UNIVERSITY OF AGDER

Climate Change Impacts and Adaptations among Ethiopian Farmers

Case studies of Hagere Selam, Tigray, and Kofele, Oromia

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Abstract

This thesis' empirical investigation is based on case studies from two places in Ethiopia; Hagere Selam in Degua Tembien sub-district in Tigray Region, and Kofele in Kofele sub-district in Oromia Region. The overall topic is climate changes impacts and adaptations among farmers in these two communities. There are tendencies indicating a future with warmer climate and less rainfall, even this is also in dispute. It has been shown that that the majority of farmers have experienced negative impacts of climate change. This research argues that most farmers are doing successful adaptation strategies. This is argued amongst others because the impacts of climate changes do not usually lead to increased poverty. On the other hand, there are often clear limitations to adaptations, related to amongst others economy and access to information, labor and land. Some of the most common adaptation strategies and coping mechanisms are crop diversification, mixing of crop cultivation and livestock breeding, tree planting, taking off-farm work, soil and water conservation, selling of assets, and use of new or suitable seed varieties. Education, wealth, age, household size, gender of head of household, and access to credit are among the factors that might contribute to explain different levels of adaptive capacity within these two communities.

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List of Contents

Picture 1: *Tef* field in Meremieti, Tigray Region

Source: Author (October 2010)

List of Figures

List of Tables

List of Pictures

List of Appendices

Abbreviations

CIA – Central Intelligence Agency

CIMMYT – International Maize and Wheat Improvement Center

CEEPA – Center for Environmental Economics and Policy in Africa

COP – Conference of Parties

CSA – Central Statistical Agency of Ethiopia

EIAR – Ethiopian Institute of Agricultural Research

EPA – Environmental Protection Agency

EPRDF – Ethiopian People's Revolutionary Democratic Front

FDRE – The Federal Democratic Republic of Ethiopia

GCDAMP – Glen Canyon Dam Adaptive Management Program

GDP – Gross Domestic Product

Grid-UNEP – Grid-Arendal together with UNEP

IPCC - Intergovernmental Panel on Climate Change

NAPA – The National Adaptation Programme of Action

NMA – National Meteorological Agency (In Addis Ababa)

NOAA – National Climatic Data Center

PRECIS – Providing Regional Climates for Impact Studies

PRSP – Poverty Reduction Strategy Paper

PSNP – Productive Safety Net Program

SWC – Soil and water conservation

FAO – Food and Agriculture Organization

REST – Relief Society of Tigray

ROBA - Rural Organization for Betterment of Agropastoralists

OECD – Organisation for Economic Co-operation and Development

UNESCO – United Nations Educational, Scientific and Cultural Organisation

UNECA – United Nations Economic Commission for Africa

UNEP – United Nations Environment Program

UNFCCC – United Nations Framework Convention on Climate Change

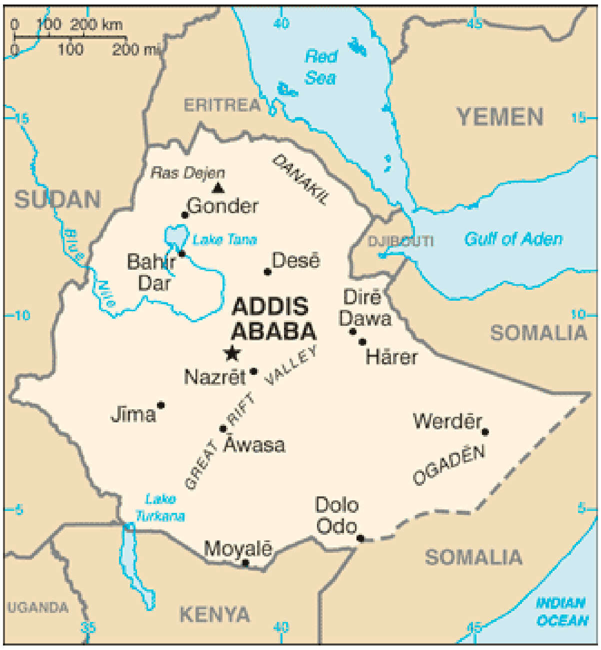
USAID – United States Agency for International Development

USDA - United States Department of Agriculture

WHO – World Health Organization

Chapter 1: Introduction

Agriculture in developing countries faces a number of challenges, and climate changes are some of them. According to UNEP, (2007: 40) climate changes are major global challenges. Climate changes are depleting the natural resource base that rural livelihoods depend upon (Eldis 2010). There has been a warming trend in Ethiopia with the annual minimum temperature increasing by about 0.37°C every ten years the past 55 years (Tadege 2007: 32). Ethiopian farmers are facing severe consequences because of climate changes, and the majority population of Ethiopia is especially vulnerable to climate change impacts. It is important to map the possibilities farmers in sub-Saharan Africa have to adapt to climate changes to ensure they can contain their way of life and hopefully get better life.



Country Facts: (CIA 2011)

Total size: 1 104 300 sq km

Population: 90 873 739

Population growth rate: 3.2 %

GDP – per capita (PPP): $ 1000

Languages: Amharic 32.7 %, Oromigna 31.6 %, Tigrigna 6.1 %, Somaligna 6 %, others 23.5%

Religion: Orthodox 43.5 %, Muslim 33.9 %, Protestant 18.6 %, traditional 2.6 %, Catholic 0.7 %, others 0.7 %

Figure 1: Map of Ethiopia and its surrounding countries

Source: CIA (2011)

Ethiopia is located on the Horn of Africa, with borders to Sudan, Eritrea, Djibouti, Somalia, and Kenya. It is the oldest independent country in Africa and one of the oldest in the world with over 2000 years of history (CIA 2011). Ethiopia is the second biggest country in Africa just after Nigeria counted in numbers of inhabitants, and it has over 90 million people (CIA 2011). Ethiopia has experienced up to 10 % annual growth rate of the national economy during the last ten years, mainly because of foreign aid. Ethiopia's economy is based on agriculture, accounting for about 45 % of GDP and 85 % of total employment (CIA 2011). The agricultural sector suffers from amongst others frequent drought (CIA 2011). This means that changes in weather and climate affects most Ethiopians. According to CIA, (2011) 38.7 % of the population lives beyond the poverty line.

In this thesis, I firstly examine if the people in the villages outside of Kofele and Hagere Selam have experienced any climatic changes in their area, and if and how the climate changes has any impact on their lives. Secondly I assess which adaptation strategies the farmers use to cope with climatic changes. Thirdly I look into which factors can possibly explain different extents of adaptation. This topic has been chosen because climate changes are increasingly relevant globally, and these problems are especially vital in Ethiopia. This country has much semi-arid landscape, and, as mentioned earlier, most of the people (85 %) live in rural areas and are directly or indirectly dependent upon the weather and the natural resources through amongst others agriculture and livestock (Pettengell 2010: 7). Therefore, it is important to map the consequences these people are facing because of climate changes and to learn more about how they adapt and cope with these challenges that might even become tougher in the future. Adaptation strategies in rural areas are vital factors for development. Pettengell (2010: 7) defines climate change adaptation as "*how farmers chose to react or not react to the changes in climate and weather behavior to sustain their crop and living standard*". It refers to all those responses to climate changes that may be used to reduce vulnerability (Feenstra et al. 1998: 117).

The research questions in this study are the following:
1: Have people experienced any changes regarding the climatic conditions (rainfall, temperature, and instability) during the last twenty years?
2: What are these climatic changes?
3: To what extent has climate changes had socio-economic impacts on people's livelihood?
4: In what ways have people responded to climate changes?
5: What factors can explain various extents of individual adaptations?

Mixed methods research is used in this thesis. The main focus is on the qualitative approach, and findings from the interviews in the first phase of data collection were further developed by quantitative methods in the last phase. The data findings have mainly been analyzed together. The design of the study was case study and there are two cases, namely Hagere

Selam and Kofele. The respondents are mainly farmers living around these two towns, but also people working in governmental agricultural offices were interviewed, and data about the weather were collected from National Meteorological Agency (NMA) in Addis Ababa.

The thesis is structured in the following way: **Chapter 1** offers an introduction to the thesis, outlines the objectives, and clarifies concepts. **Chapter 2** introduces the study context. **Chapter 3** introduces subsistence agriculture in sub-Saharan Africa, and presents and discusses impacts of climate changes in developing countries and in Ethiopia. **Chapter 4** discusses adaptations due to climate changes in Ethiopia and a small summary of chapter 3 and 4 is given. **Chapter 5** explains the methodology employed in the thesis and outlines the thesis process. It justifies the choice of research strategy, design, sample, data collection techniques, ethical considerations, and limitations for this study. **Chapter 6** presents the empirical findings from the data collection and gives an analysis and discussion of the presented findings. This will be done in the light of the theoretical framework. **Chapter 7** offers concluding remarks.

Chapter 2: Study Context

2.1 Introduction to Ethiopia

Ethiopia is the oldest independent country in Africa and one of the oldest in the world (CIA 2011). It has over 90 million residents and is therefore the second biggest country in Africa counted in numbers of inhabitants (CIA 2011). Figure 2 is a map over Ethiopia. Mekele is seen in the very north, and Hagere Selam is a small town one and a half hour driving from Mekele to the north-west. Kofele is a small town 20 km. or 15 minutes driving from Shashemene which can be seen on the map south for Addis Ababa.

Figure 2: Detailed map of Ethiopia

Source: Genesis Photography (2011)

The median age in Ethiopia is 16.8 years, and 46.3 % of the population is under 14 years old (CIA 2011), so it is a quite young population. The population growth rate is 3.2 % and total fertility rate is 6.07 (CIA 2011). Only 17 % of the population is urban (CIA 2011). The life expectancy at birth is 56.2 years (CIA 2011). Ethiopia has experienced up to 10 % growth rate of GDP during the last ten years; the 2010 estimation were 7 % (CIA 2011). Still, the per capita income is among the lowest in the world and food security is extremely tenuous in Ethiopia (CIA 2011, Weir and Knighte 2000a).

Due to Arabian tribes invading Ethiopia around year 300, Ethiopia was named Abyssinia up to 1945. Haile Selassie was the emperor of Ethiopia from 1930 to 1974 (Daleke 2003). After five years, fascist Italy invaded Ethiopia on October 3, 1935 (Dehai 2011). Haile Selassie was then forced into exile in 1936. Ethiopia was annexed to Eritrea, later into an Italian colony, and then to Italian Somaliland, forming Italian East Africa (Dehai 2011). In 1941, the Italians retreated because of Britain's intervention, and Haile Selassie returned to Addis Ababa (Dehai 2011). After the colonial partner Italy left Eritrea in 1952, 30 years of war and conflict followed between Eritrea and Ethiopia. Haile Selassie was forced to leave the power in 1974 and the Derg took over. The Derg, as a communist military junta, ruled Ethiopia from 1974 to 1987 (Daleke 2003). Mengistu Haile Mariam was elected as the chairman of the Derg (Daleke 2003). The Mengistu military dictatorship was over-thrown in 1991, and democracy followed (Daleke 2003). In 1991 Eritrea also got its independence from Ethiopia. The two countries then kept peace for some years, but when Eritrea changed their currency from Ethiopian birr to their own currency in 1997, a new war followed from May 1998 to June 2000 (Shah 2000). A permanent cease-fire was reached in June 2000, and a formal peace agreement was signed in December 2000 (Dehai 2011), after UN sent 4200 soldiers to a peace keeping force near the border (Daleke 2003).

Since 1994 Ethiopia has been an independent Federal Democratic Republic with a President as head of state and a prime minister as the head of government. Meles Zenawi is Ethiopia's prime minister and he is currently head of Ethiopia's ruling party, Ethiopian People's Revolutionary Democratic Front, EPRDF.

Ethiopia is a multi-ethnic state, and they have 83 different languages (Selamta 2011). The Ethiopian Orthodox Union Church was the state church of Ethiopia until 1974 (Selamta 2011). 43.5 % of Ethiopians are Orthodox Christians. 18.6 % are Protestant and 0.7 % is Catholic. 33.9 % are Muslims. 2.7 % have traditional religions and 0.6 % is animists (Selamta 2011).

The staple food preferred by Ethiopians is *injerra* bread which is made by all types of cereals, but *injerra* made with *teff* is the most popular (Rosell 2010). *Teff* is a cereal endemic to

Ethiopia with very fine grains, and is diverse in color and habitat (Selamta 2011, Araya et al. 2010).

The climate in Ethiopia varies from hot and arid to cold and humid types. The country is also endowed with rich water resources compared to most African countries (Tadege 2007). They have temperatures between 10°C and 30°C in large parts of their country, but in Danakil it can be up to 50°C, and in the highlands, it can be quite cold sometimes and frost occurs. They have almost desert in the east, to rainforests in the west. It is a large country with much valuable waterfalls and rivers, but climate changes are evident also in Ethiopia as in the rest of the world. The weather stations for the eastern, western and southwestern parts of Ethiopia shows a significant decline in both annual and June-September total rainfall since about 1982 (Seleshi and Zanke 2004). Herein Oromia are included, but not Tigray. Decreased rainfall is very much critical for the farmers and might result in amongst others large decreases in crop yields. When it comes to the temperature, there has been a warming trend in Ethiopia with the annual minimum temperature increasing by about 0.37°C every ten years the past 55 years (Tadege 2007: 32). Increasing temperatures might be serious in some areas of Ethiopia, because it can result in increased evaporation from the field soil and make it drier even there is much rain. This might give negative outcomes amongst others for the crop harvests. Data received from Ethiopia's National Meteorological Agency (NMA 2011) also state that there have been fewer cold days in Kofele and Hagere Selam since the 1970's.

2.1.1 Ethiopian Agriculture

In Ethiopia, the rural population is usually either pastoralists or subsistence farmers. Natural resources are the basis of subsistence in many poor communities (UNEP 2007: 5), also in Ethiopia. Ethiopian farmers usually do agriculture manually; they often use oxen for plowing and they harvest with scythe. They often use donkeys, horses, or camels for pack animals. The agricultural sector is challenged by many factors, of which climate-related disasters like drought and flood (often causing famine), are the major ones (Deressa 2007). In the time period 1970 to 1996, drought and the resultant food shortage and famine were the main killers, accounting for more than 90 % of deaths (Margaret 2003). Since 1980, Ethiopia had five food crises (Desalegn et al. 2006). 25 droughts and 16 floods occurred in the time period 1970 to 1996 (Desalegn et al. 2006). Moreover, most poor farmers remain poor and vulnerable to future climate shocks (Jayne et al. 2003). Abate (1994) reports that there is no regular cycle in the recurrence intervals of droughts in Ethiopia, but an accumulation of a number of relatively dry years is likely to occur every 4-6 years. Following the 2002-03 drought, the economy of the country bounced back with 11.5 % growth in 2003-04, with agriculture being responsible for the growth of 31.5 % in exported products (World Bank 2005). The central highlands of Ethiopia are densely populated and this area is considered a marginal area for people to sustain their livelihoods (Europa Publications 2003). It is known to be highly vulnerable to rainfall failure (Europa Publications 2003). One of the main challenges to farmers in semi-arid Ethiopia has been to find out the beginning of the growing season (Araya et al. 2010). This is related to the increased irregularity of rainfall. Many farmers in Ethiopia have low agricultural performance and low income levels (Adugna n.a.).

Four potential pathways for Ethiopian agriculture are described (Devereux et al. 2005). The first is intensification of smallholder agriculture. Irrigation, use of fertilizer and new improved seed varieties can be seen as examples of this. Intensification might in different ways be effective and important on-farm coping strategies. The second pathway is livelihood diversification (Devereux et al. 2005), which might mean a mixing of crop production, livestock herding, and taking off-farm work. If the climate is changing further, these types of coping strategies might be very current. These coping strategies might also mean that agriculture is becoming a less important source of income for the households, and this is what many farmers want to avoid. The third pathway is commercialization of agriculture (Devereux et al. 2005). This might be a good alternative if the climate is changing only moderate. Farmers have a tendency to focus on the traditional cereal production (Adugna n.a.). This again is probably related to eating preferences; most people in Ethiopia prefer to eat *injerra*. They produce fewer amounts of the relatively high yielding and high income generating horticultural crops such as vegetables, root crops, fruits, flowers, spices, and chat, possibly due to a wish of attaining food self-sufficiency (Adugna n.a.). It can also be because these types of horticultural crops demands more water and are therefore less suitable. The types of vegetables grown vary amongst locations within the country, but potato, tomato, onion, cabbage, and pepper are amongst the most common grown vegetables (Ashebir et al. 2007). The fourth pathway is depopulation, meaning migration. Migration or alternatively quitting agriculture and take off-farm jobs are often the last possible option, if climate is changing drastically. Devereux et al. (2005) writes that no single route is likely to succeed, but rather a successful strategy is likely to combine elements of all four. This might be right to a large extent.

Some of the most widely grown cereals in Ethiopia are *teff*, wheat, barley, corn, and sorghum. The growing period for *teff* is approximately 90 days; wheat, barley, and corn around 110-120 days and sorghum needs 180 days to mature (Ketema 1993: 102). The climate in some areas of Ethiopia permits several crops to be grown consecutively in one year (up to four harvests during a year). The most common is to collect two or three harvests during a year (Ashebir et al. 2007). According to CSA, (2011) in Addis Ababa the average *teff* yields were approximately nine quintal per hectare (Tefera et al. 2001).

The agricultural seasons are like this: *Hagay* is the dry season from January until March. The next season is *azmera*, which is the plowing period. This happens until *kiremti*, which is the main rainy season. It usually rains between June and mid-September. *Kewie* is the harvesting and threshing period, from October until December/January. In some areas of the country they also have a *belg* season, which is a smaller rainy season around February to April (REST 1995).

2.1.2 Tigray Region and Hagere Selam

Picture 2: Farmer in Hagere Selam, Tigray Region

Source: Author (February 2011)

Tigray Region is located north in Ethiopia and has borders to Eritrea in the north, to Afar Region in the east, Amhara Region in the south, and Sudan in the west. The University town

Mekele is the capital town of Tigray, and total population in Tigray Region is 6.2 million, which represents 8 % of the total population. 85 % of the population is rural, and 95 % are practicing Ethiopian Orthodox believe in Tigray. Most people in Tigray speak Tigrinya, but small minorities speak Saho, Afar, Kunam and Agew (Tigray online 2011).

Hagere Selam is a town 2625 meters above sea level located in Tigray Region. It is in Mehakelegnaw zone and the sub-district is Degua Tembien. Hagere Selam is the administrative center of this sub-district and it has approximately 6800 inhabitants. The number of inhabitants in Degua Tembien is 113 500 (Wikipedia 2011a).

Figure 3: Map of Tigray Region

Source: tigrayonline.com (2011)

Tigray, as other parts of northern Ethiopia, belongs to the African drylands called Sudano-Sahelian region, and, as such, faces the same problems as the whole region since dryland environments denote distinctive challenges to development (REST 1995: 3). The drylands are driven by sparse, highly uneven distribution of seasonal rainfall, and by erratic occurrence of drought (REST 1995: 3). The climate of Northern Ethiopia is semi-arid (UNESCO 1979). The mean summer rainfall ranges from 300 to 700 millimeters (Araya 2005). The rainfall is characterized by temporal and spatial instability (Araya 2005, Tilahun 2006, Bewket and Conway 2007). For extended periods during the last century, Tigray has experienced amongst others land degradation which has become rather permanent features (REST 1995: 3). In northern Ethiopia, most of the agriculture is done on small farms run by households, and over 90 % of the economy depends on agriculture in Tigray (Araya et al. 2010, REST 1995: 47). Mixed arable farming is the most common agricultural practice. Given sufficient rain, many kinds of crops can be grown, such as *teff*, corn, wheat, barley, finger millet, sorghum, pulses, and beans (Araya et al. 2010, Ruthenberg 1980: 313). In the agricultural sector, animal husbandry plays an important role, especially as oxen are the main source of power for traction (REST 1995: 14). An average family's landholding is between 0.5 and 1 hectare (Araya et al.2010). Grassland, rangeland and forest are usually communally owned. The climate of Tigray is highly unpredictable characterized especially with unreliable rainfall (REST 1995: 31). Severe droughts causing famine have affected the region approximately every tenth year during the last hundred years (REST 1995: 31). Drought has been experienced as more acute attacks at irregular intervals (REST 1995: 3). It seems that Tigray Region usually get less rain than what is average for the country (REST 1995: 31). Drought is considered to be the most important agricultural constraint in Central Tigray (REST 1995: 105).

2.1.3 Oromia Region and Kofele

Picture 3: Farmers in front of their houses, Kofele, Oromia Region
Source: Author (February 2011)

Oromia has approximately 354 000 square kilometers and 32 % of the land in the country (FDRE 2011). The 2008 estimate is that 28 million people live in Oromia Region (FDRE 2011). It has 35.4 % of the country's population (Adugna n.a.). Oromia Region represents therefore the largest region in the country both counted in area and population (FDRE 2011). The Oromo represent the majority ethnic group in Oromia with 85 %, and the Oromo are also the largest group of people in the country at large. Nearly 4 million, or 10 % of the Oromian population, live in urban areas (FDRE 2011).

As Hagere Selam is in Degua Tembien, Kofele is the administrative center of Kofele sub-district. Kofele is located relatively south in Ethiopia in Oromia Region and in Arsi Zone. It is located west for Shashemene and is five hours driving from Addis Ababa. Kofele town has 13 100 inhabitants (Wikipedia 2011b) and Kofele sub-district had approximately 265 000 inhabitants in 2008, (Adugna n.a.) so it is bigger than Hagere Selam but still a medium or small town.

Figure 4: Map of Oromia Region
Source: Rippleethiopia.org (2011)

Oromia is part of the high and extensive Afro-Arabian plateau. High reliefs of over 1500 meters are dominant (Adugna n.a.). There are three major types of climate in the region; the dry climate, tropical rainy climate, and temperate rainy climate (Adugna n.a.). The dry climate is characterized by poor sparse vegetation with annual mean temperature of 27°C to 39°C. Mean annual rainfall of less than 450 millimeters is common. The hot semi-arid climate mean annual temperature varies between 18°C and 27°C. It has a mean annual rainfall of 410-820 millimeters with noticeable variability from year to year. Highlands of Oromia experience temperate climate of moderate temperature, (mean temperature of the coolest month is less than 18°C) and ample rainfall (1200-2000 millimeters) (Adugna n.a.). Kofele is part of the temperate highlands. 90 % of the people of Oromia live in rural areas, and agriculture has remained the source of livelihood for the overwhelming majority of the people. The main agricultural crops include corn, *teff*, wheat, barley, peas, beans, and various types of oil seeds

(Adugna n.a.). Oromia accounts for 51.2 % of the crop production and 44 % of the total livestock population of Ethiopia (FDRE 2011).

