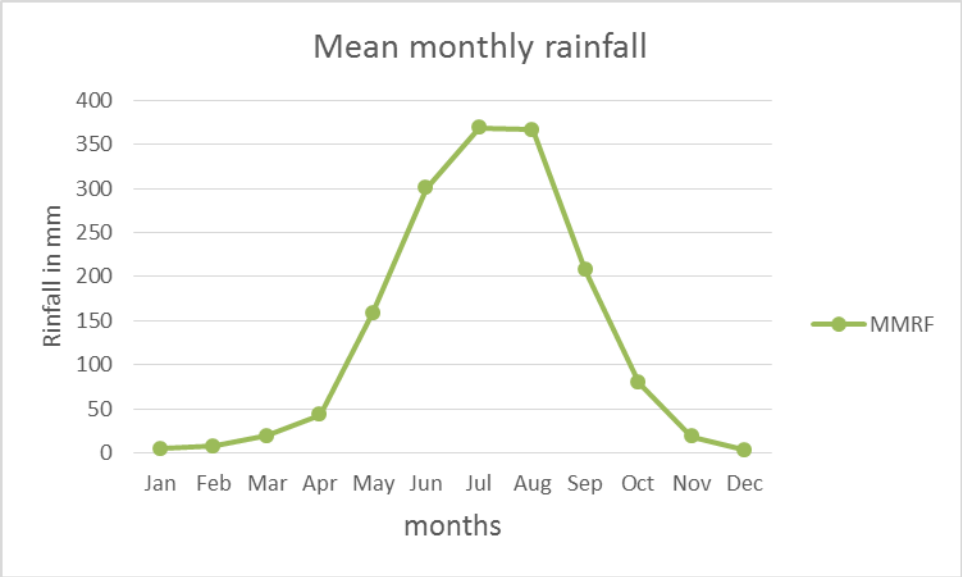

Figure 4. 4.Mean Monthly Rainfall Trend of the Study Area

4.4. Farmers Perception to Climate Variability in Koga Watershed

In order to understand farmers' perception towards climate variability in dega and woyina dega agro climatic zones of koga watershed, farmers were asked to indicate what they had perceived in variability of temperature and precipitation compared with 1990s. They were asked to specify

whether or not they had perceived: (i) changes in climate variability (ii) increases in temperature (iii) decreases in temperature (iii) no change in temperature levels (iv) increases in rainfall (vi) decreases in rainfall(vii) changes in the timing of rains (ix) no change in precipitation patterns.

4.4.1.Farmers perception to temperature variability

As indicated in figure 4.6. shows below, a cross tabulation between gender of the household head and the farmers perception towards variability in temperature between dega and woyina dega agro ecologies indicated that out of total woyina dega farmer household head respondents 94.2 % were perceived variability in temperature and the remaining 5.8 % of them were unable to perceive it in the study area. Whereas out of total dega farmer household head respondents 49.1% were perceived variability in temperature and the remaining 50.9 % farmer household head respondents were not perceived it in the study area.

In terms of gender and perception in temperature, majority of farmer household head respondents who were lived in woyina dega agro ecology (male, 95 % and female,90 %) were perceived variability in temperature compared with household heads who were lived in dega agro ecologies (male,56.1 % and female,25 %) who were perceived variability in temperature. So there is significant difference (.000 and . 000) with in gender in perceiving temperature between DHHR's and WDHHR's in the study area due to access to infrastructure, climate information, nearer distance to input and output market, access to agricultural extension services (Temesgen Deressa *et al*,2008).

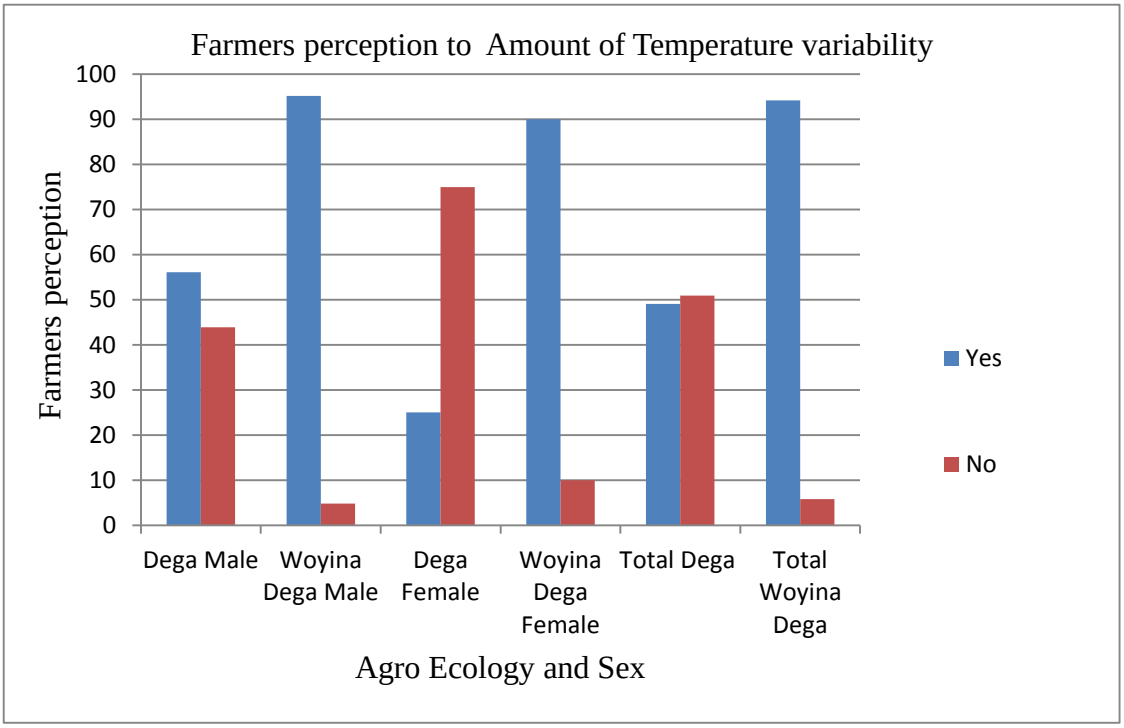

Figure 4. 5. Farmers' perception to temperature variability in koga watershed

As shows below in figure 4.7, household head respondents were asked about the direction of variability in temperature. Based on the results of cross tab analysis, in terms of gender out of total woyina dega household head respondents (male, 78.6 %, female, 50 %) were observed an increase in temperature and the remaining male, 23.6 % and female,40 % of them were observed a decrease in temperature. On the contrary the rest woyina dega household head respondents (male 1.2 % and female 10 %) were not observed any variability in temperature. Whereas out of total dega household head respondents, only male ,33.3% and female,11.1% were observed an increasing trend in temperature variability. Whereas the rest male, 23.6 % and female, 16.7 % were observed a decreasing trend in temperature variability. However, majority of dega household head respondents (male, 43.1and female, 72.2 %) were not observed any variability in temperature. In line with the meteorological evidences is that many farmers across Ethiopia perceive that increasing temperature, decreasing and erratic rainfall in their villages in the past twenty to thirty years (Bryan *et al*., 2009; Hadgu *et al*., 2014).