Oromia has relatively rich rainfall, suitable soils and other agricultural potentialities (CSA 2011). On the other side, agriculture in Oromia is mainly done by farmers that have approximately one hectare of land, and they normally use limited inputs such as fertilizers, pesticides, compost, and improved seeds. Heavy dependence on rain-fed cultivation is another challenging aspect. Yield per hectare has remained extremely low and growth in production is slow with an average yield of 12.49 quintals per hectare, which is by far below the potential of fifty quintals for wheat and up to eighty quintals for corn with the application of inputs (Adugna n.a.). Oromia also suffers from regular disasters, such as food shortages, disease outbreaks, floods, and droughts. Adugna (n.a) write that every year drought affects more than 500 000 people in Oromia. In 2006 flood has affected approximately 22 000 people and has displaced over 9000 people.

Chapter 2 gave some background information about the study context. Chapter 3 will outline climate change impacts on African agriculture.

Chapter 3: Climate Changes and its Impacts on Tropical Agriculture

In chapter 3 I will look at the climate changes and the impacts these might give and have already given on agriculture globally, and in Africa and Ethiopia. The agricultural sector will be particularly affected by climate changes (UNEP 2007: 59). Very different estimates of impacts have been yielded for the future (Feenstra et al. 1998: 117). The climate of the earth started changing already in the 20th century, with half of the most recent warming caused by increased greenhouse gas concentrations (Houghton et al. 2001). The global climate is changing because of human activities and will continue to do so in the future (Smith et al. 2003: 317). The increased concentrations of greenhouse gases in the atmosphere threaten to dramatically change the Earth's climate also in the 21st century (Houghton et al. 2001). Moreover, studies indicate that Africa's agriculture is negatively affected by climate change (Pearce et al. 1996, McCarthy et al. 2001). UNEP (2006: 9) writes that "*climate change may become the greatest obstacle to the achievement of the Millennium Development Goals to which the Sahelian countries have subscribed*". UNEP (2007: 40) also states that impacts of climate changes are already evident, and changes in amongst others water availability and food security are projected to dramatically affect millions of people. The combination of high temperatures and decreased soil moisture will be particularly hard to adapt to (UNEP 2007: 59).

In the remaining sections of chapter 3 I will present and discuss African subsistence farming, elements of climate changes, and impacts due to these climatic changes. The elements of climate changes taken into consideration in this thesis are rainfall, temperature, and instability. The impacts due to climate changes for the Ethiopian farmers discussed are reduced crop and animal yield, soil degradation and soil erosion, increased poverty, and worsening of people's health.

3.1 African Subsistence Farming

Section 3.1 offers an introduction to subsistence agriculture in developing countries and will also put light on different challenges due to climatic changes in the agricultural sector. 75 % of the world's poor live in rural areas (Pettengell 2010: 27). Ellis (1993: 3) stated that "*it is probable that at least a quarter of the world's population belong to peasant farm households*". Subsistence farmers sometimes comprise as much as 70 % of the population in some countries (Ellis 1993: 3). Peasant populations occupy the margins of the modern world economy. With one foot in the market and the other in subsistence they are neither fully integrated into that economy nor wholly protected from its pressures (Ellis 1993: 3). Subsistence farmers often represent some of the poorest people in the world (Ellis 1993: 3). The majority of the world's food producers are small scale farmers, pastoralists, and herders, and they produce the food consumed by the majority of the world's population (Nærstad 2007: 7).

OECD (2006: 26) states that *"in most developing countries, agriculture is a major employer and source of national income and export earnings. Growth in agriculture tends to be pro-poor – it harnesses poor people's key assets of land and labor, and creates a vibrant economy in rural areas where the majority of poor people live"*. This is why development in the agricultural sector might create immense poverty reduction. Growth in agriculture might also increase farmer's productivity and income (OECD 2006: 3). Moreover, enhancing growth in the agricultural sector in developing countries will be critical in achieving a sustainable path out of poverty and meeting the Millennium Development Goals, especially the target of halving the proportion of people living on less than one dollar a day (OECD 2006: 3). Development and innovation in agriculture has been recognized to be important for poverty reduction (Eldis 2010). The importance of agriculture for poverty reduction, however, goes well beyond its direct impact on rural incomes. Agricultural growth, particularly through increased agricultural sector productivity, also reduces poverty by lowering and stabilizing food prices, improving employment for poor rural people, increasing demand for consumer goods and services, and stimulating growth in the nonfarm economy. A positive process of economic transformation and diversification of both livelihoods and national economies is the key to sustained poverty reduction. It is agricultural growth that enables poor countries, poor regions, and ultimately poor households to take the first steps in this process (OECD 2006: 3). Nærstad (2007: 19) states that "a *productivity increase in the agricultural sector will most probably result in increased food security*". Greatly enhanced investment in agriculture by a broad range of stakeholders will be required if the agricultural sector is to meet the food security requirements of tomorrow's Africa (Cooper et al. 2008: 1). In many situations, production and the quality of the natural resource base upon which communities depend are declining in sub-Saharan Africa (Rosegrant et al. 2002c). As a result, cereal deficits in this region, currently standing at around 9 million tons annually, are projected to more than triple to 35 million tons by 2025 leading to sub-Saharan Africa being identified as a “food trade hotspot” (Rosegrant et al. 2002c).

Agriculture is one of the sectors most vulnerable to climate change impacts. The impacts are often strongest in Africa, because agriculture here is important for the daily subsistence, and adaptive capacity is often low (Senbeta 2009: 2, Smith et al. 2003: 11). Countries with limited economic resources, low levels of technology, poor information and skills, poor infrastructure, unstable or weak institutions, and inequitable empowerment and access to resources have little capacity to adapt and are highly vulnerable to climate changes (Smit and Pilisofova n.a.: 3). Populations dependent on agriculture are particularly vulnerable to climate changes through the climate-sensitive nature of their activities and because agricultural workers and smallholder farmers in developing countries tend to be among the most disadvantaged and marginalized (Pettengell 2010: 28). Rain-fed agriculture will remain the dominant source of staple food production and the livelihood foundation of the majority of the rural poor in sub-Saharan Africa (Cooper et al. 2008: 1). Low level of socio-economic development, inadequate infrastructure and lack of institutional capacity is often making subsistence farmers more vulnerable to climatic changes. These facts make Ethiopia more vulnerable to climatic factors including climate variability and extreme climatic events (Tadege 2007: 28).

According to McCarthy et al., (2001) vulnerability is a function of three main factors:

- Exposure: Exposure is the change in climate and what is affected, for example how many people are living in an area that could be affected by drought or flood.
- Sensitivity: Sensitivity is the direct effect of climate changes on systems, for example changes in crop yields.
- Adaptive capacity: Adaptive capacity is the ability of a system to adapt to climate changes, reduce adverse effects or take advantage of beneficial effects.

In Ethiopia exposure is high because great parts of the population are living in densely populated areas affected by amongst others reduced rainfall, increased temperatures, recurring drought, or flood. In addition, sensitivity is high in most parts of Ethiopia because large parts of the population experience impacts of climate changes amongst others because they depend on rain-fed agriculture. Adaptive capacity amongst these small scale farmers are varying and because of these three factors, vulnerability of climate changes in Ethiopia is therefore high.

Ethiopia's geographical location and topography in combination with low adaptive capacity entail a high vulnerability to adverse impacts of climate changes (Institute of Development Studies 2008). Causes for vulnerability of Ethiopia to climate variability and change include very high dependence on rain-fed agriculture which is very sensitive to climate variability and change, under-development of water resources, low health service coverage, high population growth rate, low economic development level, low adaptive capacity, inadequate road infrastructure in drought prone areas, weak institutions, and lack of awareness (Tadege 2007: 40). The next section will present different forms of climate changes.

3.2 Elements of Climate Changes

The most important elements of climate changes are rainfall and temperature. Instability will also be included in this thesis because it might contribute to explain much of the negative impacts of climate changes farmers in Ethiopia are facing. In the following I will present how these elements have changed globally and in Africa and Ethiopia.

3.2.1 Rainfall Globally

The trend in rainfall globally is that it is increased variance (UNEP 2007). Wet areas are becoming wetter, and dry and arid areas are becoming drier (UNEP 2007: 63). Recent reviews have considered an impending global water crisis in the context of continued population growth and predicted climate changes (Cosgrove and Rijsberman 2000). Cosgrove and Rijsberman (2000) suggest that the projected trends in world population growth and dynamics will place substantially greater multi-sectoral demands on water, leading to greater competition between sectors for an increasingly limited supply of abstracted water. The climate changes do also increasingly lead to climate-related disasters such as flood and drought (Pettengell 2010: 27).

3.2.2 Rainfall in Africa and Ethiopia

Most climate models predict that the Sahel region will be drier in the 21st century than it has been earlier (UNEP 2006: 9). Even slight increases in rainfall are unlikely to reverse the situation since a warmer climate means that evapo-transpiration will be more intense, and worsening the already arid conditions (UNEP 2006: 9). Moreover, the synoptic view of freshwater availability indicates that the Horn of Africa is amongst the regions of the world that will experience severe water scarcity (Magadza 2003). UNEP (2007: 40) state that "*there* *is increasing concern about the likelihood of changes in rainfall patterns and water availability, thereby affecting food security"*. In addition, water availability in some regions might be more critical in the future, due to decreases in rainfall in the sub-tropics (Pettengell 2010: 28). In Africa, the impacts of climate changes, amongst other factors, suggest an alarming increase in water scarcity for many countries, likely to face water scarcity or water stress by year 2025 (UNECA 1999, UNEP 2007: 63). Water scarcity will curtail the ability of irrigated agriculture to respond to the expanding food requirements of tomorrow's Africa. In contrast to the aspirations of the Millennium Development Goals, this raises the specter of a worsening food security crisis (Rosegrant et al. 2002a).

In addition to water scarcity, drought is amongst the challenges for the people at the Horn of Africa (Senbeta 2009: 2). Vulnerable communities in Africa suffer from climate variability, for example due to increasing frequency of droughts (AMCEN and UNEP 2002). According to Grid-UNEP, (2011) drought can be defined as a "*phenomenon that exists when rainfall has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems"*. REST, (1995: 3) on their hand, is defining drought as *"a period of two years or more with rainfall well below average*". In this thesis it will be argued that shorter time periods than two years, with drastic reduction of rainfall, also can be defined as drought. An example is in Oromia, where they had a drought in 2008, lasting for approximately nine months (United Nations 2008). These types of events will also be included as droughts in this study. This can be supported by Araya and Stroosnijder (2010), who states that; "*from the viewpoint of Ethiopians, drought is any season with low rainfall in relation to crop water demand that results in poor crop harvest or total crop failure and/or livestock suffering or dying because of feed shortages as a consequence of poor rainfall distribution/amount*".

What is defined as a drought is also dependent upon which area is discussed (GCDAMP 2009). A week without rain can be defined as a drought in some areas, while in drier areas months have to go before people consider it to be a drought (GCDAMP 2009). For example in Oromia Region, as mentioned above, they experienced a drought in 2008 and it did not rain in nine months (United Nations 2008). Due to this lack of rainfall, crop production in Oromia failed, and this leads to expectations of extended food shortages until the next harvest (United Nations 2008). Armyworm and locust infestation further depleted the limited available resources including farm lands and pasture in Oromia in 2008 (United Nations 2008). In other areas of the country, for instance in Tigray, nine months without rainfall, from September to next June, is the normal situation.

Between 1950 and 1990 there was lower rainfall, the total mean rainfall over Ethiopia was between 0 % and 20 % lower (Hulme et al. 2001). Rainfall in the 1950's was above average in Ethiopia, while in the 1960's it was below average (Nicholson 2001). During the 1970's, there were variations in rainfall within the country, but during the 1980's it was drier than average (Rosell 2010). The 1970's and 1980's stand out as dry decades whereas the 1990's return to wetter conditions (Conway 2000). Spatial disparity and time period differences between different researches makes it difficult to draw conclusions that are easily compared (Rosell 2010). Moreover, rainfall correlates with altitude. Altitudes above 1500 meters receive in average 900 millimeters rainfall annually, while areas of Ethiopia on altitudes below 1500 meters gets in average 600 millimeters (Dinar et al. 2009).

Furthermore, 53 % of the Ethiopian farmers in a study made by Deressa et al. (2009: 1) have observed decreasing rainfall over the past 20 years. Drought continues to be a major challenge for the Ethiopian community (United Nations 2008), and in the twenty-first century there has been a rising frequency of extreme droughts due to global warming in Ethiopia (Institute of Development Studies 2008). The country has faced sharp droughts at least twice per decade for the last five to seven decades, with the most serious ones in 1972-73, 1984 and 2002-03 (Mideksa 2010, Tadege 2007: 7). Climate changes have resulted in a number of years of prolonged drought in Oromia Region and also in Mekele in northern Ethiopia, and droughts in the 1980's were very severe (Dadi 2007, Araya and Stroosnijder 2010). Agricultural drought is, to a significant extent, responsible for shortfalls in food production in semi-arid areas (UNEP 2006: 42). Yet, agricultural drought cannot always be linked to low rainfall. In the Sahel, the loss of rain water through runoff, soil evaporation, and drainage below the rooting zone is often considered as the major cause of moisture stress (UNEP 2006: 42). The next two paragraphs will consider the two rainy seasons they have in Ethiopia. All parts of the country have the *kiremti* rainy season and some parts have also a *belg* rainy season.

The short *belg* rainy season in spring is very important for the farmers in the areas of Ethiopia where they have the *belg* (Rosell and Holmer 2007). The *belg* season is very important for productivity and for the food security situation in Ethiopia (USDA 2009). The rainfall during the shorter *belg* rainy season in spring has declined in Ethiopia during the last 30 years

(Rosell 2010). It is a tendency that the *belg* rains that traditionally falls from February to the end of April or May in parts of the country have turned noticeably sparser in the last decade (Nater 2010). In the eastern and southern lowlands of the country, they have in some places failed completely for the last four or five years (Nater 2010). Rosell (2010) writes that in the last decade it has become impossible in some southern parts of Ethiopia to grow crop in the *belg* season because this season has became shorter. Cereal production is considered to be a bigger problem in the last decade for farmers in some parts of Ethiopia. The *belg* season shows also an increase in temperature and potential evaporation.

The longer rainy season, *kiremti*, during the summer months from June to September is also changing. However, there is research saying that rainfall during these months is actually increasing. Rosell (2010), states that there is an increase in the annual rainfall and also in the *kiremti* rainy season in Ethiopia. High rainfall variability, more extreme rainfall during the start of the *kiremti* season and more rainy days during the *kiremti* season were found. The possibility to grow cereal during this season is considered to be more or less the same during the past 30 years (Rosell 2010). If this is correct, it is positive development for Ethiopia and Ethiopian farmers.

Hailstorm is another phenomenon that sometimes occurs in Ethiopia, especially in the highlands (Nater 2010). Furthermore, flood is also a climate related disaster that occurs in Ethiopia from time to time. Flood can be defined as "*the rising of a body of water and it's overflowing onto normally dry land*" (WordNet 2011). In 2006, flood caused significant human life and property loss in many regions in Ethiopia (Tadege 2007: 7). Moreover, regional projections of climate models do predict a rising frequency of extreme flooding due to global warming in Ethiopia (Institute of Development Studies 2008). In the next section we will leave rainfall changes and move further to discuss higher temperatures.

3.2.3 Temperature Globally

One way climate changes take form is through warmer weather conditions. EPA (2010) states the average surface temperature has, since the mid-1970's increased by about 1°F or 0.5°C. IPCC (2007), states that the Earth's temperature has increased by approximately 0.74°C since 1906. The increase in greenhouse gas concentrations in the atmosphere has led many scientists to conclude that the Earth's temperature will increase by several degrees over the next century (Houghton et al. 1992). UNEP (2007: 40) writes that the Earth's average temperature has increased by approximately 0.74°C over the past century. EPA (2010) on the other hand, state that the Earth's surface is currently warming at a rate of about 0.29ºF/0.16°C per decade or 2.9°F/1.61°C per century. NOAA, (2010) on their side, states that the eight warmest years on record since 1880 have all occurred after 2001. In the period from 1900 to 2002, the surface temperatures globally rose linearly by 0.069°C per decade; warming spurts occurred from the late 1910's to 1945 and from 1970 to the present. Moreover, the warming rate of the Earth has, since 1970, accelerated to 0.17°C per decade, about three times as fast as the average rate for the last century. However, this comparison is somewhat misleading because the actual rate of warming in 1915- 1945 was 0.16ºC per decade, essentially the same as for 1970 to the present (Balling 2003). Regional projections of climate models predict a substantial rise in mean temperatures during the twenty-first century (Institute of Development Studies 2008).

IPCC have estimated that Earth's temperature will increase with further 1.8°C to 4°C over the 21^{st} century (UNEP 2007: 40). Even with a slight warming, an increased number of extreme weather events are likely to have greater negative impact than increased average temperatures in itself (Pettengell 2010: 28). It is a trend with a dramatic and continuing rise in the number of small- and medium-scale climate-related disasters globally; since the 1980's, the average number of people reported as affected by climate-related disasters has doubled from 121 to 243 million a year (Pettengell 2010: 32). By 2015, Oxfam's projections suggest that this number will probably grow by more than 50 % to an average of over 375 million people annually (Oxfam 2010).

3.2.4 Temperature in Africa and Ethiopia

In Africa, temperatures have increased in the same way as in the rest of the world the last 100 years (EPA n.a.). Analysis for the time period 1901-1995 indicates that the African continent is now warmer than it was 100 years ago (Rosell 2010). Over the past 55 years there has been a warming trend also in Ethiopia. The temperature has been increasing by about 0.37°C every ten years (Tadege 2007: 32). Maximum temperature has not increased very much, but there have been fewer cold days (NMA 2011). Findings from a study made by Deressa et al. (2009: 1) indicate that 50.6 % of the surveyed farmers in Ethiopia have observed increasing temperatures over the past 20 years. This increase in temperature consequently gives several impacts and effects. The impacts that will most likely affect Ethiopian farmers will be presented and discussed later in this chapter.

3.2.5 Instability Globally

In addition to changes in rainfall and temperature, there are tendencies also to increased weather instability globally. Climatic instability or variety is often associated with amongst others hurricanes, typhoons, droughts, floods, and frost in tropical areas (UNEP 2003). It has for instance been an increase in the frequency of hurricanes in the North Atlantic since 1995 (Webster et al. 2005). In addition, droughts in East Africa, hurricanes in the Carrribean, and flood in Bangladesh are other examples of climate instability (UNEP 2003).

3.2.6 Instability in Africa and Ethiopia

Rain delay, unreliable waterfall, and heavy and unseasonal rain are challenges for the people at the Horn of Africa (Senbeta 2009: 2). Also in Ethiopia, seasonal rainfall is unstable and unpredictable (Nater 2010). Moreover, regional projections of climate models predict an increase in rainfall variability (Institute of Development Studies 2008). Climate changes are likely to make matters worse because of the increases in rainfall variability that has been predicted (Cooper et al. 2008: 1). In western Ethiopia, the seasonal *kiremti* rainfall has become irregular and unpredictable, with heavy flooding, an alarming increase in hail storms and unusual hot winds. Moreover, Dinar et al. (2008) report that there is strong variability of rainfall all over Ethiopia. Despite variable rainfall, which makes agricultural planning difficult, a substantial proportion of the country still gets enough rain for rain-fed crop production (Dinar et al. 2008). The increased variability of rainfall puts farmers in a delicate situation, with higher demand for flexibility in their farming strategies (Rosell 2010). A dry spell at the start, mid, or late in the growing season for the crop can be very critical for the farmers. Furthermore, a dry spell in the end of the season results in a shortened growing season and has been reported to reduce yields significantly for example in Mekele in northern Ethiopia (Araya and Stroosnijder 2010). Higher temperatures, decreased and more irregular rainfall and more unstable weather might result in various impacts for the farmer population in Ethiopia. Some of these will be discussed below.

3.3 Impacts of Climate Changes

Climate changes might give various impacts. Some of them are increasing frequency and intensity of heat waves, storms, floods, and droughts. Some of the impacts most likely to face Ethiopian farmers will be outlined and presented below. These are decreased crop and animal yield, soil degradation and soil erosion, increased poverty, and worsening of health conditions.

3.3.1 Reduced Crop- and Animal Yield

In some sub-regions of Africa, there may be an alarming increase in the risk of hunger due to global warming and decreased crop yield (Royal Society 2005a, Royal Society 2005b, Huntingford and Gash 2005). Decreased yields of major crop cereals in dry and tropical regions of Ethiopia may be one of the outcomes due to climate changes, mainly because of drier conditions (Pettengell 2010: 28). Nærstad (2007: 67) writes "*if the rain starts four weeks later than normally, in the wrong period of growth, or if the amount changes drastically, the impact on food production can be tremendous*". For instance in Kenya, yield in the driest 10 % of years is reduced by 15 % to 60 % from its average (IPCC 1990). Generally, changes in rainfall, temperature, and air humidity have significant effects on crop yields (Parry 1990: 48, Nærstad 2007: 67). Natural disasters have also negative effects on crop, livestock, and humans.

Natural disasters such as flood, hailstorms, or drought, will often result in severe impacts on the farmer population. The impacts might for example be that their crop field becomes almost useless. For affected farmers in Ethiopia, the impacts of hailstorms for example mean disruption of the planting seasons, crop damage, or sometimes completely yield loss (Nater 2010). Hailstorms across the Ethiopian highlands are often battering the *enset*, a banana-like plant also called false banana that in parts of the Ethiopian highlands is a staple crop, traditionally and still often seen as a stable pillar of food security (Nater 2010). Hail results often in damage to the *enset* (Nater 2010). Climate changes also affect animals, rangeland, and animal yields, as will be explained below.

Due to climate changes there will be, and have already been, reduced productivity and fertility of animals. This is mostly a result of heat stress and increased water requirements (Pettengell 2010: 28). Moreover, drier conditions, drought, or flood, might mean decreased grassland and rangeland for animals in arid and semi-arid regions of Ethiopia (Pettengell 2010: 28). The productivity of rangelands of Africa depends almost wholly on the amount and timing of rainfall (Parry 1990: 86). This means that many animals produce less amounts of egg and milk and the fertility of the animals can also decrease. Prolonged droughts have meant that traditional pastures have failed to re-grow during the expected wet season in Oromia Region

(Dadi 2007). From 2000 to 2002, the pasture in Oromia was so damaged that there was not enough food for the remaining livestock (Dadi 2007).

3.3.2 Soil Degradation and Soil Erosion

Soil erosion means that the upper layer of fertile soil is removed, either by wind, rainwater, or human hands (Karup 1991: 39), while soil degradation means that the soil is exhausted and no longer fertile or productive. Soil erosion is a major problem in many parts of the world, and climate changes are likely to exacerbate the problem (Boardman and Favis-Mortlock 2000). Erosion affects crop yields and the quality of agricultural land, and has many undesirable off-farm pollution impacts (Boardman and Favis-Mortlock 2000). Drought, climate changes, and variability exacerbate land degradation in Africa (UNEP 2007: 196). Especially, the Ethiopian highlands are strongly affected by soil erosion (Karup 1991: 39). Moreover, current climate variability is causing natural resource degradation in Ethiopia (Tadege 2007: 7). In many places in Ethiopia, especially in Tigray Region, soil degradation has been a problem for several decades, but it is likely that climate changes are worsening the situation.

3.3.3 Increased Poverty?

Current climate variability is imposing a significant challenge to Ethiopia by affecting food security, water and energy supply, poverty reduction and sustainable development efforts (Tadege 2007: 7). Most studies indicate that global mean annual temperature increases of a few degrees or more would prompt food prices to increase due to a slowing in the expansion of global food supply relative to growth in global food demand (IPCC 2001: 11). Moreover, rainfall variability has been reported to have significant effect on Ethiopia's economy and food production for the last three decades (Araya and Stroosnijder 2010). Furthermore, extreme weather events, such as droughts, floods, or landslides, may cause death to domestic animals (Pettengell 2010: 28). Livestock suffering and death often means that the farmer's wealth is decreased and they lose much of their resources. From 2000 to 2002, the Oromian pastoralists lost nearly two-thirds of their livestock as a result of drought (Dadi 2007).

Climate changes will most likely increase poverty in Ethiopia (Mideksa 2010). Long-term trends towards reduced rainfall, and recurring droughts, have played a role in weakening of the Ethiopian economy (USAID 2004: 9). Climate changes might raise the global economic inequality since many developing countries have a current climate close to or slightly warmer than what is considered optimal for agriculture (Mideksa 2010). Studies report that climate changes would lower incomes of the vulnerable populations and increase the absolute number of people at risk of hunger, though this is uncertain and need further research (IPCC 2001: 11). Moreover, it is established, though incompletely, that climate changes will worsen food security in Africa (IPCC 2001:11).

3.3.4 Worsening of Health Conditions

A possible impact of the changes in temperature can be worsening of health conditions. WHO (2002) states that in year 2000, climate changes was estimated to be responsible for approximately 2.4 % of worldwide diarrhea, and 6 % of malaria in some middle income countries. Continued warming is expected to cause shifts in seasonality of certain infectious diseases, such as malaria, dengue fever, and salmonellosis (UNEP 2007: 65). Even this report is disputed, Castello et al. (2009: 1) writes that "*effects of climate change on health will affect most populations in the next decades and put the lives and wellbeing of billions of people at increased risk*". Another example is that from 2000 to 2002, drought in Oromia Region made recovery very slow and resulted in increased malnutrition of children and women (Dadi 2007). Also, rainfall variability and associated droughts have been major causes of food shortages and famine in Ethiopia (Joto Africa 2009: 8). Food shortages and famine can make people undernourished or malnourished which is negative for the health in itself. Consequently, their immunity against other sicknesses is also often weakened in such a nutritional situation.

In chapter 3 – the possible effects that climate changes might create have been presented. In chapter 4 I will examine what individual farmers and governments can do to cope or react to these climatic changes.

Chapter 4: Climate Change Adaptation: Theory and Previous Empirical Findings

4.1 Introduction

In chapter 4 I will show the relations between the impacts of the climate changes presented in chapter 3, and which adaptation strategies or coping mechanisms that can be used to mitigate these negative impacts. UNEP (2007: 40) have stated that "*adaptation to anticipated climate change is now a global priority*". As Smith et al., (2003) writes, "*With the climate already changing and further change in climate highly likely to happen, adaptation is a necessarily component of any response to climate change*". Furthermore, Smith and Lenhart wrote in 1996 (p. 1) that "*it is imperative that policy-makers in regions such as Africa begin to consider what measures they should take to adapt to the potential consequences of climate change*". Now we can see that both the Ethiopian government and several individual farmers already do adaptation activities due to climate changes in many different ways, but there are still many barriers and limitations to climate change adaptations as much as facilitators and possibilities.

Adaptation is a very broad concept, and when applied to climate changes it can be used in a variety of ways (Feenstra et al. 1998: 119). Adaptation refers to all those responses to climate changes that may be used to reduce vulnerability (Feenstra et al. 1998: 117). Pettengell (2010: 7) is defining climate change adaptation as "*actions that people and institutions make in anticipation of, or in response to, a changing climate. This includes changes to the things they do, and/or the way they do them*". In other words, adaptation to climate is the process through which people reduce the adverse effects of climate on their health and well-being, and take advantage of the opportunities that their climatic environment provides (Burton 1992). Adaptation is one of the policy options for reducing the negative impacts of climate changes (Adger et al. 2003, Kurukulasuriya and Mendelsohn 2008). It also refers to the degree to which adjustments are possible in practices, processes, or structures of systems to projected or actual changes of climate (Deressa et al. 2009: 1). Differently, a coping strategy is more of a short-term response to an immediate decline in access to food and the means to survive during for example a drought (Davies 1993).

Furthermore, adaptation is often seen as a choice between either reducing general vulnerability, for example by improving people's income, or preparing for specific hazards, such as droughts. This choice between addressing the underlying causes of vulnerability to climate change impacts, and a ‘predict and adapt’ model for specific climate-hazards is an artificial choice on the ground, where a combined approach is needed (Pettengell 2010: 14). Adaptations can also be either spontaneous or planned (IPCC 1996). Adaptation is an essential strategy for reducing the severity and cost of climate change impacts (Easterling et al. 2004: 6). Climate change adaptation will be needed in many ecosystems (FAO 2007: 9).

What can individual farmers and individual households do to adapt to climate changes, and which activities are they already doing? This will be discussed in section 4.2. These questions are first looked at in a global perspective, and next, section 4.3 focuses on climate change adaptations in Ethiopia specifically. Then section 4.4 is explaining the different facilitators, barriers, and limitations to climate change adaptation. Section 4.5 outlines the role of the Ethiopian government in this situation. Section 4.6 is a discussion of chapter 3 and 4, and some conclusions and propositions are drawn.

4.2 Adaptation Mechanisms by Individuals

There are many adaptation strategies and coping mechanisms that individual farmer households can use. These include the following:

1: Crop diversification

2: Mixing crop production with pastoralism

3: Tree planting

4: Off-farm activities, diversify income

5: Soil and water conservation (SWC)

6: Selling of assets

7: Sowing drought tolerant, fast growing, suitable, or improved seed varieties

8: *Enset* production and consumption

9: Food aid or food appeal

10: Irrigation

11: Temporary and permanent migration

- Changing planting dates
- Selling home made products
- New livestock species that is better suited to drier conditions
- Intercropping

- Collection of wild food
- Crop, farm, and income insurance
- Tailor land use planning to consider potential climate changes
- Reduce run-off and improve water uptake
- Reduce wind erosion
- Change dietary preferences
- Access to appropriate technology
- Use of inter-household transfers and loans
- Increase petty commodity production
- Grain storage
- Mortgaging of land
- Credit from merchants and money lenders
- Changes in cropping and planting practices
- Orient furrows across slope
- Plant more cereal crops
- Apply less fertilizer or manure
- Ration food
- Increase income-generating enterprises
- Purchase or borrow food grain
- Send younger men abroad to work
- Making ponds and collect water in them
- Management and genetic alterations to crops
- New cropping systems and crops that reduce net green house gas production
- Saving
- Social interconnectedness
- Reduction of consumption levels

The list is based on: Bradshaw et al. 2004, Kurukulasuriya and Mendelsohn 2008, Nhemachena and Hassan 2007, Downing et al. 1997, Pettengell 2010: 28, Deressa et al. 2009: 1, Tadege 2007: 16, UNEP 2006: 26, Smith and Almaraz 2004, Senbeta 2009: 2. The first factors presented in this list with bold font will be further discussed in section 4.2 because they are thought to be relevant in an Ethiopian context. All of the factors are relevant either in Africa or globally.

Research has shown great potential on research stations and in farmers' fields, with 'achievable' yields often several times greater than those obtained by regular farmers (Rosegrant et al. 2002c). However, adaptation amongst farmers has been low in sub-Saharan Africa. Whilst 'islands of success' continue to provide hope for the future, small upscaling of such successes is reported, and widespread impact is not evident (Rosegrant et al. 2002c). Extreme impacts of climate changes such as drought or flood are likely to become more frequent and more severe with climate changes (Smith et al. 2003). As Smith et al. (2003: 19) reports, "*adaptation measures are very specific to a particular location and situation. What may work in one place or with one socioeconomic group may not work or may not be feasible elsewhere".* The reason for this might be among other different agro-ecological zones, different climate and different assumptions for adaptations. Therefore, *"there is a need to tailor adaptations to fit each case and circumstance. This means that it is essentially impossible to specify or develop appropriate and applicable adaptation measures without detailed knowledge of the system or community for which the adaptation is intended*" (Smith et al. 2003: 19).

The role of adaptation to climate changes and variability is increasingly considered important in academic research, and its significance is being recognized in national and international policy debates on climate changes (Smith et al. 2000: 1). It is difficult to predict exactly how people will respond to climate changes and studies have made very different assumptions about adaptation (Feenstra et al. 1998: 117).

Table 1 is a matrix showing the relations between adaptive capacities and high and low impacts of climate changes.

Table 1: Climate change adaptation matrix

	Adaptive capacity	
Impacts	**Low**	**High**
High	Vulnerable communities	Development opportunities
Low	Residual risks	Sustainability

Source: Smith et al. 2003: 83

Table 1 tells that a community with low adaptive capacity and low impacts is "*residual risks*". They do not have the demand to adapt yet, and if they will be demanded to do adaptation activities due to increased impacts, they will become "*vulnerable communities*". If a community has high adaptive capacity and the impacts are low, the community will achieve "*sustainability*", but if the adaptive capacity is high and the impacts are also high, the community will become a "*development opportunity*".

The absence of adaptation means doing nothing to make up for difficult impacts. It can mean, for example, that a particular threat has been considered together with the costs of potential adaptive response, and that it has been considered better to do nothing and take the risk, rather than bear the costs of adaptation (cost-benefit analyses) (Feenstra et al. 1998: 120). All socio-economic sectors, such as agriculture, are now to some extent adapted to climate, and these adaptations have to be changed to fit the new conditions of a changing climate (Feenstra et al. 1998: 123). There is a wide range of coping strategies used by semi-commercial farmers in all parts of the world to mitigate the effects of weather. The best developed of these, and probably the best understood, are those coping strategies for drought used in India and Africa. These are generally characterized by a mix of technological, economic, and social responses which can best operate for a couple of months (Feenstra et al. 1998: 123).

It has been concluded that much greater emphasis will have to be given to increasing the productivity of global rain-fed agriculture which currently provides 60 % of the world's food (Rosegrant et al. 2002b). This is especially true in sub-Saharan Africa where currently nearly 90 % of staple food production will continue to come from rain-fed farming systems (Rosegrant et al. 2002b). In such an endeavor, there are special challenges in Africa's rain-fed farming systems, because it is here that some of the poorest and most vulnerable communities live (Cooper et al. 2008). They manage and largely rely upon rain-fed agriculture and pastoral systems for their livelihoods and are the custodians of the natural resource base upon which such enterprises depend. Added to the constraints imposed by extreme poverty and often a degrading resource base is the inherent risk associated with the seasonal variability of rainfall amounts and distribution (Cooper et al. 2008). Recognizing the importance of rain-fed agriculture in sub-Saharan Africa for both individual as well as national food security, agricultural research and development initiatives have, for decades, developed and promoted agricultural and pastoral innovations that aim to increase the value and productivity of assets at hand. These can be land, labor, or capital. In many instances, such innovations not only target increased productivity, but also attempt to mitigate climatically induced uncertainty of production through specific soil, crop, and rainfall management strategies (Cooper et al. 2008: 3).

Local coping strategies are an important element of planning for adaptation (UNFCCC n.a. : 37). In Africa, rural farmers have been practicing a range of agricultural techniques as coping strategies and tactics to enable sustainable food production and deal with extreme events (UNFCCC n.a. 37). Over generations, and especially in the more arid environments where rainfall variability impacts most strongly on livelihoods, farmers have developed coping strategies to buffer against the uncertainties induced by year-to-year variation in water supply coupled with the socio-economic drivers which impact on their lives (Cooper et al. 2008: 4).

The ability of agricultural communities and agricultural stakeholders in sub-Saharan Africa to cope better with the constraints and opportunities of current climate variability must first be enhanced for them to be able to adapt to climate changes and the predicted future increase in climate variability. Tools and approaches that allow for a better understanding, characterization, and mapping of the agricultural implications of climate variability and the development of climate risk management strategies specifically tailored to stakeholders needs are now available. Application of these tools allows the development and dissemination of targeted investment innovations that have a high probability of biophysical and economic success in the context of climate variability (Cooper et al. 2008). Such tools have an important role to play and must be more widely applied to directly address such needs (Cooper et al. 2008). While farmer strategies have been of greatest importance and have evolved over many generations in the drier and more risk prone environments in Ethiopia, they have perhaps only recently become of importance in many of the wetter and more assured environments as a range of factors are resulting in agriculture becoming a less viable foundation for rural livelihoods. Such factors are population pressure, declining soil fertility, weed invasion, decreasing farm size, disease, lack of markets or access to markets for high value produce, and lack of off-farm employment (Jayne et al. 2003).

In many parts of the world, longer-term climate changes have been and are impinging on the livelihoods of rural communities and thus the nature and relative importance of such coping strategies cannot remain unchanged. Adaptation to these longer-term changes is required both by farming communities as well as those stakeholders with whom they interact and on whom they often depend (Cooper et al. 2008).

For agricultural communities and agricultural stakeholders in sub-Saharan Africa to adjust to climate changes and the predicted increases in climate variability, their ability to cope better with the constraints and opportunities of current climate variability must first be enhanced (Cooper et al. 2008). If this does not happen, the challenge of adapting to greater climate variability will prove daunting for most and impossible for many. To achieve the required improvements in rural livelihoods and adaptive capacity, there is now taking place an urgent imperative to accelerate investment in rain-fed agriculture (Cooper et al. 2008). This can amongst others be done through the identification and targeting of investment innovations that have a high probability of economic success, adaptation and impact in the context of climate variability and change (Cooper et al. 2008).

The extent to which people and institutes are able to successfully respond to a new set of circumstances that they have not experienced before, such as a changed climate, will depend upon their adaptive capacity (Cooper et al. 2008). This is well illustrated by a village level study conducted in the semi-arid tropics of India over a 25-year period in 10 villages (Bantilan and Anupama 2002). Evidence from the villages of Aurepalle and Dokur in Andhra Pradesh reveals the acute effects of persistent drought and increasing water scarcity on livelihood strategies. Almost all dug wells in both villages had dried up and village irrigation tanks, previously filled through run-off, have not filled for a decade. Farmers are now forced to leave much of their land fallow, and the income derived from agriculturally related activities has declined dramatically. However, farmer households have successfully adapted and diversified their livelihood strategies through amongst others increased off-farm activity and seasonal job migration. Indeed, as a result, they today have higher incomes than earlier. In other words, the communities in these two villages, under the particular new stresses that they have experienced, have had a high adaptive capacity (Cooper et al. 2008). In the next section the adaptation possibilities in Ethiopia will be discussed.

4.3 Adaptation Mechanisms in Ethiopia

The eleven strategies that were presented with bold font in section 4.2 have been chosen because of literature findings and also from fieldwork returns.

4.3.1 Crop Diversification

Crop diversification is well known in sub-Saharan Africa. Simultaneous growing, mixing or intercropping different types of crops, or cultivars of the same crops, is quite common in northern Nigeria and in many other areas of the Sahel (UNEP 2006: 32). This strategy seeks to avoid risks of total crop failure rather than maximizing yields of one particular crop (UNEP 2006: 32). Also in Ethiopia crop diversification is widespread. Crop diversification is the most commonly used method to overcome climate changes in Ethiopia (Deressa et al. 2009). Greater use of different crop varieties in the same season could be associated with lower expenses and ease of access by farmers (Bradshaw et al. 2004, Kurukulasuriya and Mendelsohn 2008). Diversification is identified as a coping strategy that has evolved to deal with both expected rainfall uncertainty and evolving within season fluctuations in rainfall (Cooper et al. 2008). There are many benefits with crop diversification. It is more secure because if one variety fails, you probably still have some other crop varieties that are successful. Secondly, with rotating of crop varieties on each plot of land, soil fertility will be maintained and the soil might not be exhausted. Moreover, adaptation options include planting of drought tolerant and early maturing crop varieties (CEEPA 2006: 6). The seed types do not necessarily need to be new and improved, they can also be traditional varieties that naturally to some extent are drought tolerant or grow fast.

Use of home gardens and diversification of herds and incomes are other useful types of diversification (UNFCCC n.a.: 37). Maintaining a high level of plant biodiversity within the farm boundaries and in the agricultural landscapes has been a recognized strategy to reduce food insecurity (UNEP 2006: 32). There are many reasons for doing different kinds of crop diversification, and climate changes might be one of these reasons. Crop diversification becomes more and more important when the climate is changing.

4.3.2 Mixing Crop Production with Pastoralism

Mixed species herds, widespread and seasonally available pastures, splitting animals into discrete herds, and mobility in response to seasonal variation in pasture productivity are key strategies in Ethiopia (McIntire 1991). In the drier areas of Ethiopia, cropping is largely impossible and certainly riskful both with regards to production and environmental degradation (Cooper et al. 2008). In these areas pastoralism dominates. In dry areas coping strategies assume even greater importance, but are perhaps less diversified due to the more restricted asset base and the more marginalized nature of such communities (Cooper et al. 2008). In other areas of the country, crop production can be mixed with pastoralism and risk can be reduced this way. CEEPA (2006: 6) states that "*owning livestock may buffer the farmers against the effects of crop failure or low yields during harsh climatic conditions*". If farmers have these types of resources it may function as an important safety net and also contribute to extra income, because animal products can be sold, and livestock can also be sold during difficult periods. Selling of livestock is identified as a coping mechanism to climate variability and extremes in Ethiopia (Tadege 2007: 16). Desalegn et al. (2006: 1) found that selling of livestock were a common coping strategy during drought periods amongst farmers in the Upper Awash Basin in Ethiopia. Livestock is therefore often an important buffer for many farmers. Also, for many farmers usually known as crop cultivars, livestock is positive. In conversely, those farmers traditionally relying on livestock would often have benefits if they can start to cultivate crops and in this way mix crop production and pastoralism.

4.3.3 Tree Planting

Deressa et al. (2009: 1) identified tree planting to be one of the major methods used by farmers to adapt to climate changes in the Nile Basin of Ethiopia. Vegetation like trees, plants, and grass are valuable because the roots protect the soil from erosion. Trees are valuable during floods and droughts, and many trees together might give lower temperatures in the near area, a more fresh air, and also shadow.

4.3.4 Off-Farm Activities

Farmer's vulnerability to climate changes can be mitigated if the farmers have off-farm work on the side. Desalegn et al. (2006: 1) found that sale of labor was a successful coping strategy among farmers in the Upper Awash Basin of Ethiopia during drought periods. Traditional and contemporary coping mechanisms in Ethiopia also include increased petty commodity production (Tadege 2007: 16). Off-farm activities can for instance be selling of honey, clothes, or home made products like mattresses, hot food, beverages, whips and ropes. Where the opportunities exist, working as wage laborers and trading commodities are common in Ethiopia (Cooper et al. 2008). Furthermore, Mideksa (2010) writes that a promising way of mitigating drastic consequences (of climate changes) is to shift to nature independent activities such as manufacturing or meaningfully ensuring the rural sector through increasing the rate of development. It is when the degree of the economy's dependence for input and output on the agricultural sector is lower that adaptation to climate changes becomes easier (Mideksa 2010). Mideksa (2010) is further arguing that a meaningful development involves transformation from an agricultural to a non-agricultural economy, because this will reduce the dependence on agriculture. Since most of the Ethiopian labor force directly and indirectly depends on the agricultural sector for livelihood and employment, it is when this sector becomes more productive and ensures food self sufficiency that it will release the necessary labor and capital for the manufacturing and service sectors (Mideksa 2010). However, raising productivity in the agricultural sector becomes even more challenging as temperatures increase, and it will largely depend upon technological progress in the area of drought resistant crops, improved seeds, improved information access, and better farming practices (Mideksa 2010).

4.3.5 Soil and Water Conservation (SWC)

One of the adaptation strategies found in Deressa's research in the Nile Basin of Ethiopia (2009: 1) was soil conservation. Many areas of Ethiopia are mountainous and the crop fields are rarely flat. Often they are located in a hill side or in a valley side. This creates extra demand for soil and water conservation to prevent the soil and rainwater from being washed away. Terraces are often built, and together with soil bends, stone bends, deep trenches, and special harvesting methods, those are the most common strategies to conserve soil and water in the field.

In the Sahel, 20 % to 40 % of annual rainfall is lost as runoff (UNEP 2006: 42). This often results in agricultural drought and massive soil erosion in some sites, such as hillsides and plateau edges, and flood in others, such as low lying land and valley bottoms (UNEP 2006: 42). Reij (1991: 3) write that "*yet most soil and water conservation projects in sub-Saharan Africa have failed*". In Ethiopia they have often used different kinds of soil and water conservation strategies since around 1990, and soil and water conservation strategies have probably developed much since that time. Soil and water conservation strategies are mainly used because of soil degradation and soil erosion, and because farmers due to this, want to rehabilitate their fields. These activities are increasingly important today because climate changes to some extents are accelerating these processes.

4.3.6 Selling of Assets

Sale of agricultural tools and other assets are identified as a coping mechanism to climate variability and extremes in Ethiopia (Tadege 2007: 16, Desalegn et al. 2006). Farmers may sell some of their resources in market, and this can be an important extra income, and can also function as a safety net and a coping mechanism. Material assets within the household can be seen as a buffer against difficult periods, in the same way as for example livestock.

4.3.7 New or Suitable Seed Varieties

Although farming methods in Ethiopia are still rather traditional, farmers in many areas do have the option of using new, higher-yielding crop varieties (Weir and Knighte 2000a). Traditional and contemporary coping mechanisms to climate variability and extremes in Ethiopia include changes in cropping and planting practices (Tadege 2007: 16). Deressa et al.'s research in the Nile Basin of Ethiopia (2009) identified that one of the adaptations amongst farmers was the use of different crop varieties. Some farmers have access to improved varieties, such as certified wheat or improved barley, potato, or corn. Sometimes government or NGO's distribute these types of grains freely or subsidized, other times the farmers can buy them new or second hand.

Some of the traditional crop varieties are very useful because they either tolerate dry conditions or are fast growing. *Teff, red teff*, barley, corn, and potatoes are some of those varieties. For example *teff* is adapted to a wide range of environmental conditions and can be grown at altitudes from 1000 to 3000 meters above sea level (Teffera et al. 2000). Barley is grown at elevations between 1800 and 3000 meters above sea level. Both *teff* and barley are adapted well to the harsh environments in Northern Ethiopia. These two crops are grown for various purposes: *teff* grain is for food while its straw is an excellent livestock fodder. Barley is a major food source in various forms, including beer, and its straw is also an important source of fodder (Araya et al. 2010).

4.3.8 *Enset*

Closely related to the former section, *enset*, or false banana, is a relatively drought resistant plant and it is a highly valuable plant in many Ethiopian communities, especially in the south. *Enset* is a suitable plant in some parts of Ethiopia and therefore more or less an example of the former section. It is however so important that it is decided to be taken as an individual section. *Enset* provides more amount of foodstuff per unit area than most cereals in Ethiopia.