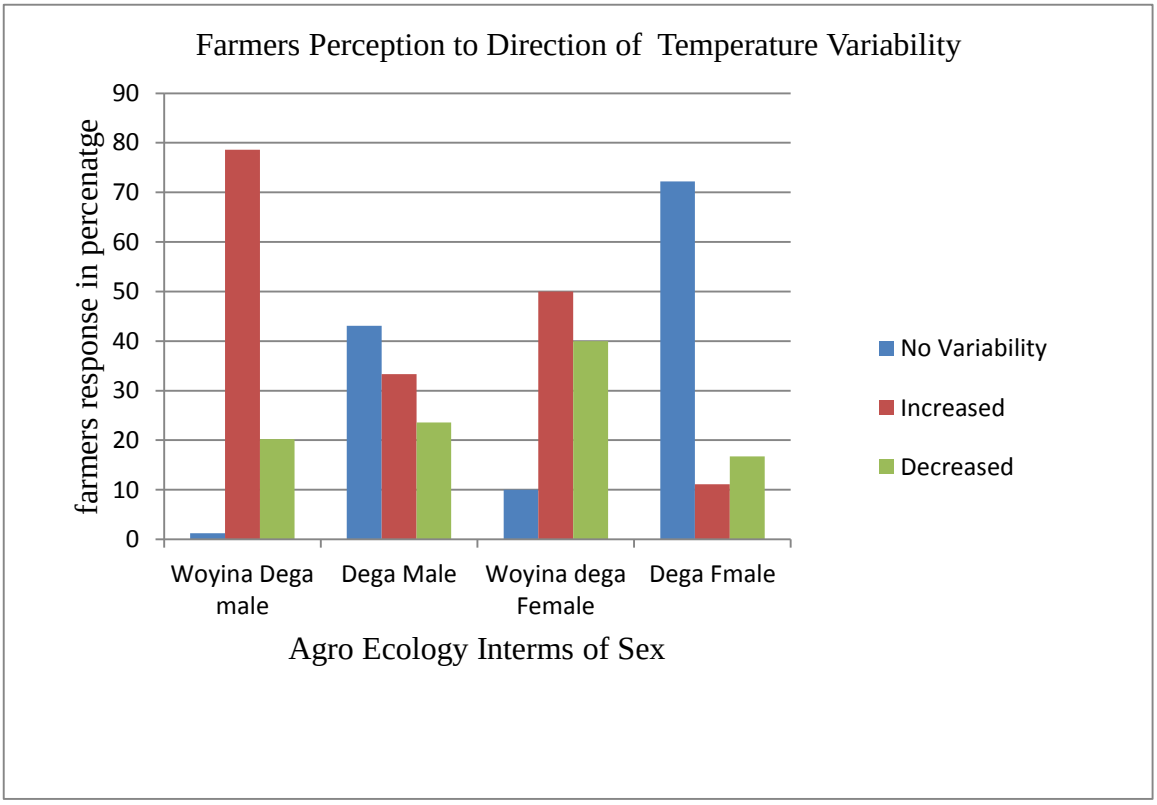

Figure 4. 6. Farmers perception to variability in trends of temperature

In terms of education as shows below in Figure 4.8, out of total literate woyina dega household head respondents, majority of (95.3%) were noticed variability in temperature. Whereas, the remaining 4.75 % literate woyina dega household head respondents were not noticed variability in temperature. With respect to dega household head respondents out of total literate respondents (50 %) were perceived variability in temperature and the remaining 50 % were not noticed it. This is due to that even though they are educated in status, there level of education was very low i.e. their education level was traditional Orthodox Church school and read and write.

Besides these literate farmer household head respondents, not literate farmers were asked about their perception in temperature variability. Based on their response as indicated in Figure 3 below, majority of woyina dega household head respondents (93.4 %) were perceived variability in temperature whereas the remaining 6.6 % were not noticed it. whereas note literate dega household head respondents (48.8%) were perceived variability in temperature and the remaining note literate DHHRs were not noticed it. This finding is in line with the work of other researchers

that farm household heads with an access to formal education greatly contribute to climate change adaptation and reduce vulnerability in the basin (Nhemachena and Hassan, 2007).

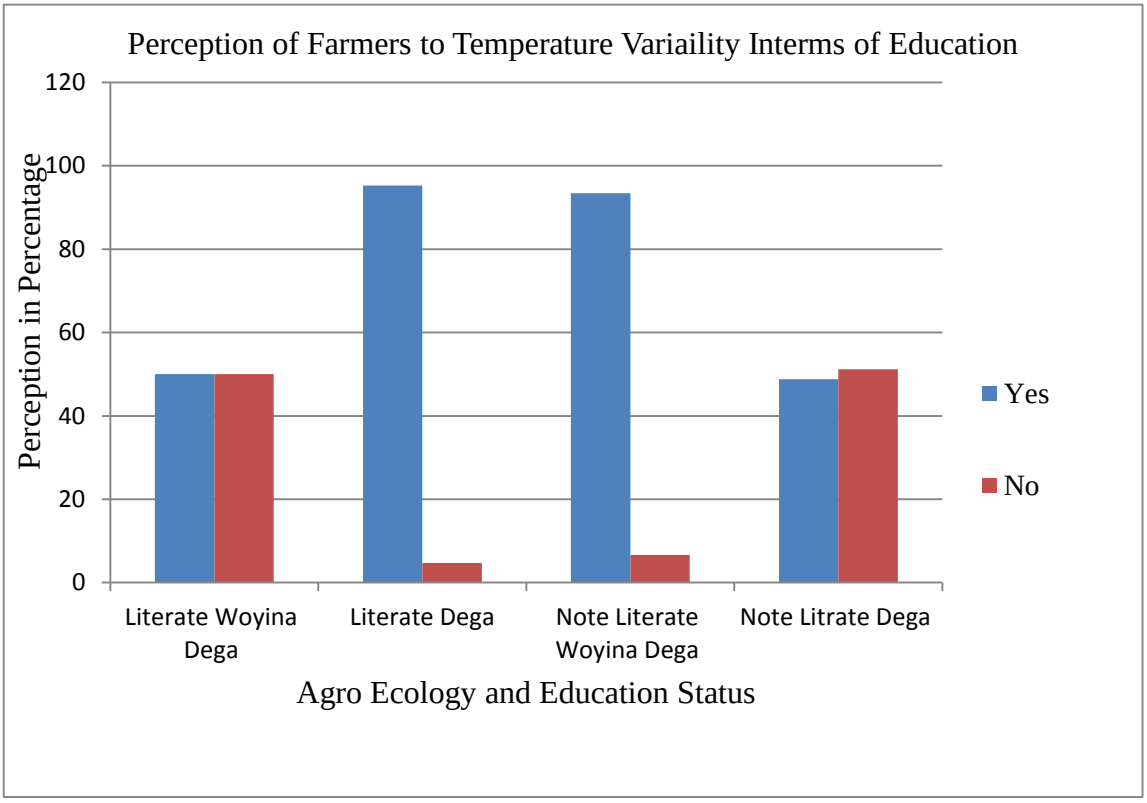

Figure 4. 7.Koga watershed farmer's perception to variability in temperature amount (in terms of education)

As indicated above the respondents perception that were collected and analyzed through questionnaires are in line with metrological data (temperature were shown an increasing trend by 0.026 ^{o}C and rainfall amount showed a decreasing trend by -31.27mm.

4.4.2.Farmers perception to variability in precipitation

In terms of gender and precipitation cross tab results as shown below in Figure 4.9, majority of respondents who were lived in woyina dega agro ecology (male 88.1%,female 95 %) were better perceived variability in amount of precipitation compared with DHHR's (male,27.6 % and female 25 %). The remaining WDHHR's (male, 11.9 %, female, 5 %) were not noticed variability in amount of precipitation. Whereas the remaining majority DHHR's (male 72.4, female, 75 %) were not noticed variability in amount of precipitation.

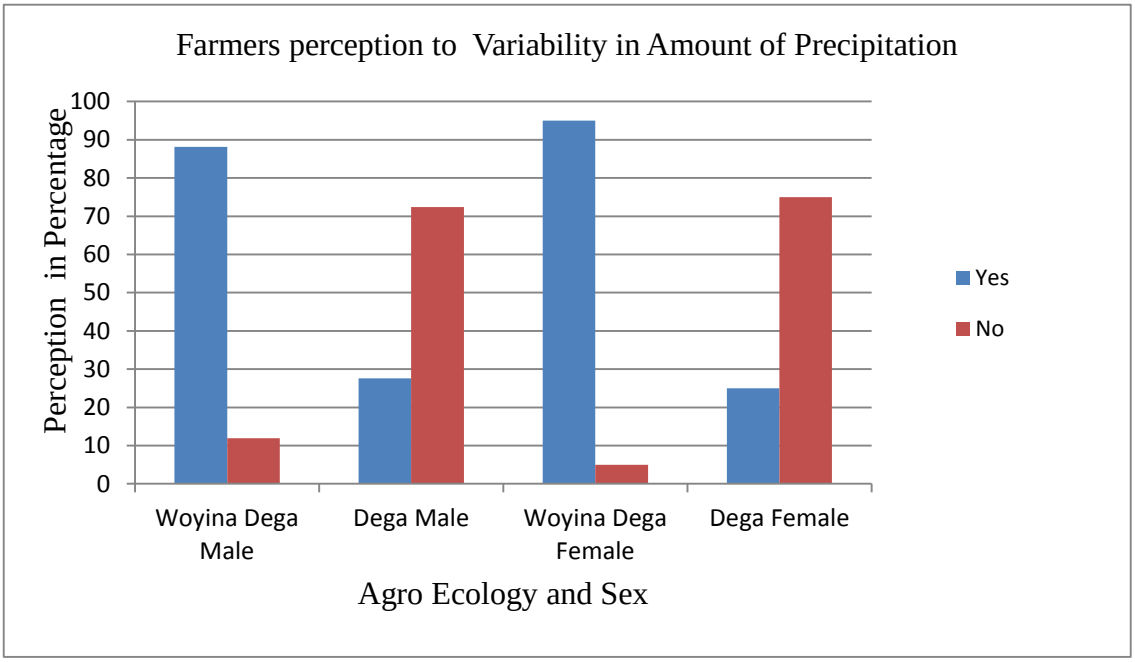

Figure 4. 8. Farmers' perception to precipitation amount in percentage in koga watershed

In terms of direction of precipitation amount as shows in Figure 4.10 below, majority DHHRs (male, 71.7 %, female, 72.2 %) were observed no variability to precipitation. Similarly WDHHRs (male, 6 %, and female, 9.6 %) were not observed variability to rainfall amount. On the other hand farmers who were lived in woyina dega agro ecology (male,61.9 % ,female,55 %) observed a decreasing trend in precipitation from year to year compared with DHHR's (male,22.8 %,female,13.9 %) who were also observed a decreasing trend in it. Whereas the remaining WDHHR (male, 27 %, female,9.6 %) were observed an increase in precipitation amount.