It is estimated that 40 to 60 plants occupying 250-375 square meters can provide enough food for a family of five to six people. The trend for quite a number of households is food insecurity, and *enset* is to a large extent improving this situation for those households that are growing it (Nater 2010).

4.3.9 Food Aid

Food appeal and food aid have been identified as a coping mechanism to climate variability and extremes in Ethiopia (Tadege 2007: 16). During for example critical times of drought, government, NGOs, relatives and others can help farmers financially or otherwise (Desalegn 2006: 8). Relief agency costs associated with droughts in Ethiopia in 1999 is estimated to have coasted 5.3 million US $ (United Nations 1999).

4.3.10 Irrigation and Diverting of Water

Rain-fed agriculture in sub-Saharan Africa will remain vital for food security (Cooper et al. 2008). At the same time, irrigation can be a valuable strategy for making agriculture more stable and safe. Types of irrigation are for example dams and ponds, hand dug wells and other types of wells, flood irrigation, sprinkler irrigation, lifting water using a petrol-fuelled pump engine, and irrigation by gravity. In Ethiopia, only 2 900 km2 (2003 estimation), or 1 % of cultivated land, is irrigated (CIA 2011, Joto Africa 2009: 8). Use of irrigation is one of the least practiced adaptation strategies among the major adaptation methods identified in Ethiopia (Deressa et al. 2009). Increased irrigation demand will occur in rain-fed agriculture in the future, especially in sub-tropical Africa (Pettengell 2010: 28). CEEPA (2006: 6) writes that adaptation options globally include investment in technologies such as irrigation. Enhancing robustness of water supply systems is one adaptation possibility (Smith et al. 2003: 3). This makes irrigation a recognized adaptation strategy. Still there are several barriers to irrigation. Ethiopian farmers often own very small plots of land and are faced with very low technological capacity to irrigate (Deressa et al. 2009). The limited use of irrigation in Ethiopia could be attributed to the need for more capital and low potential for irrigation (Maddison 2006, Nhemachena and Hassan 2007). FAO (2007: 10) states that "*Climate change adaptation for agricultural cropping systems requires a higher resilience against both excess of water, due to high intensity rainfall, and lack of water, due to extended drought periods*".

Out of the total yield reduction and crop failure seasons which occurred due to water stress in Mekele in the 1990's and 2000's, more than 80 % of yield reductions and more than 50 % of crop failures respectively could have been avoided if adequate irrigation supply was made for September in Mekele (Araya and Stroosnijder 2010). Making ponds for collecting water during the rainy season seemed to be an important coping strategy in Mekele and water collected in these ponds during rainy season can be used to irrigate the crop fields from September to harvest in October. If rainfall is low and unreliable, capturing the little that falls and making it available to crops could provide an effective and sensible way of improving farm productivity and reducing farmers' vulnerability to agricultural drought. At the same time, improving water infiltration in the uplands and hillsides can reduce floods in for example valley bottoms (UNEP 2006: 42). Despite the risk of drought and vulnerability of the people to recurrent drought, little has been done to develop techniques for assessing drought risk and to determine how and which variables are related to crop failure circumstances in the northern Ethiopia (Araya and Stroosnijder 2010). Droughts in Mekele in the 1980's might not have been mitigated with the provision of supplementary irrigation targeting only for the month of September (Araya and Stroosnijder 2010). This might be because the droughts in the 1980's were very severe, while in the 1990's and 2000's the droughts in Tigray were less serious. Water resources are important limiting factors for production in the extremely dry climate around Mekele (Ashebir et al. 2007). Flood and furrow irrigation, currently practiced by the majority of farmers, are wasteful forms of irrigation, but on the other hand drip or sprinkler irrigation requires capital (Ashebir et al. 2007). Many farmers may want access to credit and would need to be sure that they would obtain improved crop yields if they were to invest in irrigation equipment (Ashebir et al. 2007).

4.3.11 Migration

Climate changes are expected to affect humanity through for example migration (Epstein 2000, Tol et al. 2007). Traditional and contemporary coping mechanisms to climate variability and extremes in Ethiopia include permanent and temporary migration in search of employment (Tadege 2007: 16). For example in the highlands of Ethiopia, environmental changes contribute to encouraging migration out of rural areas (Morrisey 2008: 1). Humans may change their behavior to cope with a different climate, or if necessary may migrate (Feenstra et al. 1998: 119). This means that it is often several other activities farmers can do to mitigate the impacts of climate changes before they migrate. Migration is often seen as the drastic last choice option.

Some people in for example Oromia Region, live a semi-nomadic lifestyle (Dadi 2007). They migrates a couple of times during a year in search for pastures for their livestock. For example they have a permanent farm one place, but parts of the year they move the family and their livestock to other areas and come back several months later (Dadi 2007). A semi-nomadic lifestyle can be seen as a general coping strategy. This lifestyle was presumably not created as an adaptation strategy to climate changes, but to the general scarcity of grazing land and as a sustainable natural resource management strategy. This lifestyle might however, still be positive for the environment, and when climate changes are getting more current in this region, the semi-nomadic lifestyle might become a valuable adaptation strategy for some farmers, but it is difficult to maintain this lifestyle, and it is threatened from many directions (Dadi 2007).

4.4 Facilitators, Barriers and Limitations to Adaptation

In section 4.4 I will present and discuss several factors that can possibly facilitate adaptation on the one hand, or conversely be a barrier to adaptation on the other hand. There are many factors both enhancing and hampering farmer's adaptation possibilities.

Despite having perceived changes in rainfall and temperature, a large percentage of Ethiopian farmers have not made any adjustments to their farming practices (Bryan et al. 2009). This might be due to many reasons. The main barriers to adaptation cited by farmers in Ethiopia were amongst others lack of access to or shortage of land, labor, credit, and information on adaptation methods, poor potential for irrigation, and financial constraints (Bryan et al. 2009, Deressa et al. 2009: 1). Poor adaptive capacity, unresponsive governments, and weak policy mechanisms might also be barriers to adaptation (Salehyan 2005).

Shortage of land has been identified as a barrier to adaptation. It is argued that the Ethiopian land tenure system, whereby all land is owned by the state and must be distributed equally to farmers imposes severe limitations to potential improvements of agricultural activities (Ashebir et al. 2007). There are many who maintain that the equalization of assets in rural communities has led to agricultural stagnation (Hailesellasie 2004).

There are many facilitators and organizers of climate change adaptations. Factors influencing Ethiopian farmers' decision to adapt include wealth, and access to extension, credit, and climate information (Bryan et al. 2009). Some international agencies are also facilitators of adaptation. For example The National Adaptation Programme of Action (NAPA) is a mechanism within the UNFCCC, designed to help the Least Developed Countries including Ethiopia to identify their priority adaptation needs to climate changes and to communicate these needs to the Conference of Parties (COP) of the UNFCCC and other concerned bodies (NAPA 2011). Another example is the Poverty Reduction Strategy Papers (PRSPs, country-based strategies for poverty reduction) that is providing a starting point to identify national level risks from climate changes. These steps are vital in order to avoid planning and implementing strategies that are not in line with current and future development needs, which could result in *maladaptation,* whereby people inadvertently become more vulnerable to climate changes as a consequence of interventions (Conway and Schipper 2010). Consequently, in 2007, 8.3 million people in 'chronically' food insecure households in rural Ethiopia, received resources from the Productive Safety Net Program (PSNP) through cash transfers or food payments in exchange for participation in labor-intensive public works projects (Conway and Schipper 2010). Such social safety nets are also important. The International Crop Research Institute for the Semi-arid Tropics (ICRISAT) is working in partnership with a wide range of stakeholders in Africa who have expressed specific climate risk management concerns and who share the vision of enhanced and more resilient rural livelihoods in Africa, better able to cope with current climate variability and adapt to future climate changes (Cooper et al. 2008: 11). Finer-scale forecasts and more fine-tuned early warning systems, accompanied by a rapid delivery of information can be seen as facilitators to adaptation. High resolution (less than 50km x 50km) regional climate models are now emerging and can give much more detailed outputs at a lower scale (UNEP 2006: 28). For example the PRECIS (Providing Regional Climates for Impact Studies) regional climate model developed by the Hadley Centre for Climate Prediction is being used in India, China, and in the southern African region to generate scenarios. Such models should be extended to other climatically sensitive areas such as the Sahel region.

Efforts were made to compile information on climate change impacts from various sources such as the Initial National Communications of Ethiopia to the UNFCCC, the IPCC reports and other sources. Impact and vulnerability assessments in priority sectors were undertaken as part of the process of developing the Initial National Communications of Ethiopia to the

UNFCCC (Tadege 2007: 41). In this context, Tadege (2007: 7) means that planning and implementing climate change adaptation polices, measures, and strategies in Ethiopia will be necessary. This might be true to a large extent because climate change adaptation is needed and therefore it is need for the right framework or political condition that can enhance such activities (Tadege 2007: 7). The adaptive capacity of communities is determined by their socioeconomic characteristics (Smith et al. 2001: 879).

Various barriers and facilitators which might influence farmers' choices on adaptation are listed below. This list of factors is based on Pettengell 2010, Bryan et al. 2009, Deressa et al. 2009: 1, Ashebir et al. 2007, Tadege 2007: 7, Feenstra et al. 1998: 118.

1: Wealth
2: Gender of head of household
3: Education
4: Age
5: Household size
6: Access to information
7: Access to weather forecasts
8: Access to credit
9: Agricultural education or training
10: Social capital
11: Distance to market
12: Agro-ecological settings

- Climate change adaptation policies, measures, and strategies
- Systems in place for dissemination of information
- Well-functioning social systems
- Access to labor
- Irrigation potentials
- Equitable distribution of power
- Access to land
- Ethnicity
- Stable and effective institutions
- Access to technology
- Productive use

These factors might contribute to explain the farmers' resource base and ability of different groups and individuals to adapt (Feenstra et al. 1998: 117). In general, the stronger, more resilient and more varied the asset base, the greater is people's adaptive capacity and the level of security and sustainability of their future livelihoods (Cooper et al. 2008).

There are few of these factors listed above that are strongly present in Ethiopia. Smallholder farmers have considerable experience of dealing with climate variability, and local knowledge helps them to cope during difficult periods. These coping strategies are largely unsuitable to deal with the sustained changes and increased variability associated with climate changes, as they rely on the conditions returning to normal again. As a result, assets are depleted, limiting options for adaptation (Pettengell 2010: 28). In the following twelve factors that might contribute to the explanation of adaptive capacity amongst farmers will be evaluated one by one. The most important is probably wealth.

4.4.1 Wealth

Farm and nonfarm income, farm size, and livestock ownership, represent wealth. It is regularly hypothesized that the implementation of new agricultural technologies requires sufficient financial wellbeing (Knowler and Bradshaw 2007). Other studies that investigate the impact of income on adaptation found a positive correlation between income and adaptive capacity (Franzel 1999). Higher income farmers may be less risk averse and have more access to information, a lower discount rate, and a longer term planning horizon (CIMMYT 1993).

As mentioned above, livestock is a way of measuring wealth and plays a very important role by serving as a store of value and by providing traction (especially oxen) and manure required for soil fertility maintenance (Yirga 2007). Farm and nonfarm income and livestock ownership are hypothesized to increase adaptation to climate changes (Deressa et al. 2009).

Studies on adaptation of agricultural technologies indicate that farm size has both negative and positive effects on adaptation, showing that the effect of farm size on technology adaptation is inconclusive (Bradshaw et al. 2004). However, because farm size is associated with greater wealth, and it is hypothesized to increase adaptation to climate changes (Deressa et al. 2009).

4.4.2 Gender of Head of Household

When it comes to question of whether male headed or female headed households are preferable, scientists do not agree. For example Asfaw and Admassie (2004) are saying that male headed households are preferable, because male-headed households are more likely to get information about new technologies and undertake risky businesses than female-headed households. Moreover, having a female head of household may have a negative effect on the adoption of soil and water conservation activities, because women may have limited access to information, land, and other resources due to traditional social barriers (Tenge De Graaff and Hella 2004). A study by Nhemachena and Hassan (2007) shows contrary results, arguing that female-headed households are more likely to take up climate change adaptation methods. Deressa et al. (2009) also conclude that women are more likely to adapt than men because they are responsible for much of the agricultural work in the Nile Basin of Ethiopia. Women therefore have greater experience and access to information on various management and farming practices. Thus, the adoptions of new technologies or adaptation methods appear to be rather context specific (Deressa et al. 2009). These authors have done research in different areas of Ethiopia and it might be that all of them are right. The cultural aspect of this issue is important, and gender roles probably differ a lot from one area to the next. On the other hand, gender might in most cases be irrelevant because the majority of Ethiopian farmers are married, and then the wife and the husband usually work together as one unit and it does not matter if it is the male or the female who is doing the adaptation activities when the other is doing other types of work.

4.4.3 Education

Higher level of education is believed to be associated with access to information on improved technologies and higher productivity (Norris and Batie 1987). Evidence from various sources indicates that there is a positive relationship between the education level of the head of household, the implementation of improved technologies, and adaptation to climate changes (Igoden et al. 1990, Lin 1991, Maddison 2006). Therefore, farmers with higher levels of education are more likely to adapt better to climate changes (Deressa et al. 2009).

An understanding of the sources of agricultural productivity gains - and the role played by education - is particularly important in a country such as Ethiopia, where very few children go to school (Weir and Knighte 2000a). A primary reason given by many people for never attending school or for quitting school early was that they were needed to help with farm or household activities. If the expected private returns from schooling for parents who make enrolment decisions are low, and do not take into account externality effects of education upon farm productivity, too little investment in education will be made. A vicious circle of poverty and low school enrolment will be set in motion (Weir and Knighte 2000a).

4.4.4 Age

Studies in Ethiopia have shown a positive relationship between numbers of years of experience in agriculture and the implementation of improved agricultural technologies (Kebede et al. 1990). Experience in farming increases the likelihood of uptake of adaptations to climate changes (Maddison 2006, Nhemachena and Hassan 2007, Deressa et al. 2009). Age of the head of household can be used to capture farming experience (Deressa et al. 2009). On the other hand, a negative relationship between age and implementation of improved soil conservation practices can be identified (Shiferaw and Holden 1998). So age might often mean better experience, access to information, and knowledge, but also other things like a weaker health, and consequently age and experience might give both positive and negative outcomes.

4.4.5 Household Size

The influence of household size on adaptation methods can be seen from two perspectives. The first assumption is that households with large families may be forced to divert part of the labor force to off-farm activities in an attempt to earn income in order to ease the consumption pressure imposed by a large family (Yirga 2007). The other assumption is that large family size is normally associated with a higher labor endowment, which would enable a household to accomplish various agricultural tasks. Households with a larger pool of labor are more likely to implement agricultural technology and use it more intensively because they have fewer labor shortages at peak times (Croppenstedt et al. 2003). It is expected that households with large families are more likely to adapt to climate changes (Deressa et al. 2009).

4.4.6 Access to Information

Access to information might increase the likelihood of adapting to climate changes (Deressa et al. 2009). Extension on crop and livestock production and information on climate represent access to the information required to make the decision to adapt to climate changes. Various studies in developing countries, including Ethiopia, report a strong positive relationship between access to information and the adaptation behavior of farmers (Yirga 2007), and that access to information through extension increases the likelihood of adapting to climate changes (Maddison 2006, Nhemachena and Hassan 2007).

4.4.7 Access to Weather Forecasts

Access to weather forecasts is important for the farmers to be able to plan what to do on the field. Erratic rainfall patterns and changing seasons are upsetting farming cycles in many parts of the world. Many Ethiopian communities are experiencing changes in seasons, with rainfall being concentrated into fewer, more extreme events, or the delayed onset of rainy seasons. With traditional farming calendars becoming less reliable, farmers need interventions to help them to plan and prepare, including weather forecasts for deciding when to sow and when to harvest, and seasonal forecasts for what to sow and how to manage risk (Pettengell 2010: 28).

There exist a number of constraints which needs to be addressed before the potential of climate forecasts can be fully exploited for the local communities. The regional nature of seasonal forecasts may limit their relevance for planning at the national or local level. Knowing whether seasonal rainfall will be above or below normal alone will not necessarily make a weather forecast useful to potential end-users. One needs to be careful when delivering output information to avoid ‘finger pointing’ in case of bad decisions by farmers. The confrontation of weather forecast outputs with traditional indicators of rainfall, together with a sound discussion on the possibilities of different outcomes, is likely to make seasonal weather forecasts more acceptable by farmers (UNEP 2006: 28). It is important that the weather forecasts often are correct, if the farmers are to make agricultural decisions based on the weather forecasts. A forecast will be meaningful only if it allows enough lead-time for decision making (UNEP 2006: 28-29). Models can now predict the number of rainy days with great accuracy, but it is difficult to predict if any dry spells is coming or not. The analysis of the number of modeled rainy days against a defined baseline may therefore give an indication on the likely occurrence of dry spells during the growing season (UNEP 2006: 28).

4.4.8 Access to Credit

Availability of credit eases the cash constraints and allows farmers to buy inputs such as fertilizer, improved crop varieties, and irrigation facilities. Research on adaptation of agricultural technologies indicates that there is a positive relationship between the level of adaptation and the availability of credit (Yirga 2007, Pattanayak et al. 2003, Deressa et al. 2009).

4.3.9 Agricultural Education or Training

Adaptation options include educating farmers (CEEPA 2006: 6). Such education might be valuable for the farmers and might make the farmers more secure in their agricultural decisions. Agricultural training and education might also increase the farmers' income because they might become more clever farmers and yield higher productivity.

4.4.10 Social Capital

Social capital might positively influence adaptation to climate changes (Deressa et al. 2009). Social capital is represented by the number of relatives of a household in the local area and farmer-to-farmer extension. Informal institutions and private social networks play three distinct roles in adaptation of agricultural technologies (Katungi 2007). First, they act as conduits for financial transfers that may relax the farmer's credit constraints. Second, they act as conduits for information about new technology. Third, social networks can facilitate cooperation to overcome collective action dilemmas, where the adaptation of technologies involves externalities. Ethnically based and participatory social relationships act as forms of social capital in the decision to approve fertilizer (Isham 2002).

4.4.11 Distance to Market

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

4.4.12 Agro-ecological Settings

It is also hypothesized that different households living in different agro-ecological settings use different adaptation methods. This is due to the fact that climatic conditions, soil, and other factors vary across different agro-ecologies, influencing farmers' perceptions of climate changes and their decisions to adapt (Deressa et al. 2009). Altitude is a crucial factor. Highland fields might demand other adaptation techniques than midland or lowland fields. Agro-ecological settings also set clear barriers and limitations on one hand, and possibilities on the other. For example a farm in a lowland area might often have access to irrigation water from a river nearby, but it is otherwise often hot and dry in these areas. Irrigation is often impossible in highland areas, but on the other hand, highland areas can often enjoy more rainfall and a colder climate and therefore crop is likely to grow more properly. FAO (2007: 6) state that "*people living in marginal areas such as dry-lands or mountains face additional challenges with limited management options to reduce climate change impacts*".

4.5 The Role of Government

There are numbers of actions the Ethiopian government can do and currently are also doing to enhance the farmers to adapt to climate changes. Awareness raising, credit, dissemination of technology and provision of safety nets to some lowland farmers and emergency aid are among the coping strategies provided by the Ethiopian government institution (Senbeta 2009: 2). Some of the most crucial elements will be discussed here in section 4.5. The elements are: Enhance adaptation through policies, distribution of new seed varieties, enhance and give education, drought preparedness and warning systems, infrastructure, economic safety nets, welfare systems, and food aid, respectively.

4.5.1 Enhance Adaptation through Policies

Farmers' capacity and possibility to adapt to climate changes depends amongst others on the political conditions and frameworks that the government might decide. Policies might influence both extents of adaptations and can also enhance specific forms of adaptation, for example sowing of suitable seed varieties if they distribute such. Rosegrant et al. (2002c) state that *"policies must be put in place and decisions taken to greatly accelerate the current trends of investment within the agricultural sector in sub-Saharan Africa"*. Agricultural policies should be adapted to climate change impacts, and policies can try to avoid subsidies or taxes based on type of crop or acreage (Pettengell 2010: 28, Smith and Lenhart 1996: 1). This latter might be positive because it might result in speculation among the farmers in deciding which crop type one should sow based on subsidies, taxes, or market prices. Moreover, policies can also promote and increase efficiency of irrigation (Smith and Lenhart 1996: 7). Furthermore, public institutions might disperse information on conservation management practices and liberalize agricultural trade (Smith and Lenhart 1996: 7). Pettengell (2010: 28) writes that changing management practices will be required: "*Adaptation requires consideration of how people use and manage natural resources, given that this will be under increasing stress from climate change*". Another suggestion is that technologies for adaptation should be targeted at the needs of the poorest and most vulnerable people, including women, favoring small-scale technologies that can be taken up and adapted locally (Pettengell 2010: 28). Knowledge of the adaptation methods and factors affecting farmers' choices enhances policies directed toward tackling the challenges that climate changes are imposing on Ethiopian farmers (Deressa et al. 2009: 1). Adapting rural livelihoods will require a range of investments, policies, planning, and information (Pettengell 2010: 28). It will also be a need for access to appropriate technology (Pettengell 2010: 28). This is aspects of climate change adaptation where the Ethiopian government has a role to play and can take leadership. The government has legitimacy, power, and resources to for example invest, investigate, make information campaigns, and to change policies so it will be easier for farmers to do adaptation activities, and they are also already doing it to some extent. For example the government can advise people to avoid monoculture, and policies can encourage farmers to plant a variety of heat- and drought resistant crops (Smith and Lenhart 1996: 7). The governmental development agents working in Ethiopia's sub-districts are to some extents already advising farmers in agriculture, and some policies are put in place to protect the environment. Food storage and distribution systems should be upgraded and expanded and policies can be put in place to enhance the liberalization of agricultural trade.

4.5.2 Distribution of New Seed Varieties

A crucial factor for farmers to adapt to climate changes is their access to improved seed varieties that are better suited to drier, warmer, or more instable weather conditions. New crop types might be developed and seed banks can be enhanced (Smith and Lenhart 1996: 7). Developing flood- or drought tolerant varieties is one part of the solution, but so is ensuring that they are widely available where they are needed most, and that access is not hampered by a lack of information, expense, or intellectual property rights (Pettengell 2010: 28).

Adaptation options include strengthening institutional set-ups working in research (CEEPA 2006: 9). Farmers in Ethiopia have already got amongst others certified wheat, an improved barley variety called *savin* and an improved potato variety called *gudane*. Both Tigray and Oromia Region have its own agricultural research institute. This is governmental organizations that aim to amongst others develop high yielding- disease- and insect resistance crop varieties (in Oromia), and tries to enhance increased productivity, and minimize soil and water loss (in Tigray) (EIAR 2005). These agricultural research institutes are valuable contributors in this work and will probably be a great resource in the future.