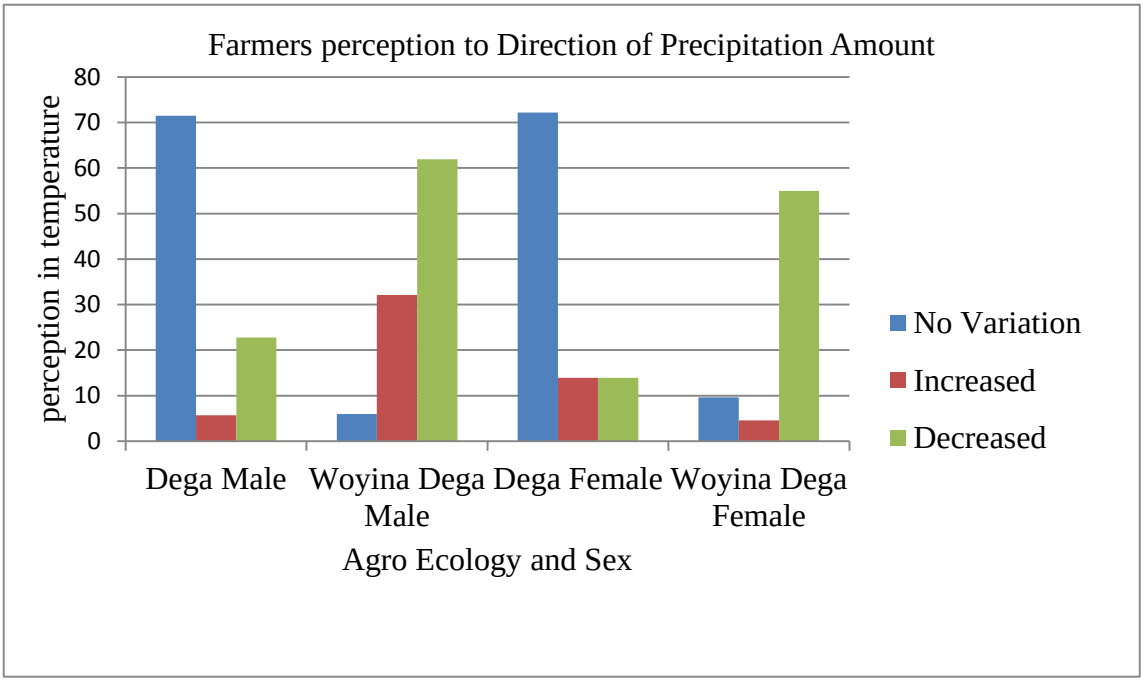

Figure 4. 9.Farmers perception to direction of precipitation amount in the study area

4.5. Indicators of Climate Variability Observed by Farmers in Koga Watershed

Cross tabulation result shows in the Figure 4.11 below, that farmer's observation of indicators of climate variability in the study area. Majority of the respondents observed these indicators; whereas some of respondents have not observed these indicators. Drought, cool, too maximum rainfall, too low rainfall was not significantly different between dega and woyina dega farmer household head respondents observation. On the other hand flood, off seasonal rainfall, high temperature, hailstorm, early onset and early offset of rainfall season were highly significantly different between two agro ecologies in the study area.

About 8o.5 % of DHHRs were confirm the problem of flood and the remaining 19.5 % of the respondent revealed that there is no observation in the problem of flood in their locality. Whereas 62.5 % of woyina dega respondents confirm the problem of flood and the remaining 37.2 % of respondents were not observed the problem of flood in the watershed. So, based on respondent's observation as indicated in the above results, there is significant difference in observing the problem of flood in dega and woyina dega respondents. On the other hand, 85.6 % of woyina

dega respondents perceived the presence of off seasonal rainfall compared with dega respondents (66 %). On the other hand the remaining 8.7 % of woyina dega respondents not perceived the presence of off seasonal rain fall compared with 15.7 % of dega respondents, who were not observed.

In addition, majority of woyina dega respondents (94.2 %) perceived that the presence of high temperature in there locality compared with dega respondents (79.9 %) who were perceived the presence of temperature. While 5.8 % of woyina dega respondents were not perceived the presence of high temperature compared with 20.1% of dega respondents.

In addition majority of dega respondents (87.4 %) revealed as there were problem of hail storm compared with woyina dega respondents (61.1%) who were revealed the problem of hail storm in the study area. The remaining 12.6 % of dega respondents were not revealed hail storm compared with woyina dega respondents (38.5%).

Furthermore majority of woyina dega respondents (93.3 % and 94.4 %) were observed the problem of early onset and early offset of rainfall season respectively compared with dega respondents (78.6% and 81.1%) who were observed this problem. While woyina dega respondents (6.7 % and 5.8 %) were not observed early on set and off set of rainfall season in the watershed respectively compared with dega respondents (21.4 % and 18.6 %) who were not observed the problem of early onset and early off set of rainfall season respectively. The reason that this difference is that, Respondents who were lived in woyina dega agro ecology had better access to climate variability information ,access to agricultural extension and training ,access to modern education than respondents who were lived in dega agro ecology of the study area.

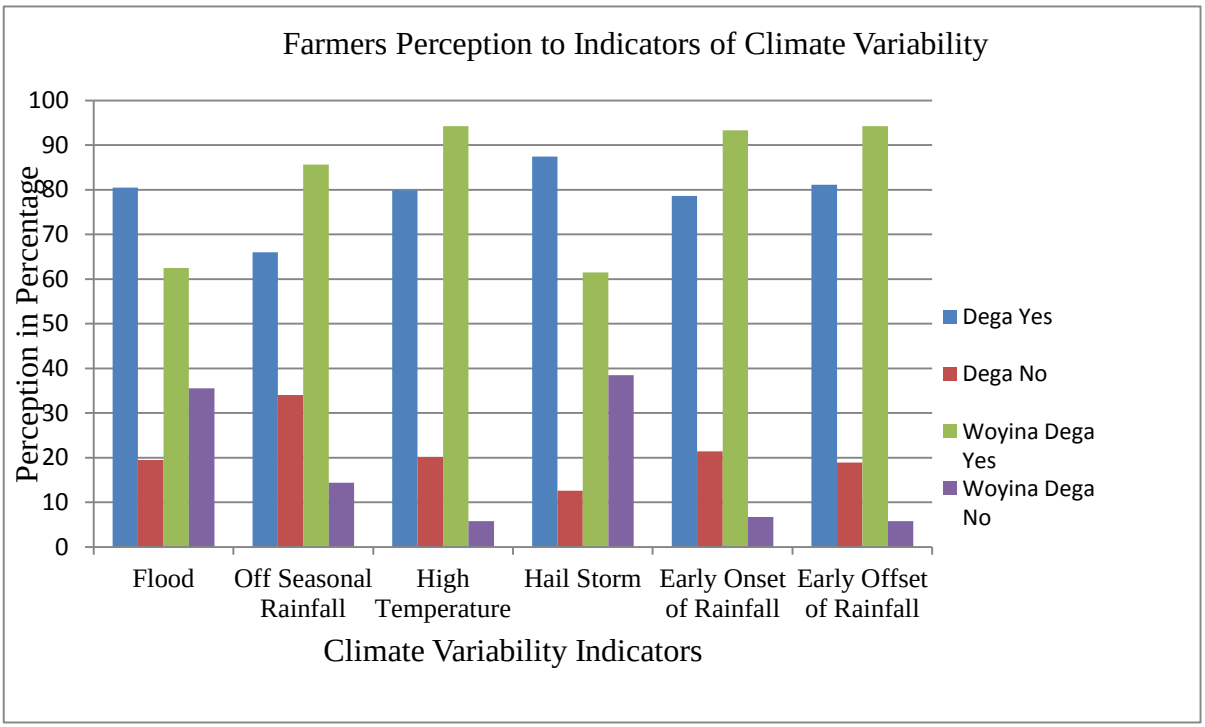

Figure 4. 10.Farmer's perception to climate variability indicators

4.6. Farmers Difference in Using Adaptive Strategies Between Dega and Woyina Dega Agro Ecology of Koga Watershed

House hold heads were asked about whether they were taken or not adaptation measures in response to variability of temperature and precipitation in the study area. Based on chi square analysis results in Figure 4.12 below, indicated that, majority of woyina dega household heads (male 91.9 %, female 72.2 %) were implemented at least one kind of soil and water conservation activities compared with DHHR's (male, 50.4 %, female 16.7 %) who were implemented at least one or two kinds of soil and water conservation activities in the study area in response to temperature and precipitation variability problems. Whereas the remaining woyina dega farmers (male 8.1,female 27.8%) were not used soil and water conservation in response to climate variability compared with dega household head respondents (male 49.6 % ,female 83.3 %) .

This is because male headed households have greater preferences to use soil and water conservation as a strategy that require labor, finance and climate information than female headed households'. This is in line with the argument that male headed households' are more likely to get information about new technologies and take risky business than female headed households'

(Temesgen D. et al. 2009). Abaje et al. (2013) noted that unlike men, women have limited access to information, land and other resources.

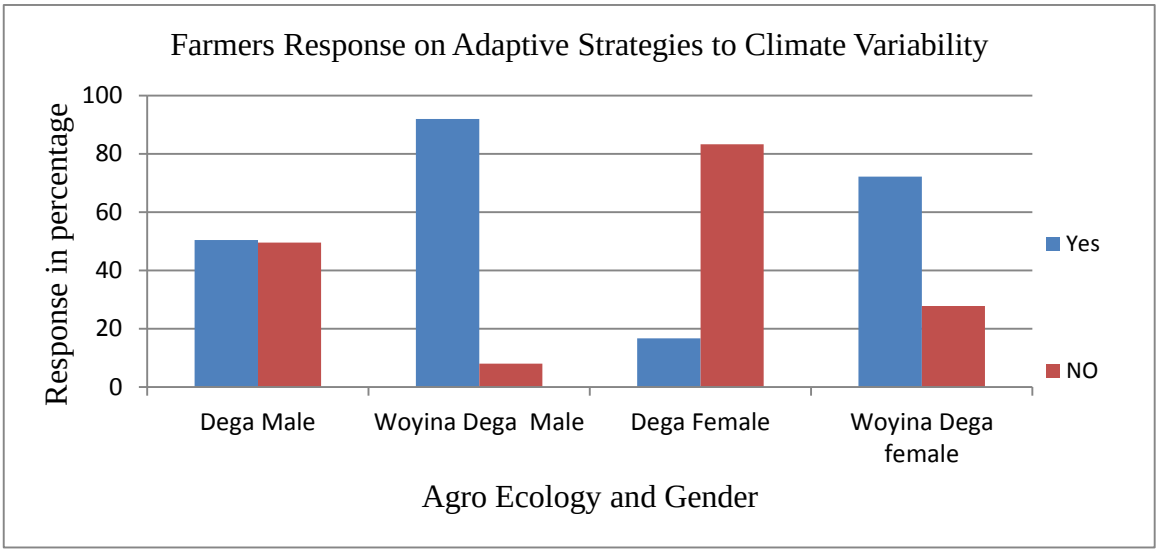

Figure4.11.Farmers response in terms of gender on adaptive strategies to climate variability in the study area

In terms of education as indicated in Figure 4.13. below, majority of woyina dega literate household head respondents (91.1 %) were taken at least one kind of adaptation strategies compared with literate dega household head respondents (55.9 %) who were taken at least one kind of adaptation strategies against variability in temperature and precipitation problems. On the contrary majority of dega respondents who were not had access to basic education (60.8 %) were not taken at least one type of adaptation measures in response to climate variability problems compared with literate dega house hold head respondents (13.6 %) who were not had access to basic education. This significant difference in taking measures against climate variability problems were due to woyina dega household head respondent's access to basic education. Education is assumed to be an important factor in accessing advanced information on new improved agricultural technologies and increased agricultural productivity (Elahi et al., 2015).

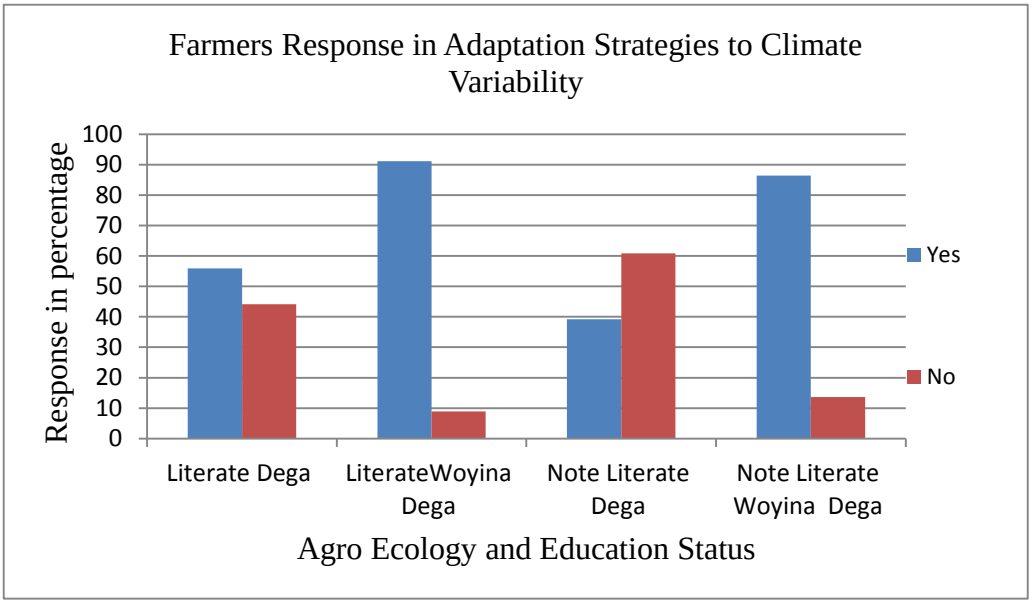

Figure 4. 12.Farmers response in adaptation strategies to climate variability problems (in terms of education

In terms of implementing soil and water conservation activities as indicated in Table 4.3 below, majority of woyina dega household head respondents (male 91.9 % and female 66.7 %) were practiced at least one kind of soil and water conservation activities compared with dega respondents (male, 47.2 % and female 16.70 %) who were practiced soil and water conservation activities. On the contrary the remaining dega house hold respondents (male, 52.8 % and female, 83.3 %) were not implemented SAWC activities in the study area. On the other hand the remaining WDHHR's (male, 8.1% and female, 33.3 %) were not implemented SAWC as adaptation strategies against climate variability problems.

With respect to education ,as shown below Table 4.3,majority of literate WDHHRs (93.3 %) were implemented at least one type of SAWC activities in the study area compared with literate DHHRs (52.9 %) who were implemented in response to climate variability problems. Whereas majority of literate dega household head respondents (47.1 %) were not chosen soil and water conservation activities as an adaptation measures in response to climate variability problems compared with literate woyina dega household head respondents (6.7 %).

On the other hand majority of note literate WDHHRs (83.1 %) were chosen SAWC activities as adaptation strategy to climate variability, the remaining 16.9 % were not chosen it. Whereas

majority of DHHRs (63.2 %) were not used SAWC activities as an adaptation strategy to climate variability problems and the remaining 36.8 % of not literate DHHR's were used it as an adaptation strategy to climate variability problems. So there is a significant difference in implementing SAWC as an adaptation strategy between woyina dega and dega house hold head respondents.

*Table 4. 2.*cross tab results between adaptation strategies and socio economic characteristic**s**

Adaptation strategies		Yes (%)	NO (%)
ISAWC*Sex*agro ecology	Male dega	47.2	52.8
	Male woyina dega	91.9	8.1
	Female dega	16.7	83.3
	Female woyina dega	66.7	33.3
ISAWC*Age*agro ecology	Dega age 30-49	38.2	61.8
	Woyina dega Deg age 30-49	87.8	12.2
	Dega age 50-65	39.2	60.8
	Woyina dega -age 50-65	89.5	10.5
	Dega age >65	52.6	47.4
	Woyina dega -age >65	82.4	17.6
ISAWC*Education*Agro Ecology	Dega literate	52.9	47.1
	Woyina dega literate	93.3	6.7
	Dega not literate	36.8	63.2
	Woyina dega not literate	83.1	16.9

With respect to cross tabulation results between agro ecology and gender in using improved crop varieties as shown below in figure 4.14, 90.7 % of male and 72.2 % of female woyina dega household head respondents were used improved crop varieties compared with dega respondents (male, 55.3 % and female, 33.3 % of female respondents who are found at dega in response to climate variability problems. Whereas the remaining 44.7 % of male and 66.7 % of female dega respondents were not used improved crop varieties compared woyina dega respondents (male, 9.3 % and female, 27.7 %) in response to climate variability problems.

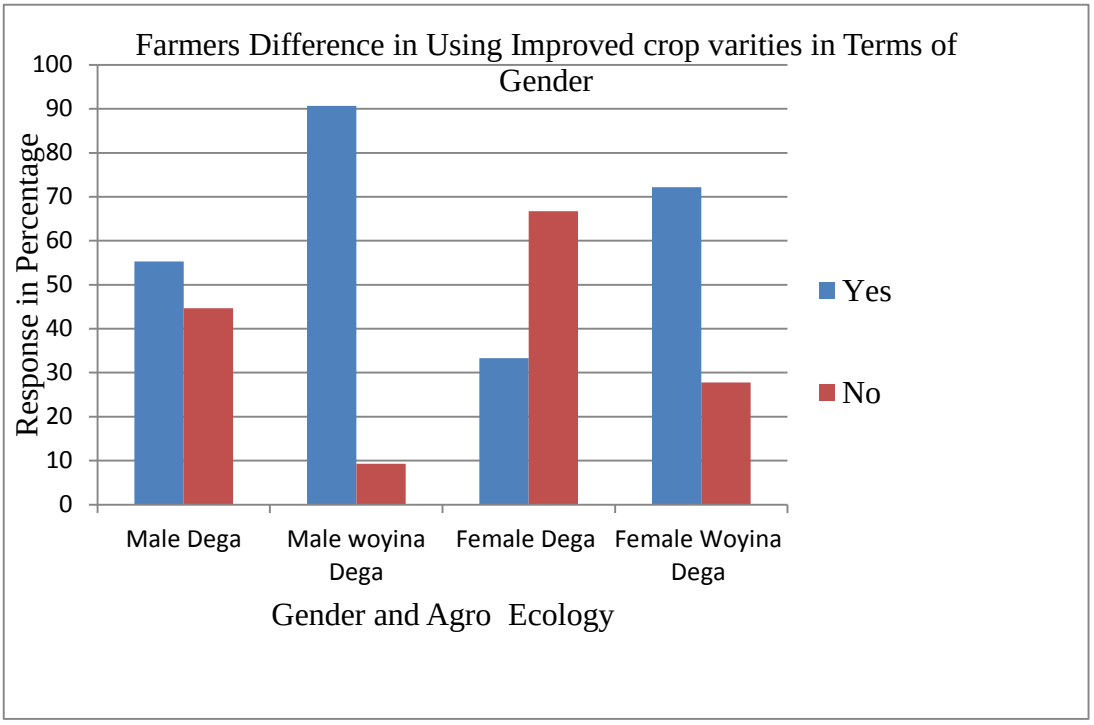

Figure 4. 13. Farmers difference in terms of gender between agro ecologies in using improved crop varieties as adaptation strategy to climate variability