4.5.3 Enhance and Give Education

More and better education within the farmer households may often mean better understanding of both climate changes and the possible reactions to this, and might contribute to explain extents of adaptation. The government and private investors are facilitators of education in Ethiopia. Likewise, lack of education might be a barrier to climate change adaptation because the farmers among other things do not have access to information. The expected numbers of years at school during a life time in Ethiopia is nine years for boys and eight years for girls (2008 estimation) (CIA 2011).

Potential benefits of schooling are manifold. They may accrue to the individuals receiving education, to their households, and to their community or society. They may be internalized by the decision-taker(s) or not taken into account in the decisions. To the extent that individuals or households fully perceive the benefits of schooling to themselves and there are no constraints on schooling, they will invest in the amount of education that maximizes their private utility. However, there will be a socially sub-optimal level of investment in the presence of positive externalities. Externalities are generally defined to include the effects of economic actions which are not taken into consideration by the economic agent. These external effects may be negative or positive. Economic agents may not be aware of the effects of their actions on others or they may not care about them. Even if external benefits or costs are recognized by the economic agents involved, there is often no market for the externality. That is, those who are affected by the activities of others are usually able neither to pay them to produce more of a positive externality nor to impose on them the full social costs of a negative externality (Weir and Knighte 2000b).

4.5.4 Drought Preparedness and Warning Systems

Use of early warning systems is a much important task to make function in Ethiopia. Early drought warning and preparedness is urgent in the whole Africa (Downing et al. 1997). Governments can and should promote agricultural drought management (Smith and Lenhart 1996: 7). Drought preparedness, drought warning, and management is important, and drought is likely to happen more and more often in the future, so the resources invested in this will most likely not be wasted. If a drought warning system was put in place in Ethiopia, the farmers would had more time to plan and prepare for the upcoming droughts, and most likely their adaptive capacity would be improved.

4.5.5 Infrastructure

Infrastructure plays a role in the facilitators or barriers to climate change adaptation. Distance and access to a market is important for many reasons, for example to get access to formal and informal information about climate change adaptations and other farming techniques and strategies. Those farmers living close to, and with good access to a market, can go there regularly and talk with other farmers, and in this way might have easier access to the latest "news" and trends in agricultural techniques. Those living in outskirts of their sub-district, with long distance to a market, do probably go there less often and might therefore lose important ideas, knowledge and information. The roads are often in poor conditions, and the farmers might use a lot of time on walking that could have been used to work on the farm if the market was located closer, or if better bus facilities were there. Those living far away from the administrative center in their sub-district might also have challenges with electricity and the radio net, which can make it difficult for them to hear news on the radio. Finding mobile phone connection can also be difficult in areas far from a city. Roads, electricity, radio signals, and phone networks are therefore important also to get access to information about climate changes and adaptation strategies, distribution arrangements, and so on. The government in Ethiopia together with private companies and NGOs play a leading role and has the responsibility for the infrastructure in Ethiopia.

4.5.6 Economic Safety Nets, Food Aid and Development

It is important that farmers have some kind of safety nets, and that they have access to food aid if necessary. If they have this security, they might be more innovative and willing to take some risks and try out new adaptation strategies. UNEP (2007: 68) writes that success in global adaptation to climate changes can only be realized if climate concerns are mainstreamed in development planning at national and local levels.

4.6 Conclusion, Summary and Propositions of Chapter 3 and 4

It has been done research on climate change impacts and adaptations in agriculture other places in sub-Saharan Africa and Ethiopia, but never, as I have found, in Hagere Selam or Kofele. It is important to map the consequences of climate changes and adaptation strategies to better know how adaptation strategies can be improved, enhanced, and supported. To be able to come up with effective strategies to cope with climate changes, knowledge about the impacts is demanded. When it is better known what kind of adaptation strategies the farmers use, it is easier to realize what they need help with. Table 2 shows associations between different elements of climate changes and adaptation strategies.

- means that the element of climate changes and the adaptation strategy is highly related

∇ means that the element of climate changes and the adaptation strategy have some linkages

Table 2: Matrix showing the correlation between elements of climate changes and adaptations

	Rainfall	**Temperature**	**Instability**
Crop diversification	•	•	•
Crop and pastoralism	•	•	•
Tree planting	•	•	•
Off-farm activities	•	∇	•
Soil/water conservation	•	•	•
Selling of assets	•	∇	•
New seed varieties	•	•	•
Enset	•	∇	•
Food aid	•	∇	•
Irrigation	•	∇	•
Migration	∇	∇	•

Based on Deressa et al. 2009, CEEPA 2006: 6, Desalegn et al. 2006, Tadege 2007: 16, Nater 2010, Epstein 2000

The first research question that has been discussed is “have people experienced any changes regarding the climatic conditions during the last twenty years?” In the literature review, many indications and evidences were found that climate is changing. If climate was not changing, climate changes would probably not have been an academic issue at all. For example Deressa et al. (2009) write that Ethiopian farmers in the Nile Basin have observed changes in climate over the past 20 years. The Ethiopian government has a role to play when it is coming to measuring of climate, and they have several weather stations throughout the country that are recording amongst others rainfall and temperatures. This is done through National Meteorological Agency and the related local weather stations.

The second research question is “what are these climatic changes?” The most important factors seem to be changes in rainfall and temperature, and also increasingly instable weather. For example Deressa (2009: 1) found that 53 % of the Ethiopian farmers in the survey have observed decreasing rainfall, and 50.6 % have observed increasing temperatures over the past 20 years. Moreover, Tadege (2007: 32) is also stating that there has been a tendency to warmer temperatures in Ethiopia over the past 55 years. National Meteorological Agency is measuring rainfall amounts and temperatures to be able to see changes over time.

The third research question was “to what extent has the climate changes had socio-economic impacts on the people’s livelihood?” We saw that the main impact of climate changes is decreasing crop and animal yields (Pettengell 2010). Other impacts found in other studies in Ethiopia are soil degradation and soil erosion, increased poverty, and worsened health conditions (Boardman and Favis-Mortlock 2000, Mideksa 2010, Dadi 2007).

The fourth question to be examined is about the different possibilities people have to respond to climate changes. Ethiopian farmers have often responded through adaptation to counteract the impact of the climate changes (Deressa et al. 2009). Some of the main actions that can be done to mitigate the impacts of climatic changes are crop diversification, combine crop cultivation and livestock breeding, planting of trees, off-farm work, soil and water conservation, selling of assets, new seed varieties, *enset*, food aid, irrigation, and migration (Deressa et al. 2009, McIntire 1991, Cooper et al. 2008, Tadege 2007: 16, Weir and Knighte 2000a, Nater 2010, Epstein 2000, Tol et al. 2007). The government has an important responsibility when it comes to enhancing adaptations among the Ethiopian farmer population. They are amongst others distributing improved seed varieties and tree seedlings, and they give some food aid during critical periods of drought and flood.

The last research question is “what factors can explain various extents of individual adaptations?” There are many factors that might contribute to explain the level of adaptive capacity within a household. Some factors are possibly externalities, such as education, distance to market or infrastructure, and social capital (Norris and Batie 1987, Maddison 2006, Deressa et al. 2009). Other factors might be wealth, age, gender of head of household, agro-ecological settings, or whether the household have access to information, weather forecasts and credit (Knowler and Bradshaw 2007, Kebede et al. 1990, Asfaw and Admassie 2004, Deressa et al. 2009, Pettengell 2010, Yirga 2007). For example it is regularly hypothesized that the implementation of agricultural technologies (and adaptations) requires adequate financial wellbeing (Knowler and Bradshaw 2007). If some of these factors are lacking, this can be seen as barriers to adaptations. Some of the greatest barriers are probably the already mentioned financial constraints, and also poor potential for irrigation, shortage of land and labor, and lack of information on adaptation methods (Bryan et al. 2009, Deressa et al. 2009: 1). The government should for instance give information, infrastructure facilities, and education.

In the next section, chapter 5 will explain the methodology employed in this research. It justifies the choice of research strategy, design, sample, data collection techniques, ethical considerations, and limitations for this study.

Chapter 5: Methodology

5.1 Research Strategy

A research strategy refers to the overall directions for how the research will be conducted, and is a general orientation to the conduct of social research (Bryman 2008: 698, 22). However, it can be useful to think of the relationship between theory and empiricism in terms of deductive and inductive strategies. On the other hand these two strategies are not clear-cut, but can preferably be seen as tendencies rather than distinctions (Bryman 2008: 13). Deductive approach will be used in this thesis because theory presented and discussed in the literature review will be tested in the empirical part. Theory and the research questions deduced from it are examined in chapter 3 and 4, and then this drives the process of analyzing empirical data in chapter 6 (Bryman 2008: 9).

Normally research strategy is divided between a qualitative and a quantitative approach. Bryman (2008: 22) states that "*qualitative and quantitative research can be taken to form two distinctive clusters of research strategy*". Further Bryman writes that (2008: 23) "*quantitative and qualitative research represent different research strategies and each of them carries with it striking differences in terms of the role of theory, epistemological issues, and ontological concerns*".

An epistemological issue concerns the question of what is, or should be, regarded as acceptable knowledge in a discipline and also about how knowledge can be acquired (Bryman 2008: 13, Ritchie and Lewis 2005: 23). Epistemology means the perception of how knowledge is generated (Ryen 2002). The choice of research strategy depends amongst others on the epistemological position (Ryen 2002). For example, it can imply explaining human behavior against an external reality (*positivism*) or understand human behavior from the point of view of the actors and entities of study (*interpretivism*) (Bryman 2008: 13-16). Secondly, the central point due to ontology and social entities are whether social entities can and should be considered as objective entities that have a reality external to social actors, or whether they can and should be considered social constructions built up from the perceptions and actions of social actors (Bryman 2008: 18). Ritchie and Lewis (2005: 23) state that "*Ontology is concerned with the nature of the social world and what can be known about it*".

Social research is influenced by a variety of factors (Bryman 2008: 24). The researchers own values might have influenced and impinged on the research and decisions taken in many different ways. Bryman (2008: 24) write that "*Values reflect either the personal beliefs or the feelings of a researcher*" and are a form of preconception. Research cannot be value free but it should be recognized and acknowledged that there is no untrammeled incursion of values in the research process. It is important to be self-reflective and then demonstrate reflexivity about the part played by such factors (Bryman 2008: 25). I think values have played a very small part during all stages of my research partly because of the nature of my topic, which is to a large extent "safe" to talk about. Values played a central role when I decided the topic, because I chose topic and research country after my personal interest.

5.2 Mixed Methods Research

"*A research method is simply a technique for collecting data*" (Bryman 2008: 31). Mixed methods research is used to produce this master thesis because it might be a good idea to use both qualitative- and quantitative research methods to find out most and best possible information about my research topic. Some researchers think it can be value in mixing the two methods, while other writers think that these two methods are so different in their philosophical and methodological origins that they cannot be effectively blended (Ritchie and Lewis 2005: 38). To see it from the positive side, mixed methods research "*would seem to allow the various strengths from both quantitative and qualitative methods to be capitalized upon and the weaknesses offset somewhat*" (Bryman 2008: 603). This paper argues that the use of mixed methods research might have given a better understanding of the situation in the villages outside of Hagere Selam and Kofele than what could have been made with the use of only one of the methods.

In this research it was first used qualitative interviews to get a thorough picture of the situation in the villages and to identify the most common impacts and coping strategies. When an overview and general understanding of the situation was received, I changed the interview into a shorter questionnaire which was much less time consuming, but I still got answers to the most important questions.

5.3 Research Design: Case Study

Bryman (2008: 30) states that "*a research design relates to the criteria that are employed when evaluating social research*". Further, Bryman (2008: 31) writes that "*a research design provides a framework for the collection and analysis of data*". In this study it is used mixed methods research to do case studies in two Ethiopian sub-districts. Each of the two cases will be analyzed and compared. "*The basic case study entails the detailed and intensive analysis of a single case*" (Bryman 2008: 52). Case study research is concerned with the complexity and nature of the case (Stake 1995). In this case study it is communities that are the focus of study, Hagere Selam and Kofele, respectively. As Yin notes, "*by comparing two or more cases, the researcher is in a better position to establish the circumstances in which a theory will or will not hold*" (Yin 2003: 40). The two case studies in this research are exemplifying cases. With this kind of case "*the objective is to capture the circumstances and conditions of an everyday or commonplace situation*" (Yin 2003: 41). The notion of exemplification implies that cases are often chosen not because they are extreme or unusual in some way but often because they epitomize a broader category of cases (Bryman 2008: 56). I have not chosen Hagere Selam and Kofele because they are extreme in any way, but because the farmers here are mainly like farmers at other places in sub-Saharan Africa. One factor is a bit special, and that is that both Hagere Selam and Kofele are highland areas. This makes their climatic conditions a bit different from farmers living in midland or lowland areas. I chose this type of case because in this way the thesis is a bit more relevant in a general, sub-Saharan context. In this way it is still not possible to generalize, but the general trends in climatic changes and level of adaptive capacity might possibly give the picture of the situation in a bigger geographical location than just Hagere Selam and Kofele.

5.4 Criteria for Evaluation of Social Research

There are several criteria for evaluation of social research. Reliability is one of them. It is concerned with the question of whether the results of a study are repeatable or not (Bryman 2008: 31). A reliable measurement is one where we obtain the same result on repeated occasions (De Vaus 2002: 52). I want to argue that my research is reliable because it is easy for other researchers to ask the same research questions in Hagere Selam or Kofele and check if they will get the same findings or not. I think if I would have done the same research again, I would have got most of the same types of findings, but there is no guarantee that my sample is representative, so the frequency of different impacts and adaptations in use might differ. I want to argue that the findings from the interviews and questionnaires in this research might not be 100 % reliable, but to a large extent, they are. Many questions asked during the interviews demands that the respondents have a good memory. For example I asked when natural disasters occurred and how climate have changed in their area the last twenty years. It might be difficult to remember if a drought happened four or five years back. Other types of questions might also have been unclear for them, and I did not always specify each and every impact, natural disaster, or coping mechanism I was looking for in the interviews. These questions were open ended in the in-depth interviews, but a list of yes – no-questions in the questionnaires; because of this I might have got more yes from the questionnaires, and a bit less information from the interviews than what possibly could have been the case if I specified what I was looking for. This means my research might be an underestimation of both impacts and adaptation strategies. Moreover, when I asked the introductory questions, for example about household size, and I meant how many family members that live together in the household, it might have been uncertainties and misunderstandings about who should be considered as household members. Next, when it comes to crop in quintal it might be some irregularities because there are different ways of counting. Some are counting the cereals only, while others are also considering potatoes and corn which weight a lot.

Secondly, validity is concerned with the integrity of the conclusions that are generated from a piece of research (Bryman 2008: 32). I want to argue that my research is valid, and my research is answering the research questions. I think my empirical findings are valid because they all depend on the answers from the respondents, and I think they all answered my questions quite honestly. The findings from the two case studies in this research might be relevant in those two sub-districts only. It cannot be said that exactly these findings can be transferred to other sub-districts in Ethiopia or to other countries. There are of course many similarities between farmers in all developing countries. They face many of the same challenges, also when it comes to climate change adaptation, but these two case studies are for example conducted from highland areas, and the topography of Ethiopia makes each district a bit unique.

5.5 Pilot Testing

Pilot interviews were done in October 2010 to test and improve the interview guide. Pilot testing was also done to assess the reliability and validity of indicators before conducting the study. Pilot testing is done by administering the questions to a similar but smaller sample than in the actual study (De Vaus 2002: 52). I did around five pilot interviews in Meremieti outside Mekele, Tigray, and this gave me ideas of how to improve my interview guide and also how to make the questions more relevant to the respondents and to my research questions. I also got a better understanding of approximately how long time an interview would take.

5.6 Sampling

Purposive sampling, or criterion based sampling, was used to find respondents for this survey. This is a type of non-probability sampling (Ritchie and Lewis 2005: 78). Non-probability sample means that the selected respondents have not been selected using a random selection method. Essentially, this implies that some units in the population are more likely to be selected than others (Bryman 2008: 168). Representativeness cannot be ensured with this method, but it can still provide much useful information (De Vaus 2002: 90). Purposive sampling means a hybrid approach in which the aim is to select groups that display variation on a particular phenomena but each of which is fairly homogenous, so that subgroups can be compared (Ritchie and Lewis 2005: 79). For example was it demanded that the respondents had to be farmers and they had to live in the respective areas of research. Then I chose different kinds of people according to for example gender, age, and wealth. The respondents had to be chosen strategically after their relevance for the study, through stratified purposive sampling, which is a particular kind of purposive sampling (Patton 2002). I tried to ensure that the sample was as diverse as possible within the boundaries that I have made (Ritchie and Lewis 2005: 83). I used purposive sampling because it seemed to be the most simple and straight forward way to collect respondents. Farmers are also very much easy to find because the majority population around Hagere Selam and Kofele are farmers, and they do probably not differ that much from each other when it comes to perceptions about climate, knowledge, and agricultural and adaptive capacity. I interviewed farmers amongst others in their homes, in their fields, along roads, in market, in cafés, and beer houses. Because much of the interviews were taken outdoors I did not use a recorder. It was often much wind and other noise, and the recorded interviews might have been difficult to hear. I also think that many of the respondents and maybe also the interpreter and me included would have been less comfortable with the use of recorder. Analysis and transcription of recorded interviews are also time-consuming, and I made the decision that it is not worth it. I never missed recorded tapes during my writing up of findings or the analysis, and I had good notes that I used. I transcribed the notes from my note book into an Office Word program and SPSS program, but I also collected findings directly from the writing books to double check data.

Purposive sampling was a good sampling method to use in my research because it firstly allowed me to ensure that all the key constituencies of relevance to the subject matter were covered and secondly to ensure that within each criteria, some diversity were included so that the impacts of the characteristic concerned could be explored (Ritchie and Lewis 2005: 79). I have 60 samples from Hagere Selam and 50 from Kofele.

Sampling error is error in the findings deriving from research due to the difference between a sample and the population from which it is selected (Bryman 2008: 168). This is likely to happen, especially in this research since non-probability sampling is approached. As sample size increases, sampling error decreases (Bryman 2008: 179). Most of the time decisions about sample size are affected by considerations of time and cost (Bryman 2008: 179). Moreover, non-response was almost absent during this data collection, both in Hagere Selam and in Kofele. There were a couple of farmers that we asked for an interview that said they were in hurry and said that they could not participate right now, but otherwise, all the asked farmers accepted to participate, but not all respondents answered all the questions. If a population is highly heterogeneous, the sample size needs to be larger than if the population is more homogenous (Bryman 2008: 182). My opinion is that the farmers in these two sub-districts are quite homogenous when it comes to issues included in my research. Even there are big sub-districts and large populations, I feel that the sample size I achieved in these two case studies makes a good enough picture of the farmers' situation because in the last days of data collection in each of the two places, there was little new information to receive, and the farmers mainly answered the same to my questions.

5.7 Data Collection

The data collection took place in January and February 2011. The first three weeks were spent in Tigray and all the data collection and observation needed from Hagere Selam was done, and then three weeks was spent in Addis Ababa and Kofele and the same things were done in Kofele as in Hagere Selam. All the data collection was carried out in the communities; mainly by talking with farmers in their homes or in the crop field. I also talked to people working in government agricultural offices or employees working for NGOs concerned about climate change adaptation, and I found data about the climate from National Meteorological Agency in Addis Ababa.

5.8 Qualitative Methods for Data Collection

5.8.1 Semi-Structured Interviews

During the data collection, I used some qualitative in-depth interviews in the beginning of the periods in both Hagere Selam and Kofele. Ritchie and Lewis (2005: 148) write that "*the aim of the in-depth interview is to achieve both breadth of coverage across key issues and depth of coverage within each"*. The in-depth interview is often described as a form of dialogue (Burgess 1982, Lofland and Lofland 1995). It can also be seen as a conversation with a special purpose (Webb and Webb 1932: 130). There are of course some differences between a normal discussion and an in-depth interview, such as their objectives and the roles of researcher and respondent (Kvale 1996, Rubin and Rubin 1995). Further, Ritchie and Lewis (2005: 141) state that *"in an in-depth interview it is intended to combine structure with flexibility*". I think those two qualities were combined and balanced well in my interviews, but it is difficult for many respondents to start to talk freely and out of the questions because they do not know what kind of information I want to get from them. The main focus was therefore on structure, not on flexibility, but the respondents were free to add any comments at any time. One interview took about one to one and a half hour, but became shorter after I changed to questionnaires.

5.8.2 Participant Observation

An important part of the research was also observation. I always observed what the farmers did during my visits to the villages for making interviews. Observation is not really data collection, but anyway, important parts of the field work because it gives the researcher a better understanding of the respondent's situation. It was positive to try to see the situation through the local people's eyes.

5.8.3 Document Analysis

A lot of information and theory have been found through secondary data. Articles, books, and statistics are important parts of the thesis, not least in the former literature review in chapter 2, 3 and 4. Data about the weather in Hagere Selam and Kofele from the 1950's - 70's up to around 2008 has also been analyzed.

5.9 Quantitative Data Collection

5.9.1 Questionnaires

After approximately 20 - 30 qualitative interviews, the strategy in each of the two communities were changed into a quantitative questionnaire and 20 – 30 questionnaires were made. This was done to receive the most important data without using too much time on questions that I already knew the answers to.

5.10 Interpretation of Data/Data Analysis

The findings from the qualitative and the quantitative parts were mainly analyzed together, either manually or by SPSS. Citations from the respondents are from the qualitative in-depth interviews only. Some statistics was made from SPSS and Excel. Bivariate analysis was made from the quantitative material to generate descriptive statistics. This was done with the use of Pearson's correlation. Bryman (2008: 327) writes that Pearson's r is a method for examining relationships between different variables, as for example between education and adaptive capacity.

5.11 Ethical Considerations

5.11.1 Anonymity and Confidentiality

It is important to keep the respondents anonymous in the thesis and their characteristics should not make it possible for the reader to search them up. It means that the identity of the respondents should not be known by anybody outside the research team (me and the interpreters) (Ritchie and Lewis 2005: 67). Ritchie and Lewis (2005: 67) write that "*Confidentiality means avoiding the attribution of comments, in reports or presentations, to identified participants"*. The respondents might get unforeseen problems if the research team for example talked about them while other people were listening, so we did not do that.

5.11.2 Informed Consent and Voluntary Participation

Respondents' informed consent to participate must be obtained before the interview is starting (Ritchie and Lewis 2005: 66). Before the interviews started, the respondents should understand the purpose of my study, that I am coming from Norway, that it is done with permission from Mekele University, that I plan to use the information for a master thesis, that most of the questions will consider climate change impacts and adaptations, and approximately how long time the interview will take (Ritchie and Lewis 2005: 66). Voluntary participation is a principle meaning that people should not be required to participate in a survey (De Vaus 2002: 59). I think to a large extent both informed consent and voluntary participation were compiled during my research and I think most Ethiopians are not afraid of saying no if they are not interested.

5.11.3 No Harm to Participants and No Invasion of Privacy

Other ethical considerations concern the safety of the respondents. There should of course not at all be done anything that can do harm to the respondents in any way. The questions should also not be apprehended as an invasion of privacy (Bryman 2008: 118). I think this research topic is very much "safe" and it is not very much sensitive or tabooed, but the questions about for example age, education level, and household size could be a bit overwhelming for some of the respondents.

5.12 Limitations and Challenges

Some of the limitations of the study are time and resources. It is limited money that can be spent on this research. I found a cheap room to live in and there was cheap food available. Transportation and costs for interpretation was more of a challenge.

Challenges were to some extent language and interpreter challenges. The relationship between the researcher and the respondent will often be a bit more professionally and distanced with the use of interpreter. Hopefully that had no direct impact on the quality of the data collected. Actually in Kofele, I think it was an advantage that I was a foreigner and did not know the culture from before, because many of the respondents thought it was strange and a bit unprecedented that I as a stranger came there and asked questions. Since I was a foreigner, I was a bit excused because I did not know better.

The National Meteorological Agency in Addis Ababa has weather data for most years starting from around 1960 or 1970 up to around 2010, but it depends from place to place which years have been recorded. I paid approximately 150 Norwegian kroner for the data presented in this thesis, and I also got some data for free that Norwegian People's Aid in Addis Ababa bought for me; this is also included in the thesis. The data from Hagere Selam and Kofele is a bit difficult to compare because weather data has not always been recorded from the same years in the two weather stations and the reliability of the data are also not excellent.

Chapter 6: Findings and Analysis

Chapter 6 will present the empirical findings and the analysis of these. This will be done in the light of the literature presented in chapter 3 and 4. Chapter 6 is structured after the five research questions and these will be presented and discussed one by one. The research questions that will be answered and analyzed here are the following: 1) Have people experienced any changes regarding the climatic conditions during the last twenty years? 2) What are these climatic changes? 3) To what extent has climate changes had socio-economic impacts on people's livelihood? 4) In what ways have people responded to climate changes? 5) What factors can explain various extents of individual adaptations? A summary and discussion will be given at the end to assemble the main points and tie up any loose ends.

6.1: Have people experienced any changes regarding the climatic conditions (rainfall, temperature, and instability) during the last twenty years?

This question is crucial to finding out if subsequent research questions are relevant and important or not.

- Hagere Selam

Yes, to this question, in Hagere Selam, 95 % of the respondents said they have experienced changes in climatic conditions during the last twenty years. The majority of respondents in Hagere Selam, 91.7 %, said they had experienced negative climatic changes. 5 % of the respondents said they do not remember climate changes, and 3.3 % said the climate had changed in a positive way the last twenty years.

- Kofele

Yes, to this question, all the respondents in Kofele said that they had experienced climate changes the last twenty years. 98 % said they can remember negative climate changes, 0 % said they do not remember climate changes and 2 % said they had experienced positive changes in the climate the last twenty years.

6.2: What are these climatic changes?

So, the majority of the respondents in both Kofele and Hagere Selam have experienced changes in the climate the last twenty years. Section 6.2 will explain what kinds of climate changes the respondents are talking about. The climate changes identified are mainly related to rainfall, temperature, and instability. These three elements of climate changes will here be presented and analyzed one by one.

6.2.1 Rainfall

Rainfall is a crucial element in climate changes for the Ethiopian farmers. The season's crop yield and animal yield are very much dependent on the right amount and timing of rainfall. Figure 5 is a diagram showing how annual rainfall has changed over time in Hagere Selam and Kofele.

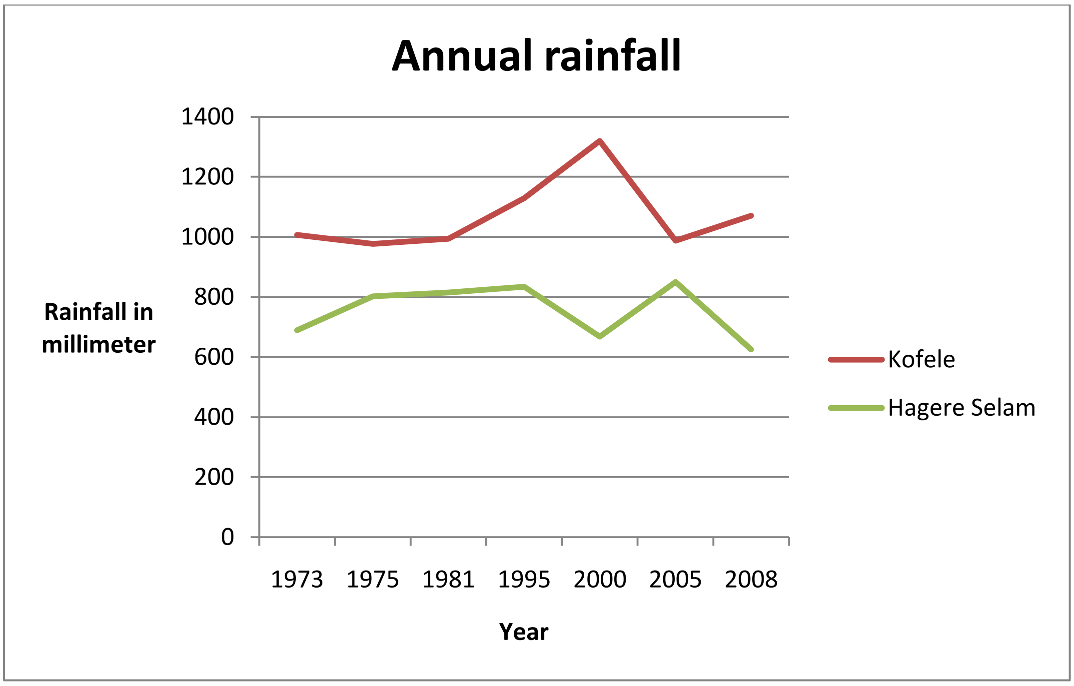


Figure 5: Annual rainfall in Hagere Selam and Kofele, 1973 to 2008

Source: National Meteorological Agency, Addis Ababa, (February 2011)

Rainfall seems quite stable, and at the same time it seems that in 2000 and 2008 Kofele received more rainfall than normal while Hagere Selam received less rainfall than normal. Highland areas get on average 900 millimeter rainfall annually (Dinar et al. 2008). Kofele is therefore a bit above the average and Hagere Selam a little bit below the average.

Rainfall in some specific months is also presented here. Figure 6 illustrates how rainfall changed in Kofele and Hagere Selam in June from 1973 to 2008.

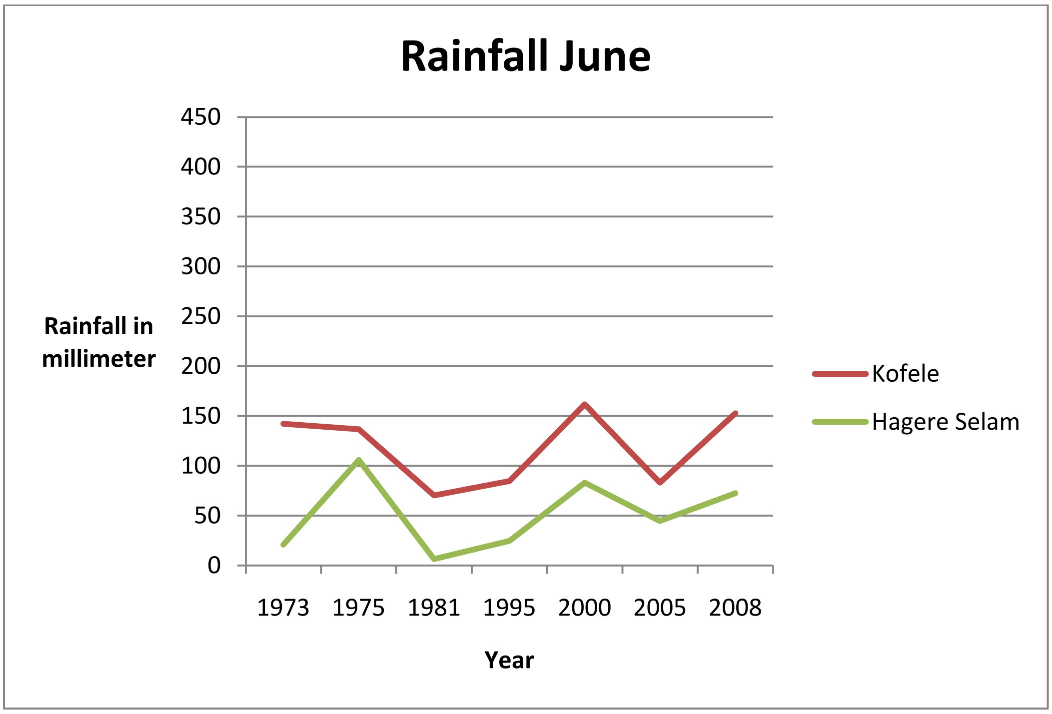


Figure 6: Rainfall in June in Kofele and Hagere Selam, 1973 to 2008

Source: National Meteorological Agency, Addis Ababa (February 2011)

Figure 6 shows that there is fairly close correspondence between the rainfall in Kofele and Hagere Selam, but Kofele always gets more rain than Hagere Selam. June is the first month in the *kiremti* rainy season which is very important for farmers. Rainfall in June tends to be stable or maybe slightly increasing, which is usually positive for the farmers. Figure 7 shows rainfall in July in Kofele and Hagere Selam from 1973 to 2008.

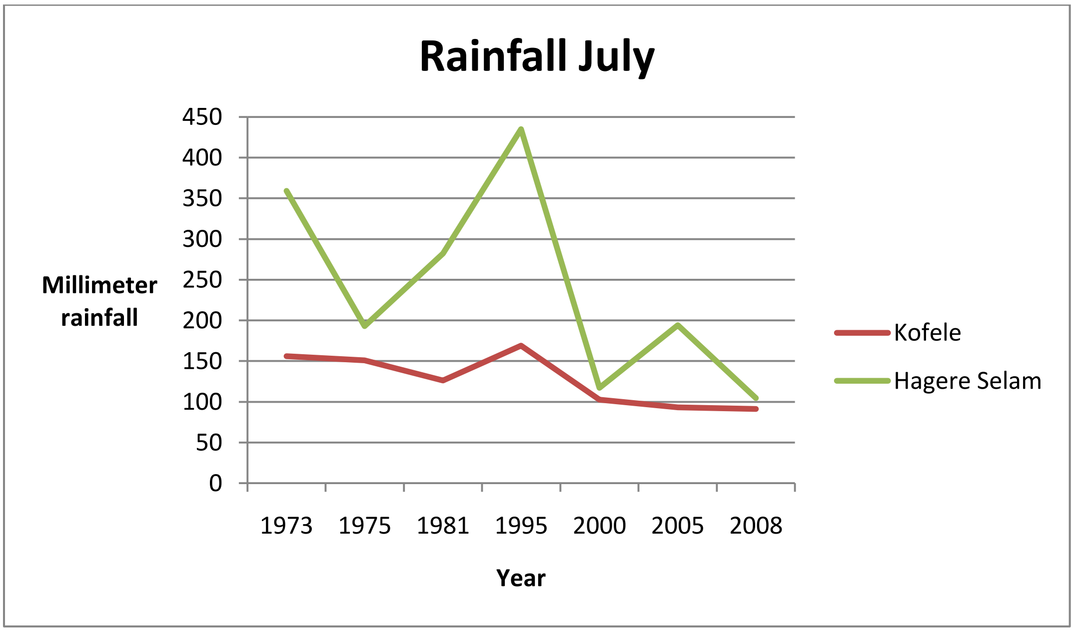


Figure 7: Rainfall in July in Kofele and Hagere Selam, 1973 to 2008

Source: National Meteorological Agency, Addis Ababa (February 2011)

Figure 7 shows that July rainfall has clearly decreased both in Hagere Selam and Kofele from the 1970's up to 2008. 2008 was a drought year in Kofele, so it might be that the amount of rainfall in Kofele in July has again risen over recent years. In 1995, Hagere Selam had large amounts of rainfall and this is not common. Rainfall changes in each of the two places will from now on be presented one by one. The first is Hagere Selam.

- Hagere Selam

71.7 % of the respondents in Hagere Selam said rainfall had decreased. 5 % said rainfall had decreased and was also more irregular, while 3.3 % said rainfall was more irregular. This means that 80 % of the respondents have experienced negative changes in rainfall. For example one respondent said that "*Twenty years ago there was more heavy rainfall and the rainy seasons were longer, maybe five months. Now it normally rains less and for a shorter period of time, maybe two and a half month*". Another respondent said, "*Yes, we have had changes in the climate, but there is less climate changes here in Ethiopia than, for example, in Europe. This year we had a good harvest; it was better than the last ten years. The last ten years crop yield has decreased due to decreased rainfall.*" Further, one respondent said that the long-term trend shows a tendency to shorter rainy seasons with less annual rainfall, and the seasons usually start later and stop earlier than before. 8.3 % of the respondents reported positive elements of changes in rainfall the last twenty years. Table 3 attempts to describe the answers the respondents gave when I asked them how they thought rainfall had changed in Hagere Selam over the last twenty years.

Table 3: Respondents' experiences with rainfall changes in Hagere Selam

Experiences with rainfall changes		
What kind of changes	**Frequency**	**%**
Rainfall decreased	43	71.7 %
No response	7	11.7 %
Rainfall decreased and more irregular	3	5 %
Rainfall more irregular	2	3.3 %
Rainfall increased	2	3.3 %
Do not know	2	3.3 %
No change	1	1.7 %
Total (n= 60)	**60**	**100 %**

Source: Fieldwork returns (2011)

In addition, they also have a problem with hail in Hagere Selam sometimes. 25 % of the respondents in Hagere Selam said that they sometimes faced challenges because of hail. It might be that higher temperatures due to climate changes both high up in the sky and closer to the ground make the hail melt before it reaches the ground and would probably be very positive for the farmers if the frequency and intensity of hail decreased. On the other hand it is also possible that climate changes results in more extreme temperatures, both warm and cold. It is not certain that there will be less frost and hail in the future; maybe hail will also increase in frequency and intensity.

In addition to hail, drought and flood also have to do with rainfall. 35 % of the respondents in Hagere Selam said they can remember floods and 33.3 % said they can remember drought. Hagere Selam is traditionally a dry area and drought periods are not a new phenomenon for them. Every year it is dry for nine months from the end of the rainy season in September to the start of the rainy season the next year in June. The most important months with regard to rainfall are June to September, which is the rainy season they call *kiremti*. Changes in rainfall during these months are shown in figure 8.

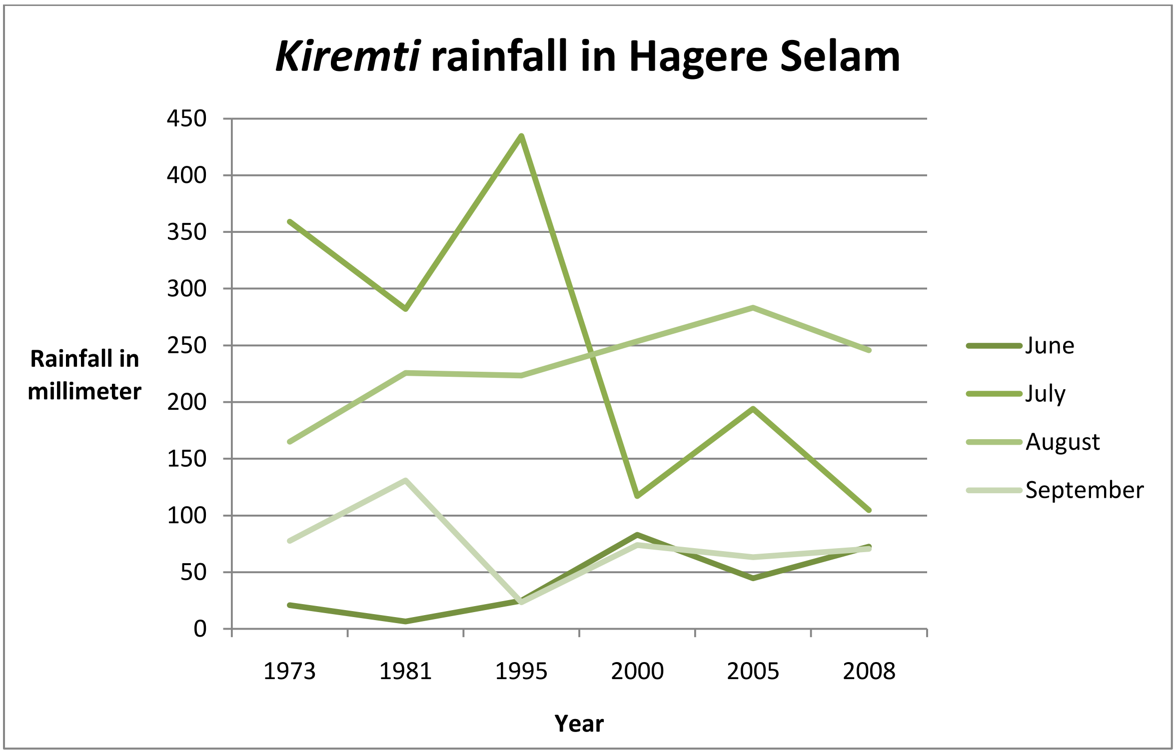


Figure 8: Rainfall in Hagere Selam in rainy season, 1973 to 2008

Source: National Meteorological Agency, Addis Ababa (February 2011)

It seems that rain in June and August is actually increasing a little, while rainfall in July has decreased drastically, as we also saw in figure 7. Rainfall in September also generally decreases, so it might mean that the rainy season stops earlier now than in the 1970's and 1980's. Total rainfall during the rainy season has decreased to some extent.

Changes in rainfall in June to September during the last thirty to forty years are presented in table 4.

Table 4: Average rainfall in the rainy season in Hagere Selam, before 1983 and after 1995

Year	June	July	August	September
1973 – 1983	36.3 mm	256.6 mm	251.6 mm	22.1 mm
1995 – 2008	56.2 mm	212.7 mm	247.0 mm	7.2 mm
Difference	19.9 mm more	43.9 mm less	4.6 mm less	14.9 mm less

Source: National Meteorological Agency, Addis Ababa (February 2011)

Table 4 shows that rainfall has decreased to some extent in three of the four rainy season months.

October and November are also vital months when it comes to rainfall, because these are the months when the farmers harvest and thresh their crop, and the farmers do not usually want rain during this time. Table 5 presents the data on whether rainfall has changed or not over the last thirty to forty years in these months.

Table 5: Off-season rainfall in Hagere Selam, before 1983 and after 1995

Year	October	November
1973 – 1983	7.1 mm	0 mm
1995 – 2008	9.6 mm	15.0 mm
Difference	2.5 mm more	15.0 mm more

Source: National Meteorological Agency, Addis Ababa (February 2011)

Table 5 shows that off-season rainfall in the harvesting period has to some extent increased in Hagere Selam from the period 1973 - 1983 to 1995 - 2008. Rainfall during these months can have crucial negative effects on the crop yield.

- Kofele

In Kofele, 54 % of the respondents said they think rainfall has generally decreased during the last twenty years. For example a young man in his 20s said that "*in my childhood it used to rain heavily all day in the rainy season. Now the rainfall has clearly decreased.*" 30 % of the respondents said the rainfall has decreased and also become irregular, and 14 % said the rainfall is more irregular today than twenty years ago. This means that 98 % of the respondents in Kofele can remember negative changes in rainfall. 2 % of the respondents said there had been no changes in rainfall. Table 6 shows these numbers in a structured manner.

Table 6: Respondents' experiences with rainfall changes in Kofele

Experiences with rainfall changes		
What kind of changes	**Frequency**	**%**
Rainfall decreased	27	54 %
Rainfall decreased and more irregular	15	30 %
Rainfall more irregular	7	14 %
No change	1	2 %
Rainfall increased	0	0 %
Do not know	0	0 %
No response	0	0 %
Total (n= 50)	**50**	**100 %**

Source: Fieldwork returns (2011)

Table 6 shows that the respondents in Kofele are quite clear and agree that rainfall has decreased and is to some extent more irregular now than twenty years ago.

Some types of natural disasters have to do with rainfall. 4 % of the respondents in Kofele mentioned hail, and 8 % mentioned heavy rainfall. In Kofele they have faced increased frequency of droughts in recent years. Traditionally they have not had this problem; Kofele is a green area and they are traditionally known to have enough water. In 2008 they had a drought in Kofele and they did not have rainfall for nine months. If this 2008 situation in Oromia is compared to Tigray, this is normal for Tigray. They do not have a *belg* season in the Tigray Region, so it is, as mentioned earlier, normally dry for nine months from September up to next June; without them calling it drought. Therefore, drought is very area-specific. 50 % of the respondents said they remember drought periods, and 2 % said they remember flood. Figure 9 shows the changes in rainfall in the most important rainy season in Kofele.

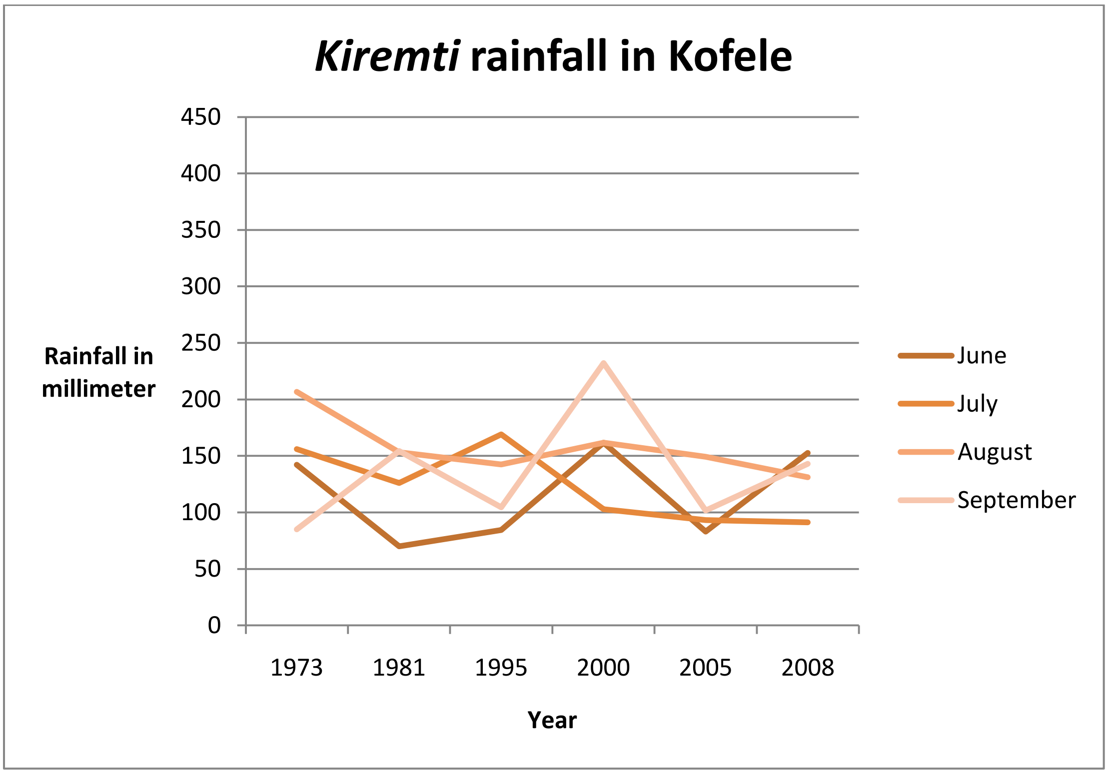


Figure 9: Rainfall in Kofele in the main rainy season, 1973 to 2008

Source: National Meteorological Agency, Addis Ababa, (February 2011)

June rainfall is quite stable in Kofele; July and August rainfall has decreased to some extent; while September rainfall might increase to some extent. The general trend is stability or a slight decrease of rainfall in these months.