In terms of education and using improved crop varieties as shows in Figure 4.15 below, literate woyina dega household head respondents (88.9 %) were taken improved crop varieties as an adaptation measure compared with literate dega household head respondents (50 %) who were used it as an adaptation strategy, and the remaining literate woyina dega and dega respondents (11.1% and 50 %) were not chosen improved crop varieties as an adaptation strategy to climate variability respectively. Whereas not literate woyina dega and dega respondents (86.4 % and 50.45 %) were used improved crop varieties as adaptation strategy to climate variability problems respectively, and the remaining not literate woyina dega and dega respondents, (13.6 % and 49.6 %) were not chosen it as adaptation strategy to climate variability problems.

So based on the Table output below there is a significant difference between literate and not literate woyina dega and dega respondents in choosing improved crop varieties as an adaptation strategy in response to climate variability problems in the study area.

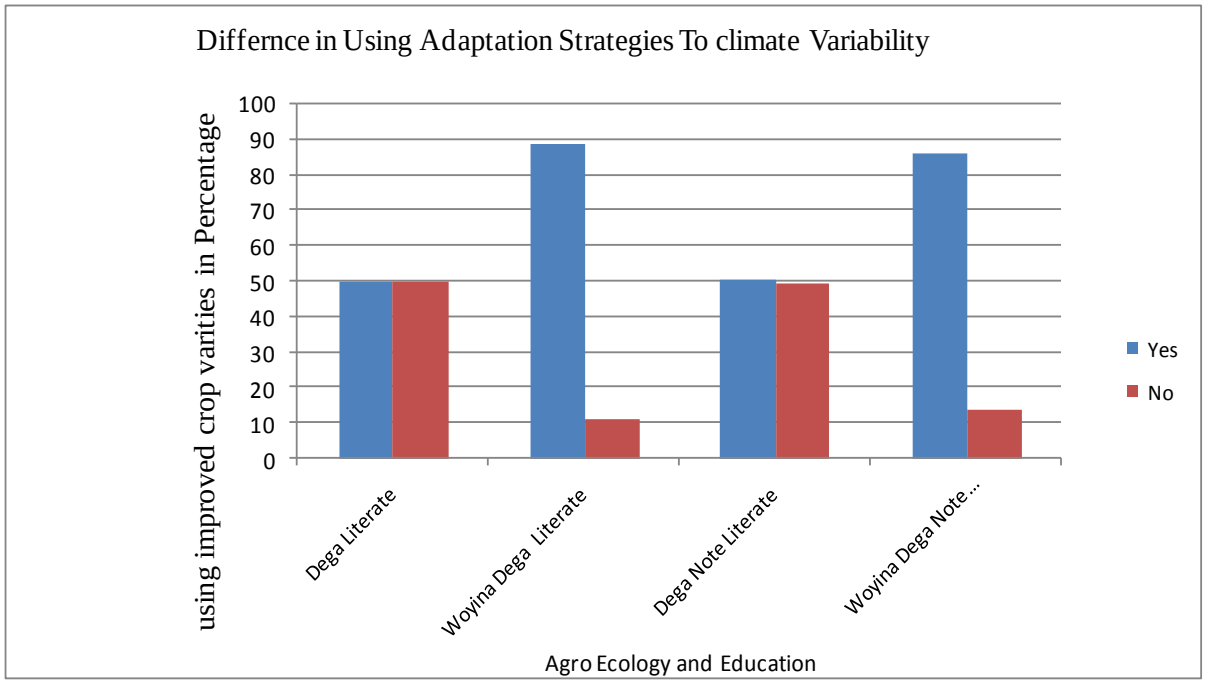

Figure 4.14.Farmers difference between agro ecologies in terms of education and using improved crop varieties as adaptation strategy to climate variability in the study area

In terms of planting tree as shown below in Figure 4.16, out of total woyina dega household head respondents (male,90.5 % and female,61.1 %) of them were planted tree ,and the remaining WDHHR's (male,9.5 % and female,38.9 %) were not used it as adaptation strategy to climate variability problems. Whereas DHHR's (male 35.8, female, 16.7 %) were used it as adaptation strategy to climate variability, and the remaining, male 64.2 % and female 83.3 % were not used adaptation strategy to climate variability.

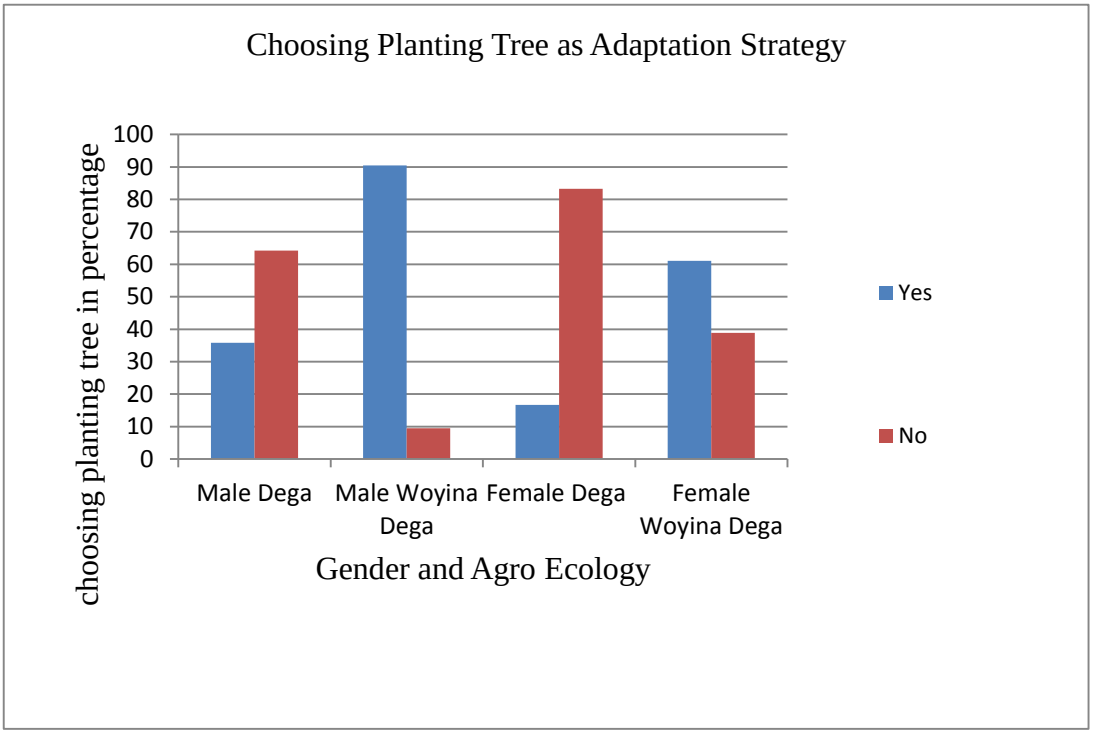

Figure 4. 14.Farmers response in terms of gender in choosing planting tree as adaptation strategy to climate variability

In terms of using diversifying income as an adaptation strategy as shows in the Figure 4.17 below ,out of total WDHHR's (male,78.8 % and female 80 %) were used diversifying income as an adaptation strategy compared with DHHR's (male ,14.6 % and female13.6 %) who were used diversifying income as an adaptation strategy in response to climate variability. On the contrary out of total WDHHRS (male,21.2 % and female12.2 %) were not used it as adaptation measure compared with DHHRs (male,85.5 % and female,86.1 %) who were not used it as an adaptation strategy to climate variability.

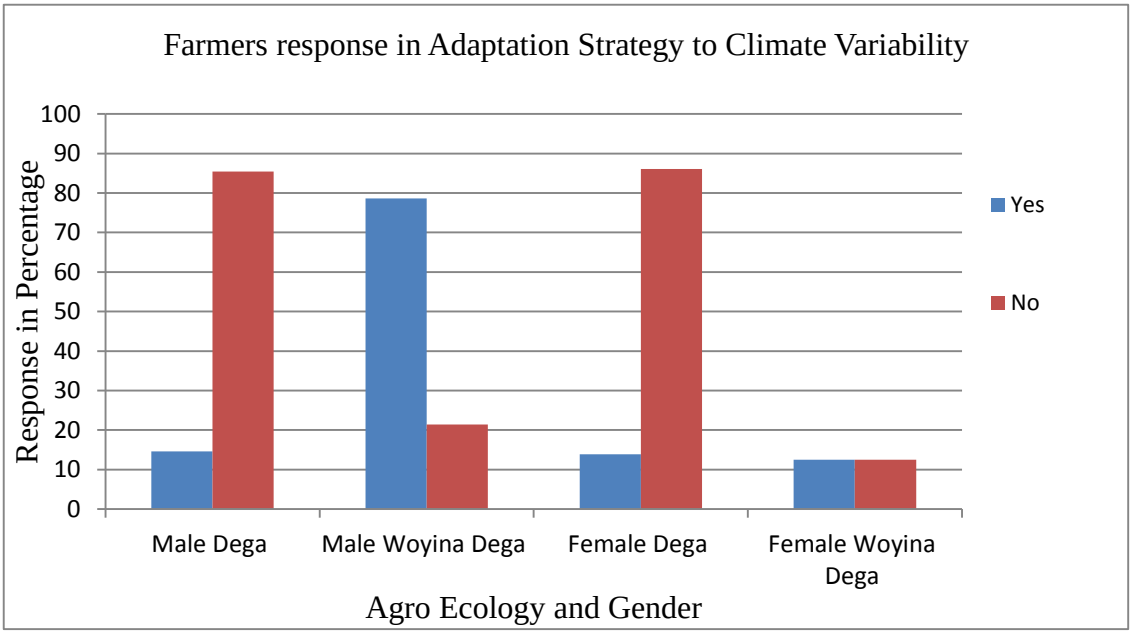

Figure 4. 15.farmers response in adaptation strategy to climate variability in terms of gender: source, own survey 2018

With respect to adjustment of planting dates out of total woyina dega household head respondents (79.8 %) were used adjustment of crop planting date as a response to climate variability problems compared with 46.5 % of dega household head respondents .On the contrary out of total 53.5 % of dega household head respondents 20.2 % of woyina dega household head respondents were not used adjustment of planting dates as adaptation measure in response to climate variability problems. So there were significant difference in taking adjustment of crop planting dates between woyina dega and dega household respondents.

In terms of education majority of literate WDHHR (80%) were used adjustment of planting dates as an adaptation measure compared with literate DHHRs (41.2 %) in response to climate variability problems. Whereas majority of note literate WDHHRs (79.7 %) were not taken adjustment of planting dates compared with note literate DHHRs (49.6 %) in response to climate variability problems. On the contrary majority of literate DHHR (58.8 %) were not used adjustment of planting dates in response to climate variability problems compared with literate WDHHR (36.7 %).

In addition house hold head respondents in the study area were asked whether they were used applying farm inputs or not based on agricultural extension workers recommendation as adaptation measures to climate variability. Based on the chi square analysis as indicated in Table 4.4 below, majority of WDHHRs (male 87.2,female ,72.2 %) were decided using farm inputs as an adaptation measures to climate variability compared with DHHRs (male dega 57.7 %, female13.9 %) who were decided to take farm inputs as an adaptation measures to climate variability. On the contrary the remaining DHHRs (male 42.3 %, female 86.1%) were not decided in taking using farm inputs as adaptation measure compared with WDHHRS (male12.8 %,female 27.8 %) who were not decided in using farm inputs as an adaptation measure.

In terms of education, majority of literate WDHHRs (84.4%) were chosen using farm inputs an adaptation measure in response to climate variability compared with literate DHHRS (41.2 %) who were not chosen it as adaptation measure. Whereas the remaining literate WDHHRS (15.6 %) and DHHRS (58.6 %) were not chosen applying farm inputs as adaptation measure to climate variability. On the contrary majority of note literate WDHHRS (84.7 %) were chosen applying farm inputs in response to climate variability compared with note literate DHHRS (49.6 %) who were used farm inputs as adaptation measure to climate variability. Whereas the remaining notes literate WDHHRS (15.3 %) and note literate WDHHRS (50.4 %) were note chosen farm inputs as adaptation measure in response to climate variability.

In terms choosing improved animal species as adaptation measure to climate variability HHR'S in the study area were asked. Based on the results of chi square analysis, out of total WDHHR'S 66.3 % were chosen improved animal species as adaptation strategy compared with DHHR'S (14.5 %) who were chosen it as adaptation strategy in response to climate variability. Whereas the remaining WDHHRs (33.1 %) were not chosen improved animal species as adaptation measures to climate variability. So there is significant difference between WDHHR'S and DHHR'S in terms of gender in choosing adaptation measures to climate variability.

With regard to choosing manure as adaptation strategy to climate variability out of total WDHHRs(86.5 %) were chosen using manure as a response to climate variability problems compared with 18.9 % of DHHR's. Whereas the remaining WDHHR's (13.5 %) were not chosen using manure as adaptation strategy to reduce climate variability problems compared with 81.1

% of DHHR'S. So WDHHR'S had a significant difference compared with DHHR'S in using manure.

Generally, farmers' living in different agro-ecological setting used different adaptation measures in response to climate variability. It has been reported that households' living in areas, where the amount of rainfall is less and high temperature than the average is more likely to employ different measures than households' receiving much rainfall and less temperature (Gutu et al, 2012). This implies that rural households' living in the woyina dega are more likely to adapt to the changing situations than those in dega due to the existence of high variability in climate compared with dega households.

*Table 4. 3.*farmers difference in adaptation strategies between socio economic characteristics

Adaptation strategies		Yes (%)	NO (%)	Level of significance
Adjustment of planting dates*sex	Male dega	84.2	38.8	.000
	male w/dega	84.9	15.1	.000
	Female dega	55.6	44.2	
	female w/dega	83.3	16.7	
Adjustment of planting dates*Education	Dega literate	41.2	58.8	
	Woyina dega literate	80	20	.000
				.000
	Dega not literate	49.6	50.4	
	Woyina dega not literate	79.7	20.3	
using farm inputs *sex	Dega male	57.7	42.3	.000
	W/dega male	87.2	12.8	.000
	Dega female	13.9	86.1	
	Woyina dega female	72.2	27.8	
farm inputs*Education	Dega literate	41.2	58.8	.000
	Woyina dega literate	84.4	15.6	.000
	Dega not literate	49.6	50.4	
	Woyina dega not literate	84.7	15.3	
using improved animal species *sex	Dega male	13.8	86.2	.000
	W/dega male	65.1	35.9	.000
	Dega female	16.7	83.3	
	Woyina dega female	72.2	27.8	

4.7.Farmers Difference in Adaptive Capacity Between Dega and Woyina Dega Agro Ecology of Koga Watershed

Farmer household head respondents were asked about their socio economic characteristics to analyze their adaptive capacity to climate variability. Based on the respondents response their vulnerability in terms of adaptive capacity were analyzed in terms six indicators that were selected based on the socio economic set up of the study area and researchers observation.

4.7.1. Agricultural Income (AI)

Based on farmers response as shown below in Table 4.5 , in terms of on farm income sub components dega household head respondents having adaptive capacity score 0.1, were more vulnerable than woyina dega household head respondents having adaptive capacity score of 0.29. This is due to the reason that if households who had more on farm income, they would have a greater chance of growing and modernize their farm by investing on it. Farmers might be used their profit that was gained from on farm agriculture to buy agricultural inputs, insecticides and pesticides. For this study, income from agricultural activities can be through sale of field crops, horticultural activities,. It is assumed that those who get income from agricultural activities are likely to be more responsive so that their source of livelihood is not affected by climate variability problems (Mudombi, 2011).

4.7.2.Off Farm Income

Shifting from agricultural activities to non-farm enterprises is increasingly adopted in many societies as a form of diversification of the rural economy (Boamah, 2014). Woyina dega household head respondents having adaptive capacity index value about (0.17) had more adaptive capacity than dega household head respondents (0.01).This is because of woyina dega household heads access to different source of income. Woyina dega household head respondents had access to infrastructure and due to this they have the opportunity to sell their agricultural products in the nearby market. The main off farm activities woyina dega households have access were mule cart services, small trade and remittance from educated families.

4.7.3.Livestock Unit

Based on the adaptive capacity indicators result, majority of household head respondents who were lived in woyina dega having adaptive capacity index of about (0.27) had more adaptive capacity index value than household head respondents who lived in dega agro ecology with index value of 0.23. The more the farmers engaged in raring animals, the more they will got the capacity to adopt climate variability problems (Seo and Mendelssohn, 2008). Woyina dega household heads had access to improved crop varieties than dega household heads due to its proximity to district agricultural office. Therefore, in terms of livestock unit, woyina dega household head respondents are more resilient to climate variability than dega household head respondents.

4.7.4.Total land size owned

In terms of total land size households owned, woyina dega household heads had higher adaptive capacity and lesser vulnerability with 0.5 adaptive capacity index value than dega household head respondents (0.23) adaptive capacity index value.

Households' with larger farm sizes are more probably to diversify their crops especially under dry seasons and reduce the negative impacts of climatic variability. The greater households have land size the lesser their vulnerability to climate variability (Abrham and Birtukan, 2016).

4.7.5.Family size

Based on the results of farmer's response on adaptive capacity indexes shown below, woyina dega household head respondents have greater adaptive capacity index value (0.6) than dega household head respondents (0.4)**.** Woyina dega household head respondents having large number of family size were highly resilient to climate variability than dega household heads.