The average amount of rainfall in Kofele has declined slightly in three of four rainy season months. This can be seen in table 7.

Table 7: Average rainfall in the rainy season in Kofele, before 1990 and after 1995

Year	June	July	August	September
1973 – 1990	121.9 mm	142.6 mm	124.9 mm	165.0 mm
1995 – 2008	120.5 mm	114.1 mm	146.0 mm	145.4 mm
Difference	1.4 mm less	28.5 mm less	5.9 mm more	19.6 mm less

Source: National Meteorological Agency, Addis Ababa (February 2011)

As can be seen from table 7, average rainfall in Kofele has decreased to some extent in June, July, and September from the period 1973 -1990 to the period 1995 - 2008. Rainfall in August has increased to some extent.

In Kofele they have two rainy seasons during a year. The second rainy season is from February/March up to May. Figure 10 shows how rainfall has changed during these months.

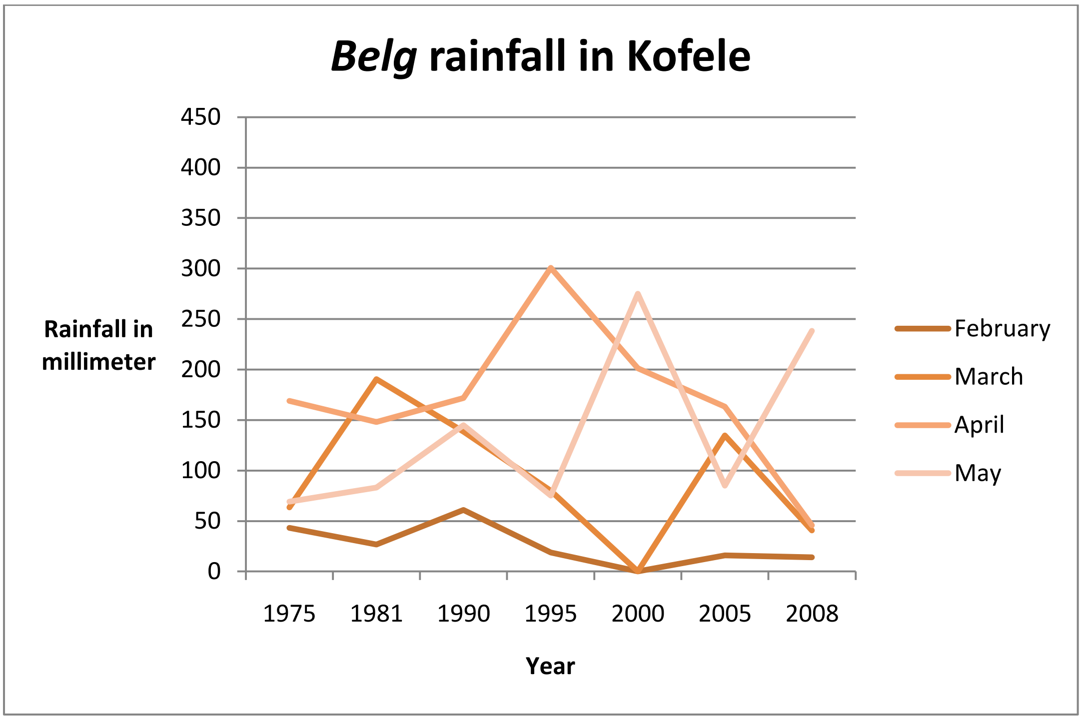


Figure 10: Rainfall in the short rainy season in Kofele, 1975 to 2008

Source: National Meteorological Agency, Addis Ababa, (February 2011)

February rainfall is very low and is probably not considered part of the *belg* rainy season by most farmers in Kofele. Rainfall in February, March, and April is generally decreasing. Rainfall in May is more unstable, and has to some extent increased. Total rainfall during the short rainy season seems to have decreased in recent years. Rainfall decrease during the *belg* season has been typical for some parts of Ethiopia during the last decade (Nater 2010).

Rainfall in the harvesting and threshing period is crucial for the farmers. Let us check whether rainfall in Kofele at this time of year has decreased or increased from 1960 - 1990 up to 1995 - 2008.

Table 8: Off-season rainfall in Kofele, before 1990 and after 1995

Year	October	November
1960 – 1990	74.1 mm	16.6 mm
1995 – 2008	94.2 mm	40.8 mm
Difference	20.1 mm more	24.2 mm more

Source: National Meteorological Agency, Addis Ababa (February 2011)

From table 8, it can look like off-season rain in the harvesting and threshing season has to some extent increased in Kofele.

6.2.2 Temperature

Temperature is a straightforward way to measure climate changes. Figures 11 and 12 show how minimum monthly temperatures in both Hagere Selam and Kofele have changed in June and July from 1975 to 2005.

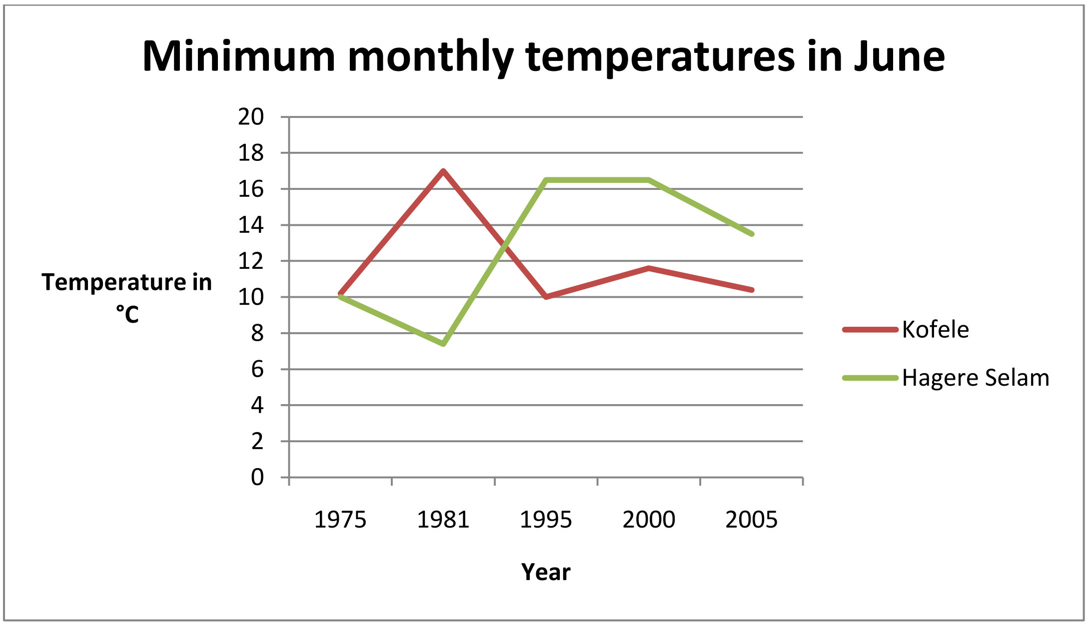


Figure 11: Minimum monthly temperatures in June in Hagere Selam and Kofele, 1975 to 2005

Source: National Meteorological Agency, Addis Ababa, (February 2011)

If we look at one specific month, for example June, which is crucial for the sowing period, we see from figure 11 that the minimum monthly temperatures in Hagere Selam and Kofele in June are a bit irregular, but the general trend is slightly increased temperatures.

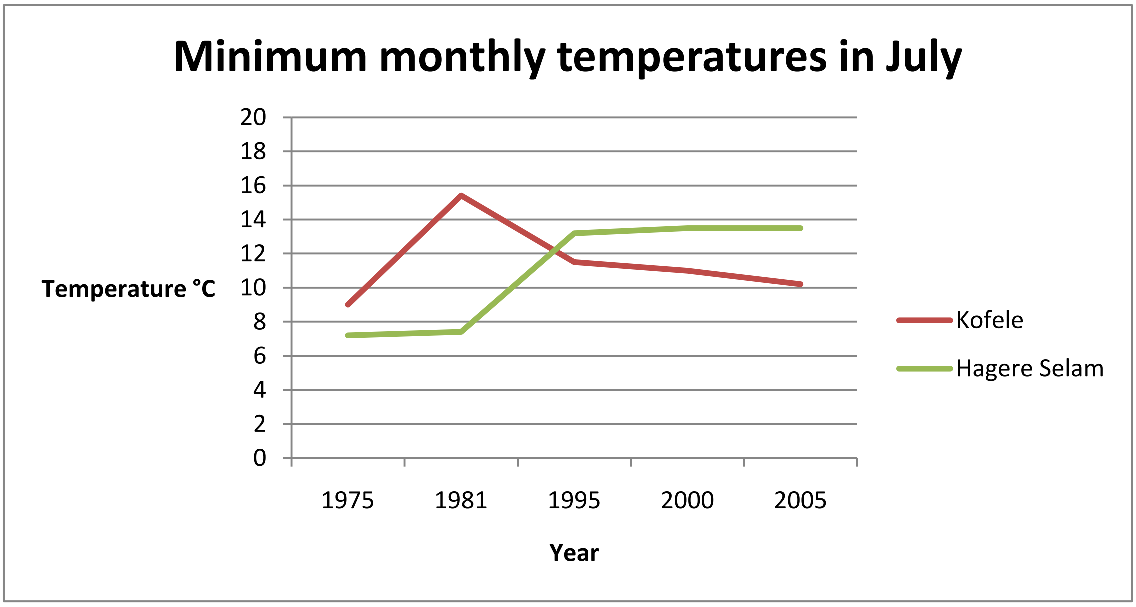


Figure 12: Minimum monthly temperatures in July in Hagere Selam and Kofele, 1975 to 2005

Source: National Meteorological Agency, Addis Ababa (February 2011)

Figure 12 shows that minimum monthly temperatures have increased to some extent both in Hagere Selam and Kofele in July from 1975 to 2005. The tendency is clearest in Hagere Selam. In Kofele it was very warm in 1981 and after that the temperature declined and in 2005 the monthly minimum temperature was only slightly warmer than it was in 1975, and colder than in Hagere Selam. Now we will look more closely at temperature changes in each of the two places.

- Hagere Selam

38.3 % of the respondents in Hagere Selam said temperatures have increased over the last thirty years. For instance one man said "*It has become hotter the last thirty years, and the area is starting to become a desert*". Another respondent said that: "*The highland area of Hagere Selam is starting to look like the hotter lowland areas*". Many other farmers agree with this. 5 % of the respondents also said temperatures have been more irregular, and extremely hot and extremely cold days occur more frequently now than twenty years ago. 40 % of the respondents in Hagere Selam said they had irregular problems with frost. Usually when there are clouds it is cold in Hagere Selam, and when it is windy, the wind is also normally cold. One respondent said that he had observed fewer cloudy days over the last five years. Table 9 summarizes the respondents' answers to how they think the temperature in Hagere Selam has changed over the last twenty years.

Table 9: Respondents' perceptions of temperature changes in Hagere Selam

Respondents' perceptions of temperature changes		
Kind of temperature change	**Frequency**	**%**
No response	32	53.3 %
Temperature increased	23	38.3 %
Temperature more irregular	3	5 %
Temperature decreased	1	1.7 %
Do not know	1	1.7 %
Total (n= 60)	**60**	**100 %**

Source: Fieldwork returns (2011)

Furthermore, figure 13 shows how minimum monthly temperature has changed in Hagere Selam in some months.

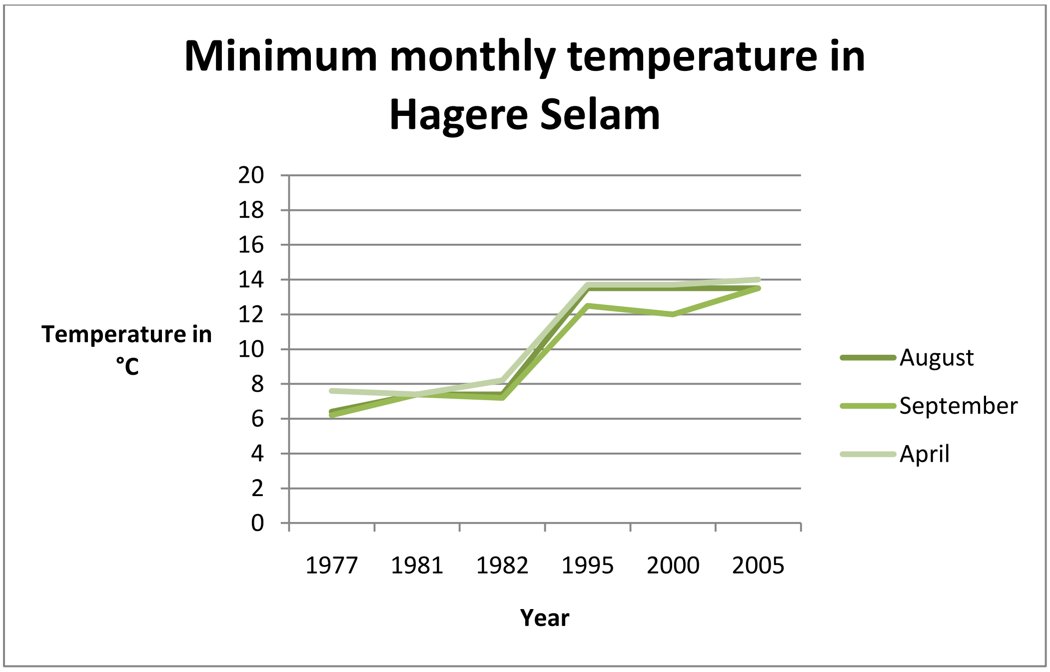


Figure 13: Minimum monthly temperature in August, September and April in Hagere Selam, 1977 to 2005

Source: National Meteorological Agency, Addis Ababa, (February 2011)

Figure 13 shows that the minimum monthly temperature in Hagere Selam clearly increases in August, September and April. This might also be the trend in the other months of the year. The biggest increase was from 1982 to 1995, and the minimum temperatures have been stable from 1995 to 2005. In the 1970's and 80's minimum monthly temperatures were around 6°C to 8°C, and in the 2000's they had risen to around 13°C.

- Kofele

The respondents in Kofele were very clear when it came to temperature. 86 % of the respondents said that they think the temperature has increased over the last twenty years; for example one woman in her thirties said that temperature had clearly increased since her childhood. 2 % said they had experienced a decrease in temperature the last twenty years. Moreover, another factor of temperature which is very critical for the farmers is frost, which can damage the crop. 10 % of the respondents in Kofele mentioned that frost was a problem sometimes. Table 10 summarizes the respondents' answers about changes in temperature.

Table 10: Respondents' perceptions of temperature changes in Kofele

Respondents' perceptions of temperature changes		
Kind of temperature change	**Frequency**	**%**
Temperature increased	43	86 %
No response	6	12 %
Temperature decreased	1	2 %
Temperature more irregular	0	0 %
Do not know	0	0 %
Total (n= 50)	**50**	**100 %**

Source: Fieldwork returns (2011)

Moreover, the minimum monthly temperature in Kofele over time is presented in figure 14.

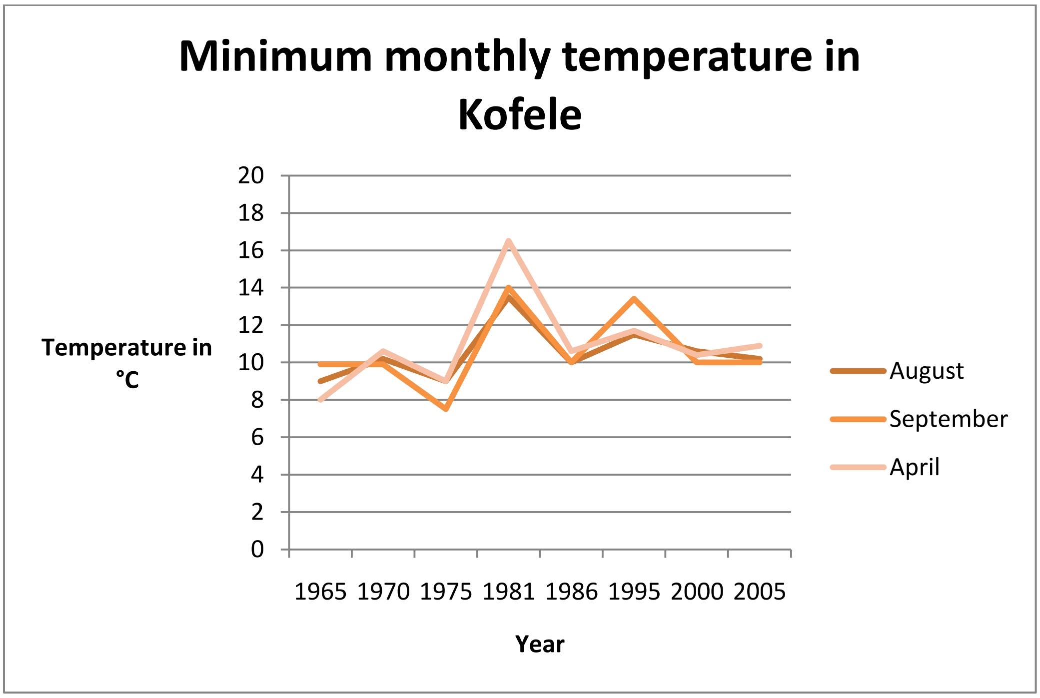


Figure 14: Minimum monthly temperature in August, September, and April in Kofele, 1965 to 2005

Source: National Meteorological Agency, Addis Ababa (February 2011)

Figure 14 show that minimum monthly temperatures have not increased as much in Kofele as in Hagere Selam. Temperatures are more stable, but a trend towards increased temperatures can be seen also here. Minimum monthly temperatures have generally changed from about 8°C in the 1960's to around 10°C in the 2000's.

6.2.3 Instability

Some types of weather instability and natural disasters are also elements of climate changes. Figure 15 shows the number of respondents remembering different types of natural disasters.

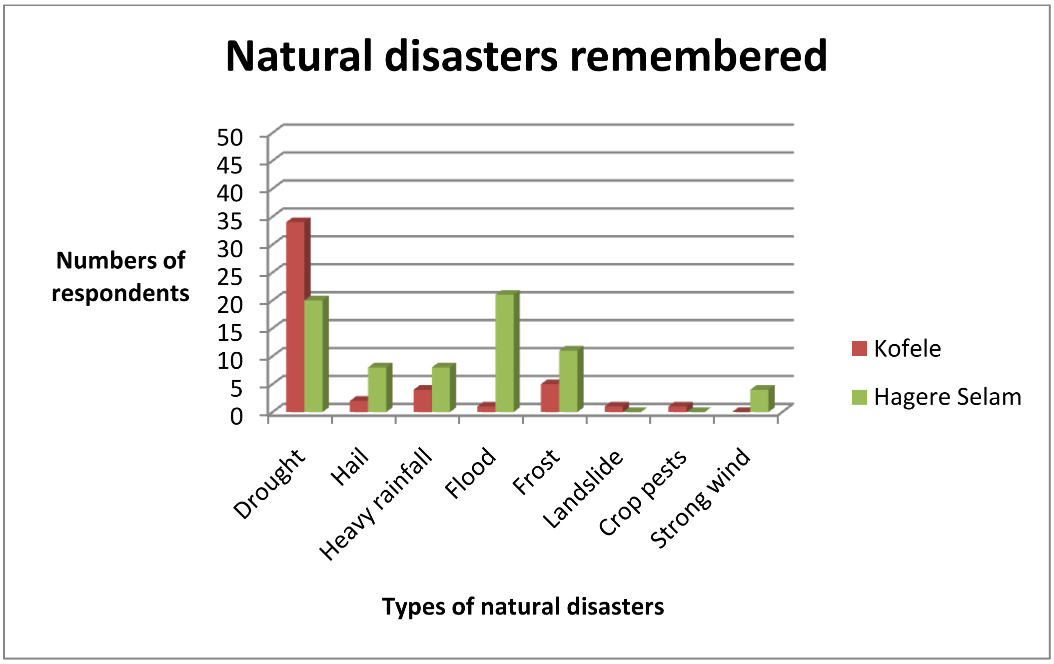


Figure 15: Natural disasters remembered by respondents in Hagere Selam and Kofele
Source: Fieldwork returns (2011)

Figure 15 show that drought is the natural disaster most present in the mind for most respondents in Kofele. Farmers from Hagere Selam remember several types of natural disasters, for example floods, drought, hail, frost, and heavy rainfall. In the remaining sections, climate instability will be presented specific to each place.

- Hagere Selam

The weather seems to be less stable in Hagere Selam these days than it was twenty years ago. 13.3 % of the respondents said they had experienced more irregularity of either rainfall or temperature in later years. To some extent, the farmers in Hagere Selam face increased instability with rainfall and temperature. One man said that *"frequently it rains very heavily, or rain does not come when expected*." Another respondent said that the weather changes from year to year in Hagere Selam, but the long-term trend shows that the rain is not properly and equally distributed anymore. These answers seem to be reliable and representative for the population in Hagere Selam. Some areas can get too much rain in too short time when another neighboring area gets little rain or no rain at all.

- Kofele

Also in Kofele, rainfall and temperature are more unstable these days than they were twenty years ago. 40.8 % of the respondents in Kofele said they had experienced more irregularity of rainfall in recent years and that the rain might come late, stop early, or be heavy off-season rain. The respondents sometimes specified during the interviews that it is not usually the amount of water in itself that is their problem. During one year, enough rain might come in total, but the irregularity of the rainfall is often an agricultural challenge. For example one respondent said "y*es, there are changes in rainfall. Ten years ago the rainfall was regular. Now it can stop in the middle of the rainy season or otherwise be unpredictable*". Another respondent said "*rain is not regular anymore. It is not very clear when the rainy season starts and stops*". A third respondent said "*rainfall is irregular. Sometimes we see rainfall through threshing time".* Therefore it seems that irregularity of rainfall is a general problem for farmers in Kofele.

The next section will move on to what kind of impacts these climate changes we have presented give on the farmer's in Hagere Selam and Kofele.

6.3: To which extent has climate changes had socio-economic impact on the people's livelihood?

In section 6.3 we will move further to look more closely at what kind of impact these climate changes presented in section 6.2 have on the farmer's. Figure 16 shows the respondents' general perceptions of climate change impacts; whether they have experienced positive, negative, or neutral impacts from climate changes.