4.7.6. Distance from input market

In terms of respondents distance to input market there is significant difference between dega and woyina dega household heads. Based on the results of this sub component indicator shown below in table 5, woyina dega household head respondents with 0.33 adaptive capacity index value were less than adaptive capacity index value of 0.5 dega household head respondents. If the

household heads home is located in near distance to input market, households will have access to buy and sell agricultural inputs as well as their products. Proximity to market may serve as a means of sharing and exchanging information with farmers and other service providers (Madison, 2007).

This study were analyzed based on IPCC framework that the more adaptive capacity, the less vulnerability. Variables listed under an adaptive capacity were given a positive value. In this study, it is assumed that people with a higher adaptive capacity are less vulnerable to damages from climate variability, keeping the level of exposure constant.

So woyina dega household head respondents having 0.33 adaptive capacity index value; were less vulnerable than dega household head respondents with the adaptive capacity index of 0.5.This is because of the indicators positive or negative relationship with vulnerability. In this case farmer's home distance from input market has a negative relationship with their adaptive capacity to climate variability. Farmers home far from input market are more vulnerable than farmers home nearer from input market. So based on agro ecology ,woyina dega household head respondents with adaptive capacity index value (0.36) were less vulnerable than dega household head respondents having adaptive capacity index value of 0.245. Hence Vulnerability = (adaptive capacity) – (sensitivity + exposure).In this relationship, higher net value indicates lesser vulnerability or highly resilient and vice versa (Ipcc, 2001).

Table 4. 4. Adaptive capacity index components and scores

Sub component	Unit of measurement		Agro ecology					Sub component adaptive capacity value	
			Dega		Woyina dega				
adaptive capacity indicators		Actual value	Max value	Min value	Actual value	Max value	Min value	Dega (highland)	Woyina dega (midland)
On farm income (AI)	continuous (Ethiopian birr)	5,974	64,280	270	19,452	64,280	270	0.1	0.29
Off farm (OI) income	continuous(Ethiopian birr)	100.6	10,000	0	1791	10,000	0	0.01	0.17
Livestock unit (LU)	Continuous (Number of livestock a household head had)	4.548	13	2	5	13	2	0.23	0.27
Land size (TLO)	Hectare	1.465	3	1	2	3	1	0.23	0.5
Family size (FAMSIZ)	Number of family members	5	8	3	6	8	3	0.4	0.6
Distance from input market (DFIM)	Distance in KM	2.5	4	1	2	4	1	0.5	0.33
Aggregate index value								0.245	0.36

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

This chapter provides summary and conclusion based on research findings on farmer's vulnerability in terms of adaptive capacity to climate variability. The study used cross-sectional data collected from 263 households in the production year 2018/2019 G.C, and applied descriptive statistics and indicator method to analyze the data.

5.2. Conclusions

Farmers in koga watershed perceive variability in temperature and rainfall. They are able to recognize that temperatures have increased, and rainfall amount decreased. However, there perception level is varied from woyina dega agro ecology to dega agro ecology. Woyina dega (midland) agro ecology respondents were better perceived climate variability than dega (highland) agro ecology respondents. Farmers' perceptions to temperature and rainfall are in line with the climatic records.

Farmers perceived variability in climate using local indicators. Among the climate variability indicators high temperature, flood, off seasonal rainfall, early off set and on set of rainfall season and hailstorm are observed by respondents. There is a significant difference in the way farmers perceived the variability in the direction of temperature and precipitation amount across agro-ecologies; and with the socio economic experience the way the variability in temperature and precipitation is perceived varies significantly. WDHHR's were better perceived climate variability than DHHRS.

The main adaptation strategies of farmers being used in the study area were: implementing soil conservation, diversifying crops, adjustment of planting dates, using farm inputs ,using improved animal species, using improved crop verities, planting tree ,using manure and diversifying income.

There was significant difference between dega and woyina dega household head respondents in implementing soil conservation, diversifying crops, adjustment of planting dates, using farm inputs ,using improved animal species, using improved crop verities, planting tree ,using manure

and diversifying income. The chi square results also indicated that resource rich farmers and farmers who have a good profile of socio economic characteristics are the most likely to adapt to climate variability and the poor are the least likely. In general, sex, age, education, farm income, off farm income, farm size, distance to the market, access to credit, number of livestock owned by farmer and access to climatic information are the contributing factor that influences farmers' difference in perception, adaptive strategies and adaptive capacity to climate variability.

5.3. Recommendations

Based on the findings of this study, the following recommendations were forwarded for reducing the impacts of climate variability on farmer's livelihood in the study area:

Based on the results of farmer's perception to climate variability, dega household head respondent's awareness to climate variability were less than dega household head respondents. So the government should work hard to aware farmers about climate variability and its impacts through agricultural extension workers and training.

Strengthening efforts on enhancing the farmers' adaptive capacity to climate variability is an important policy measurement. The government and any concern body should give emphasis to address this issue of climatic variability through paying greater attention. The result implies that adaptation is highly locally specific and hence, geographical location and socio-economic characteristics should be considered while designing adaptation strategies.

The Government should contribute to mitigate climate variability effects on agriculture by investing in research (drought resistance, short maturing varieties), soil conservation measures (terrace, ditch, check dam, agro-forestry, expanding fertilizer use, expanding markets, expanding education (farmers training centers, formal education), addressing climate variability information , developing climate forecasts, and formulating planned and anticipatory adaptation strategies. Moreover, Government policies should support the provision of access to education, credit, extension services on crop and livestock production, and information on climate and adaptation measures are necessary to better adopt with climate variability in the study area.

The government should also strengthen agricultural extension systems to vulnerable groups of farmers like women headed households, note literate household heads, farmers who have not

diversify their income, and dega household head respondents who are far from district administration. Because this group of farmers have little or no access to extension services and farm inputs, infrastructure and climate information. In the future, similar studies might be conducted which adequately and completely address the issue of vulnerability, sensitivity and adaptive capacity by interested researchers.

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APPENDIX

Appendix table 1. Conversion factors used to compute tropical livestock unit (TLU). Source: storck etal . 1991

No.	Livestock category	Conversion factor
1	Calf	0.25
2	Weaned calf	0.34
3	Heifer	0.75
4	Cow or ox	1.0
5	Horse/mule	1.0
6	Donkey/adult	0.7
7	Donkey/young	0.35
8	Sheep/goat/adult	1.25
9	Sheep/goat/young	0.06
10	Chicken	0.013
11	Bull	0.75

column	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Obs	12	12	12	12	12	12	12	12	12	12	12	12
Min	27.448	28.56	29.63	28.48	26.99	24.95	22.994	23.694	24.94	26.481	27.053	26.913
Max.	29.277	40.67	32.59	32.97	31.84	27.963	27.148	26.056	27.723	29.623	29.43	28.355
Mean	28.40	30.9	31.03	30.92	29.047	26.57	24.73	24.59	26.25	27.74	28.19	27.48
Std.d	0.50	3.17	0.86	1.478	1.46	0.88	1.17	0.76	0.98	1.17	0.88	0.47
CV%	1.7	10.3	2.8	4.8	5.0	3.3	4.7	3.1	3.7	4.2	3.1	1.7

Appendix Table 2.Maximum Temperature

Appendix Table 2. 1.Minimum temperature

	J	F	M	A	M	J	Jul	A	S	O	N	D
Obs	12	12	12	12	12	12	12	12	12	12	12	12
Min	4.2097	5.1607	8.3065	7.5172	10.91	10.203	9.4742	11.387	11.081	9.5323	7.13	4.4161
Max	17.497	19.103	19.558	21.493	20.642	17.453	13.859	13.419	12.66	15.206	15.237	15.8
mean	7.60	9.18	10.94	12.66	13.84	13.12	12.68	12.58	11.71	11.24	9.203	7.58
Std.d	3.62	3.92	3.34	3.69	2.68	1.71	1.21	0.65	0.48	1.57	2.21	3.18
CV%	47.6	42.7	30.5	29.2	19.4	13.0	9.5	5.2	4.1	14.0	24.0	41.9

Appendix Table 2. 2. Monthly Rainfall

column	Jan	F	M	A	M	Jun	Jul	A	S	O	N	D
Obs	13	13	13	13	13	13	13	13	13	13	13	13
Min.	0	0	0	0	35.9	199.4	147.5	229	117.4	0	0	0
Max.	20.6	51	74	157.2	235.2	455	579.8	766.9	296.5	163.2	52	22.2
mean	4.80	7.13	19.31	42.854	158.44	300.11	368.49	366.9	207.57	79.41	18.28	3.15
Std.d	6.9464	16.38	24.658	54.666	57.14	91.206	132.94	143.02	64.922	46.186	15.473	6.7445
CV%	144.6	229.7	127.7	127.6	36.1	30.4	36.1	39.0	31.3	58.2	84.6	214.4

Appendix 3. Survey Questionnaire

My name is Mengistu Ashebr . I am planned to write a thesis entitled investigation of farmers vulnerability to climate variability in terms of adaptive capacity in koga watershed in partial fulfillment for MSC in climate change and development .The objective of this studies is to investigate farmers vulnerability in terms of adaptive capacity to climate variability in koga watershed ,north western Ethiopia. After the completion of this research ,it will have a significant contribution in an effort to reduce the vulnerability of farmers to climate variability and its extreme impacts in this study area. Therefore, your valid contribution by giving accurate information is highly valuable in achieving the objective of this research. The information I will collect from you will serve only the academic purpose and it will be kept confidential. Thus, please feel free to convey the required information honestly.

Thank you in advance for your valuable contribution and cooperation.

General Directions

- Put (**x**) marks in space provided for closed-ended questions and write your response on space provided for open ended questions.

Part I. **Supportive Information**

i. Name of interviewer: ..... Code.....

ii. Date: ...../...../..... Time spent for interview: From.....to.....

iii. Name of respondent.....ID. code

iv. Name of Kebele: .....

v. location of the household Dega ☐ woyina dega ☐

Part II. Questions on Household Head Demographic Characteristics

1. Gender of the household head: Male ☐ Female ☐

2. Age of the household head (in years).....

3. Marital status: a) Married: b) Single; c) divorced: d) widowed: e) Other

(specify)_____

4. Educational level of household head

Note literate ☐ Literate ☐

5. The highest level of formal education completed if the household head is

literate.....

6. Number of total family members: Male..... Female.....

7. Number of active household members aged between 15-64 years Male..... Female.....

8. Farm experience of household head ----------

9. Dear respondent! The followings are indicators of good personal characteristics. Please tick

as much as it explains your characteristics.

i. Sociability/good social interaction ☐

ii. Cooperative ☐

iii. Mediator in case there is disputes/disagreement within society ☐

iv. Positive thinkers/Open mindedness ☐

v. Other specify.....

Part III. Questions on Household Head Socio-economic Characteristics

10. Farming system you follow currently

i. Crop production only ☐

ii. Livestock rearing only ☐

iii. Mixed farming ☐ iv. Others (please specify).....

11. How much income can you generate from your farming activities during last production year (i.e., January 1, 2009 E.C to December 30, 2010E. C)? Please specify in Birr:

i. From crop production.....

ii. From selling livestock and livestock products.....

iii. Selling of fruits and vegetables.....

iv. From vegetation and its products

v. Others (please specify).....

12. Do you/any members of your family has any sources of non-farm income i.e. income from Remittance, petty trade, employment in government or private enterprise, etc?

Yes ☐ No ☐

13. If yes to the above question, how much money you/your family make during last

Production year (i.e., January 1, 2009 E.C to December 30, 2010E. C) from off-farm activity? Please specify in Birr: .....

14.How much is your total expenditure during last production year(i.e., January 1, 2009 E.C to December 30, 2010E. C)? Please specify in Birr: .....

15. Total farm land operated including any grazing land (including rented land and excluding rented out land) during last production year_(in hectares)_____

Size of land rented in _____ Size of land rented out_____

16. Do you have certificate for your land? Yes ☐ No ☐

17 . How many quintals of yield have you harvested per hectare in 2009 E. C?

Maize..... millet..... Teff.....wheat..... Barely.....

Bean/pea.....potato..... Others (specify if any).....

18 . Do you have any communication devices like TV, radio, mobile phone, so on?

Yes ☐ No ☐

19. If your answer for question 18 is "Yes" what types of communication devices you have?

TV ☐ Mobile Phone ☐ Radio ☐ others specify.....

20. Dear respondent! How many of the following types of livestock do you have? Please fill in the head count column.

s/no.	Types of livestock	Head count
1	Cattle	
2	Calf	
3	Oxen	
4	Horse	
5	Donkey	
6	Goats	
7	Sheep	
8	Poultry	
9	Beehives	
10 others		

Part IV. Questions on Institutional characteristics of households

21. How far the market where you buy your agricultural inputs is (e.g. hoes, seeds, fertilizers, etc)? Distance in KM..... …… In terms of time it takes (in hour).....

22. How far is the market where you sell your agricultural outputs? Distance in KM..... . In terms of time it takes (in hour).....

23. In undertaking your usual farming activities have ever faced shortage of finance? For example to purchase agricultural inputs like fertilizer, oxen, and others

Yes ☐ No ☐

24 . Do you have access to any formal credits (DCSI) in time face shortage of money?

Yes ☐ No ☐

25. Do you have access to any informal credits (from neighbors, friends, relatives etc)?

Yes ☐ No ☐

26. If yes to '26&27' where you look for credit to fill your financial constraints? More than one choice is possible. From: Relatives ☐ Friends ☐ Non-formal money lenders ☐ Microfinance Institutes ☐

27. Do you have access to agricultural extension services in your kebele?

Yes ☐ No ☐

28. Do you receive any support from agricultural extension which could help improve your farming activities?

Yes ☐ No ☐

29 . Please specify any kind services you get from them.

.....

……

30. Have you ever got any kind of formal training which helps improve your farm Productivity ? This might be how to (protect soil from erosion, conserve rain water, use modern agricultural inputs, reduce post-harvest loss, adjustment of crops in time etc)

Yes ☐ No ☐

31. Did you have non-formal training of the above kind from farmers or did you give training to other farmers in your locality? (Farmers-to-farmers extension services)

Yes ☐ No ☐

32. If yes to '32 & 33' how do find it in terms of its contribution to improve your farming income?

Very important ☐ Important ☐ Has no effect ☐

Part v Questions on Perception of Climate variability and Adaptation Strategies Employed

33. Comparing the 1990s with the recent past 10 years i.e. 2009s, have you perceive any variability in climate? Yes ☐ No ☐

34. Comparing the 1990s with the recent past 10 years i.e. 2009s, have you noticed any Variability in the rainfall patterns? Yes ☐ No ☐

35. If yes, please specify the pattern of the change/variability in rainfall you have noticed.

Increasing ☐ Decreasing ☐

36. Comparing the 1990s with the recent past 10 years i.e. 2009s, have you noticed any Variability in temperature? Yes ☐ No ☐

37. If yes, please specify the pattern of the change in temperature you have noticed.

Increasing ☐ Decreased ☐

38. Dear respondent please fill the following if you are experienced with it.

S/no	Have you experienced with the following types of climate variability indicators?	Response		How often ?(in the past decade)
		yes	no	
1	Drought			
2	Floods			
3	Off-seasonal rainfall			
4	Too much rain			
5	Too little rainfall			
6	Higher temperature			
7	Frost (coolness)			
8	Hailstorm			
9	Others (specify)			

39. In response to climate variability, have you taken any adaptation measures in order to reduce the impacts of climate variability? Yes ☐ No ☐

40 . If your answer to question no. 42 is yes, what type of adaptation options or strategies you practiced? select (x) if you practiced adaptation options

S/No	Adaptation strategies	Practiced	Not Practiced
1	Soil and water conservation		
2	Improved crop and livestock varieties		
3	Planting tree		
4	Using irrigation		
5	Agro forestry		
6	Income diversification		
7	Adjustment of planting dates		
8	Changing fertilizers		
9	Crop diversification		
10	If others please specify		

Thank You!!

Appendix 3. 1 FGD Questions

1. Comparing the 1990s with the recent past 10 years i.e. 2009s, how do you perceive any variability in climate in the watershed?

2 . Comparing the 1990s with the recent past 10 years i.e. 2009s, have you noticed any variability in the rainfall patterns?

3. If yes, please specify the pattern of the change/variability in rainfall you have noticed. Increasing or decreasing?

4. Comparing the 1990s with the recent past 10 years i.e. 2009s, have you noticed any Variability in temperature?

5. If yes, please specify the pattern of the change in temperature you have noticed. Increased or decreased?

6. Have you experienced with the following types of climate variability indicators in the watershed? How often it occurs?

- Too much rain
- Too little rainfall
- Higher temperature
- Frost (coolness)
- Hailstorm
- shift in plant and animal species
- Others (specify)

7. In response to climate variability, how do you evaluate any adaptation measures taken in order to reduce the impacts of climate variability?

8. If you observe adaptation strategies taken, what type of adaptation options or strategies practiced in your locality among the following options?

Selecting more than one alternative is possible.

- Soil and water conservation
- Improved crop and livestock varieties
- Planting tree
- Using irrigation
- Agro forestry
- Income diversification
- Adjustment of planting dates
- Changing fertilizers
- Crop diversification
- If others please specify

9. If your answer for question number 8 is "no" what do you sagest the reasons for not practicing climate variability adaptation strategies in your locality?

10. How do you evaluate that the contribution of socio economic characteristics of households to implement adaptation strategies in the watershed?

11. Why different in implementing adaptation strategies between households in the watershed?

12. Which groups of the society do you believe that more vulnerable to climate variability why in your locality? Women, men, female, educated, non-educated, rich, poor or others? Why?

Thank You!!

Appendix 4 .Author's Biography

The researchers name is Mengistu Ashebr Sinishaw. He was born in 1987 in north western Ethiopia, Mecha district. He was graduated at university of Gondar and received BA degree in department of *"Development and Environmental management studies(DEMS)" in 2009 G.C* .He had been worked in various governmental offices .He was worked at north western Ethiopia, west Gojjam zone Dembecha district agricultural office, Mecha district water , mining and energy offices till 2o14 G..C and now he is working at, Mecha district women, child and youth affairs office as expert.