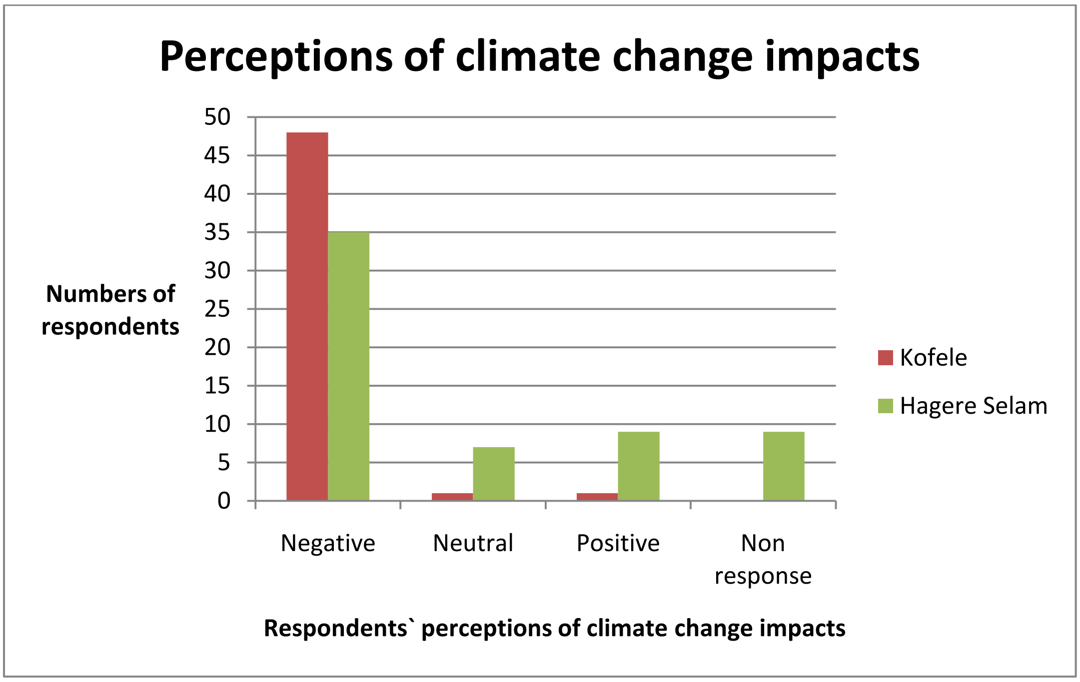


Figure 16: Respondents' perceptions of climate change impacts

Source: Fieldwork returns (2011)

Figure 16 show that the majority of respondents in both Hagere Selam and Kofele have experienced mostly negative impacts of climate changes. In Hagere Selam there are a few more respondents who have experienced positive or neutral impacts of climate changes than in Kofele, but the number is still low. Most respondents who experiences negative impacts of climate changes were clearly found in Kofele. These specific impacts will be described more in detail in the following sections.

96 % of the respondents in Kofele, and 58.3 % of the respondents in Hagere Selam have experienced negative impacts of climate changes. For example one man from Hagere Selam said that "*It has been warmer in recent years, and we do not any longer have enough rainfall. Because of that, crop yield has decreased and we have no longer enough food to eat*". This might be the situation for a great part of the population. One farmer from Kofele said that *''my own confidence in agriculture is decreased because I keep getting confused about the seasons*". In Hagere Selam more people are positive or neutral to climate changes than in Kofele. One respondent from Hagere Selam said that "*The climate has changed for the better. Ten years ago, there sometimes was heavy rainfall day and night and there was too little sunshine and it was too cold for the crop to grow properly. Now the weather is more balanced and that allows the crop to grow properly. I prefer too little rain instead of too much rain*".

One respondent from Kofele said "*Ten to fifteen years ago most of my land was peat field and I was a pastoralist farmer. Now my land is dried up and I can cultivate the land and grow cereals*". This latter seems to be the situation for a great number of farmers in Kofele and this might have great positive impacts. Another woman from Kofele said *"The climate change impacts are not that serious. They do not affect life*".

Some specific impacts of climate changes will be presented and discussed further below. These are amongst others reduced crop and animal yield, soil degradation and soil erosion, increased poverty, and worsening of health conditions. The main findings from section 6.3 will be briefly introduced in table 11.

Table 11: Types of climate change impacts in Hagere Selam and Kofele

Types of climate change impacts identified by respondents				
	Hagere Selam		**Kofele**	
	Frequency	**%**	**Frequency**	**%**
Reduced yield (crop/animal)	**24**	**40 %**	**39**	**78 %**
Animal death	1	1.7 %	19	38 %
Shortage of range land	2	3.3 %	13	26 %
Shortage of water	4	6.7 %	5	10 %
Famine	2	3.3 %	5	10 %
Increased poverty	**3**	**5 %**	**0**	**0 %**
Worsened health conditions	**0**	**0 %**	**1**	**2 %**
Soil degradation	**0**	**0 %**	**0**	**0 %**

Source: Fieldwork returns (2011)

Table 11 shows the different impacts that respondents mentioned. Those in bold font are the main impacts that will be discussed further below. Animal death, shortage of range land and water will be included in reduced crop and animal yield because they are related, and are constrained with different types of shortages. Famine will be included in the section describing worsened health conditions because famine and hunger mainly are health constraints. However, all these impacts are complex and are more or less related to each other.

According to table 11, reduced crop yield seem to be a common impact of climate changes, but still, this does not usually lead to increased poverty. This may mean that farmers are usually clever farmers that know how to adapt to climate changes.

6.3.1 Reduced Crop- and Animal Yield

- Hagere Selam

Reduced crop is the number one impact of climate changes for farmers in Hagere Selam. 40 % of the respondents in Hagere Selam have experienced reduced crop or animal yield because of shortage of rainfall and also an increase in diseases and pest on crop and livestock. Hagere Selam is naturally a dry area; it is not as green as Kofele. It is part of the Sudano-Sahelian region that stretches throughout much of Western Africa and also covers some parts of Ethiopia. Therefore, Hagere Selam has faced drought-like situations many times throughout history, and it is not a new phenomenon to them. The factors that are new to them are probably that the rain is more irregular than before, and also here rainfall has generally decreased, and the drought periods probably come more frequently now than fifty years ago. Some respondents talked about drought that had occurred the last ten to twenty years, but after 1984 there have never been serious ones like that one. Droughts do not any longer normally kill people in Ethiopia, because usually serious affected households get food aid from the government and/or international/national NGOs. Drought might however create a lot of other effects like loss of crop, loss of range land, livestock death, and shortage of drinking water. In addition, Hagere Selam sometimes also faces heavy rainfall or flood which also damages crop and soil.

In recent years, farmers usually do not harvest enough grain to feed their family for a whole year any longer. These years the harvests usually last for approximately eight or nine months, while it twenty years ago often lasted for almost twelve months. One farmer said "*I am from a lowland area and there we want much heavy rain to irrigate our land. Ten years ago we had much rain and a high income. The last ten years we have faced shortages of rainfall and our income has decreased correspondingly*". A woman said that life and rain are highly related. "*If there is good rain, we have a good life. If there is little rain, we face amongst others shortages of drinking water and the crop does not grow properly*". The rainfall varies of course a lot from year to year. One man said "*Twenty years ago there was lots of rain and we had high crop yield. We had also lots of crops like corn and sorghum but these days these types are rare from time to time*". Another one said "T*wenty years ago we sowed chickpea in* *the dry seasons, but that is not possible anymore*”. Consequently, it seems that many farmers could grow more crop varieties twenty years ago, but these few last years fewer crop varieties are likely to succeed.

- Kofele

78 % of the respondents in Kofele complained about reduced crop and/or animal yields. According to the respondents in Kofele, the general trend is that crop yield is declining. Amongst other factors, the changes in rainfall and temperature affect the crop yield negatively. One respondent said that ten years ago Kofele used to be a surplus area and many farmers produced cereals and vegetables for selling. In recent years large scale export have became impossible in Kofele because harvests has been reduced and most farmers need the harvest for own consumption. In 2008 and 2009 many households even needed food aid. Both the amount and quality of crop yield are negatively affected by climate changes in Kofele. The crop yield and the weather vary of course from year to year, and no season is exactly similar. Declining rainfall and irregular rainfall can be problematic. If it rains in harvesting periods it can affect the amount and the quality of the crop negatively. One woman said that if the *belg* rain comes too late in Kofele, the potatoes grown in the *belg* season will not ripen before the *kiremti* rainy season starts when they want to sow cereals on the same plot of land. 8.2 % of the respondents in Kofele mentioned an increase in pests and diseases on crop. Sometimes crops like potatoes, wheat, and barley are affected by blight, which is a disease or injury on the plant (Free Merriam-Webster Dictionary 2011). On the positive side, crop yield might increase for some farmers, because before the year 2000, as mentioned, much of the land in Kofele was peat field and not suitable for other use than rangeland for livestock and *enset* growing. All the farmers with this type of land were pastoralists. After year 2000, much soil in Kofele dried up due to tree planting and climate changes, so it is now suitable for crop cultivation. It is positive for many farmers that they can now cultivate land that was peat field earlier. On the other hand, if this climatic trend continues in the future with even drier years, the farmers might be forced to go back to using their land as rangeland again because the land might become too dry to be suitable for crop cultivation.

Secondly some farmers in Kofele experience decreased animal products like milk and egg so they get smaller amounts of butter, yoghurt, and the like. Fertility of livestock might also decrease due to climate changes. Farmers in Kofele rely more on livestock than farmers in Hagere Selam. 8.2 % of the respondents saw an increase in pests and diseases on livestock in

Kofele. Armyworm and locust infestation depleted farmland and rangeland in Oromia in 2008 (United Nations 2008). This means that drought periods, as those in Oromia in 2008, might increase frequency of pest and diseases on crop, rangeland and livestock.

49 % of the respondents in Kofele mentioned a drought period in general and 79 % of these specified a drought in 2008. After September 2007 there was no rain for eight or nine months. That means there was no *belg* rainy season in Kofele spring 2008 and the long *kiremti* rainy season lasted for three months only. Most of the farmers gave up growing potatoes and corn during the *belg* rainy season and they sowed only fast growing barley during the *kiremti* rainy season in summer 2008. 38 % of the respondents mentioned livestock death due to drought. Some farmers lost half or all of their livestock, and this means they lost much of their resources and income. One man said about a drought in 2003: "*It affected crop yield negatively and it killed livestock*". Droughts happened also earlier, but it is a tendency to more frequently and more intense droughts in recent decades.

12.2 % of the respondents in Kofele mentioned hail or heavy rainfall in the harvesting season 2009. This destroyed much crop, and the yield was reduced or for many households totally lost. In some areas of Kofele this came as hail and in others as heavy rain storms. One of the respondents who experienced heavy rain in this period said that this weather resulted in gully formations in his field. Gully formations means that the soil is eroded by excessive surface water flow (Victorian Resources Online 2011). Heavy rain can also otherwise wash away soil and crop and often make deep dikes in crop fields, roads, and gardens. If it rains when the crop ripens, the crop can fail partially or totally.

6.3.2 Soil Degradation and Soil Erosion

- Hagere Selam

Soil degradation and soil erosion are a challenge to many farmers in Hagere Selam because of amongst other things too intensive agriculture, monoculture, shortage of rainfall, and increased wind. However, none of the respondents mentioned a connection between climate changes and soil degradation or soil erosion. This is probably because they know there are other more important reasons for soil degradation. Soil degradation and soil erosion are negative for soil fertility and productivity, and it affect the crop yield negatively.

- Kofele

Soil degradation and soil erosion seemed to be less of a problem in Kofele than in Hagere Selam. No respondents in Kofele said that this was a negative impact of climate changes. They face, however, challenges with lack of grazing land and land that is not very suitable for cultivation, like peat fields.

6.3.3 Increased Poverty?

- Hagere Selam

5 % of the respondents in Hagere Selam mentioned reduced income or increased poverty due to climate changes. Increased poverty is very much related to reduction in crop and animal yields, and also animal death. Moreover, the farmers have also often a bigger work load now than before; climate changes are both a direct and an indirect contributor to this. However, it is a small per cent that told income was decreased, and it is positive that impacts of climate changes are not leading to increased poverty at a larger scale.

- Kofele

No respondents in Kofele said directly that climate changes leads to increased poverty. During a drought, for example, loss of livestock might have contributed to increased poverty in the community. Decreased crop and animal yields like cereals, milk, and egg might also increase poverty. Climate changes can also actually increase farmers' living standard because many might take off-farm work and earn more money than before. Many said crop and animal yield are reduced, but when this does not lead to reduced income, many farmers must have adapted to climate changes and diversified their income. It is also likely to think that it is an underestimation to say that climate changes does not lead to increased poverty in Kofele, because many respondents seemed to be proud and afraid of complaining, and they often wanted to give the impression that they were fine and had no problems.

6.3.4 Worsening of Health Conditions

- Hagere Selam

Worsening of people's health situation did not come up as a direct issue during any of the interviews from Hagere Selam, but 3.3 % of the respondents mentioned shortage of food or famine as an impact of drought, and this might aggravate people's health conditions. For example during a drought period it is likely to think that shortage of drinking water might create some health problems like dehydration or heat stress.

- Kofele

No respondents in Kofele mentioned a general increase in sicknesses among humans, but one woman said that one of the impacts of drought was that some children got sick. With a shortage of drinking water, for example dehydration, hunger, or heat stroke might follow. 10 % of the respondents in Kofele mentioned famine and hunger as an impact of drought, and this might reduce the health conditions of parts of the population. During drought periods, farmers in Kofele often face problems like shortage of drinking water for humans and animals, and the drought in 2008 caused famine and hunger in some households in Kofele. During the drought, and the year after this drought, some households faced food and water shortages, and this situation was critical for people's health in several ways. Hunger is negative in itself and it also probably makes the body weaker so it is less resistant to other sicknesses such as malaria, flu, and common cold.

As a conclusion of section 6.3, we have found several impacts of climate changes in both Kofele and Hagere Selam, and these are to a large extent negative. Still, these impacts have in most cases not led to increased poverty, and also only slightly led to worsened health conditions. Therefore, it is assumed that the farmers are clever in adaptation and coping strategies.

6.4: In what ways have people responded to climate changes?

With the impacts of climate changes fresh in mind, I shall here present several identified adaptation strategies and coping mechanisms. These will be analyzed consecutively.

6.4.1 Crop Diversification

- Hagere Selam

73.3 % of respondents in Hagere Selam used crop rotation or crop diversification; they grew two or more different crop varieties in one season. The farmers in Hagere Selam usually use crop diversification; that means that they switch crop type on each plot of land every year. Otherwise, soil fertility will decrease if they sowed the same type of crop on the same plot of land every year. Usually they sow a couple of different varieties every year, to reduce risk and vulnerability. If one variety fails, maybe another one will survive. So they usually rotate which crop varieties they sow on which plot of land from year to year. The farmers decide what to sow next time and prepare the land for that specific crop type. They know when to sow because it depends on crop type and when the rain starts. 13.3 % of respondents said they had sowed only one crop variety this last season, and the others had two or more varieties. On average, each farmer in Hagere Selam grows 2.9 different crop varieties in one season. Many respondents told that they used rotation of crop, but in drought periods, they usually stopped doing it and sowed only fast growing crops like barley on all plots of land. For example barley and *teff* are well adapted to the harsh climatic condition in Hagere Selam. Figure 17 shows the most common crop varieties sown in Hagere Selam.

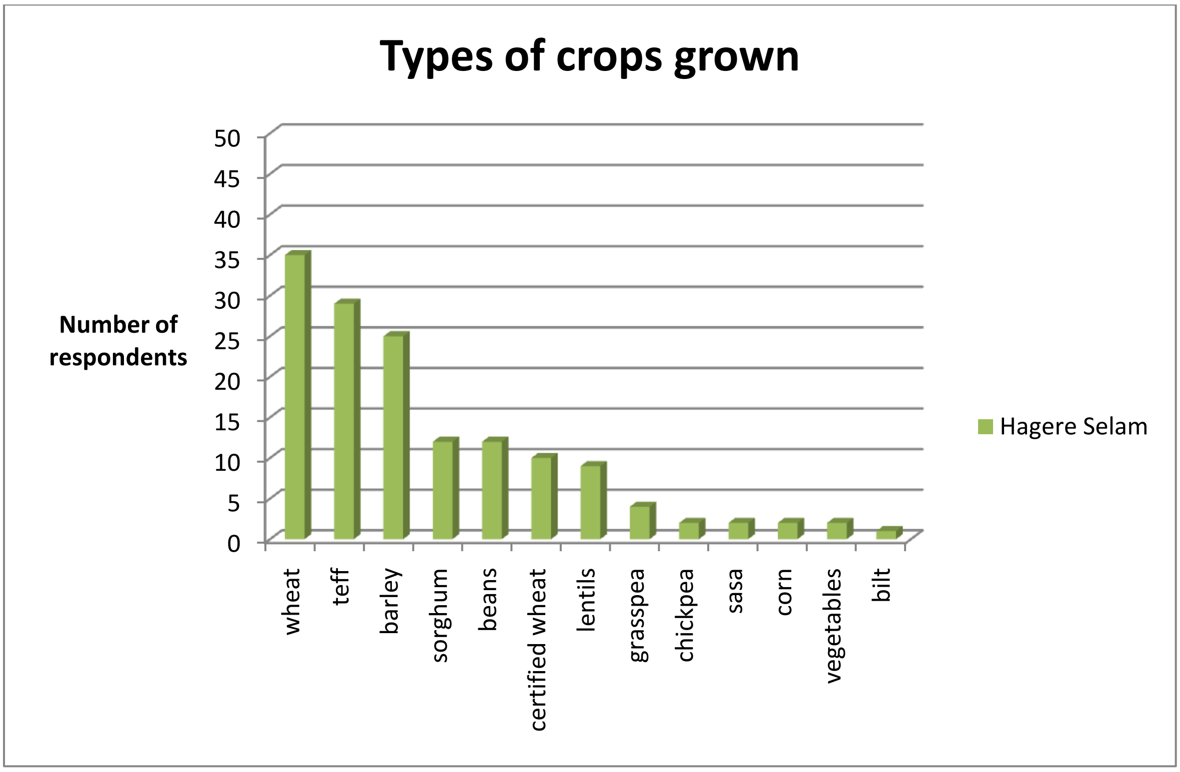


Figure 17: Crop varieties sown in Hagere Selam

Source: Fieldwork returns (2011)

- Kofele

98 % of the respondents in Kofele use crop diversification; they sow several crop varieties in one season to reduce risk. On average, the respondents from Kofele sowed 5.3 different crop varieties and vegetables. They have more possibilities than the farmers in Hagere Selam, because they usually have larger farms, and more types of cereals and vegetables are suitable in Kofele, like for example corn and potatoes. Crop diversification and rotation is partly done to increase or at least not reduce soil fertility. Crop diversification is well known in Kofele. This is not related to climate changes directly, but because the climate changes results in decreased amount of yield and also sometimes reduces the quality of the yield, it is indirectly

related. Crop diversification might balance yield and income variations. Failure of a particular crop or variety is compensated for by yield of other crops or varieties, thus ensuring household food and income security (FAO 2003: 6). Figure 18 shows which crop varieties respondents in Kofele sow.

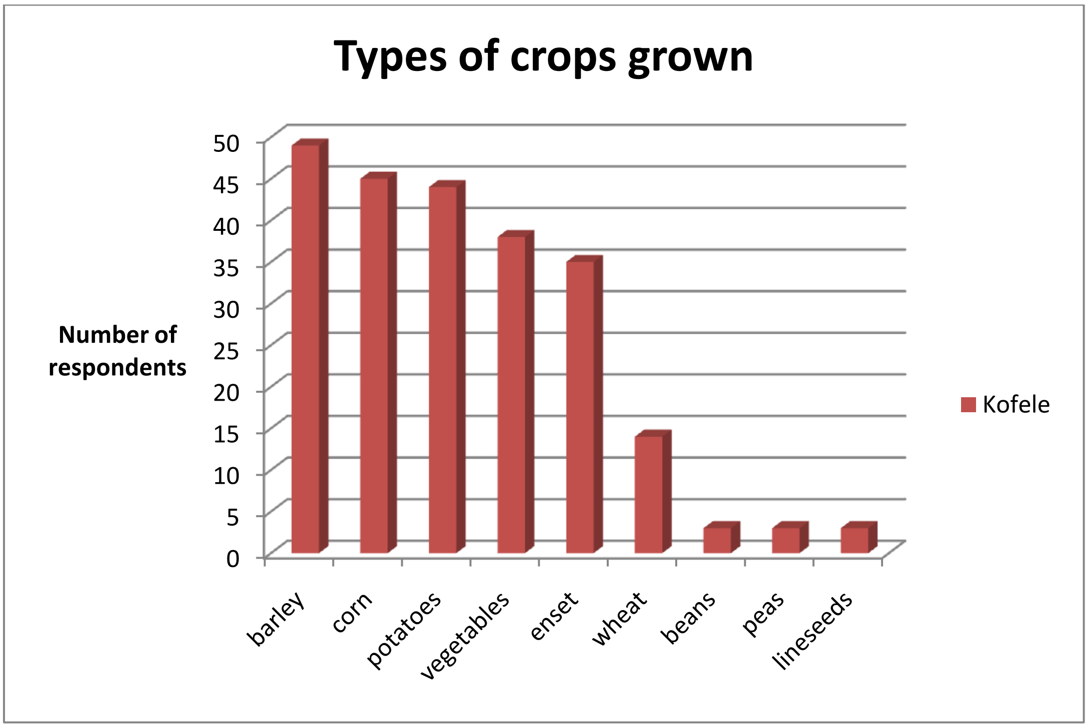


Figure 18: Crop varieties sown in Kofele

Source: Fieldwork returns (2011)

6.4.2 Mixing Crop Production with Pastoralism

- Hagere Selam

39 % of the respondents in Hagere Selam had both livestock and grew cereals. In Hagere Selam the main income for the farmers came from cereals, but many had also some livestock. Some of these animals, like oxen and donkeys are for labor, and cattle, sheep, and goats are normally kept to have access to milk and meat. Mixing crop production with livestock herds might reduce risk and make a more diversified income.

- Kofele

In Kofele, 70.4 % of the respondents both had crop fields and livestock. Farmers were traditionally pastoralists and they relied mainly on their livestock. Today much land is dried up and suitable for crop cultivation, so now they can combine crop production with pastoralism. This seems to be very positive for many farmers' nutrition and income, but it might also increase the work load.

6.4.3 Tree Planting

- Hagere Selam

50 % of the respondents in Hagere Selam planted trees to prevent flood and to mitigate impacts from climate changes. Trees have many advantages and benefits; for one thing they can generate income if they are cut and sold, or if the trees bear fruit, this can be sold. There are also some disadvantages that vary a bit from variety to variety. Some trees, especially eucalyptus, need a lot of water, so it should preferably not be planted close to crop fields because it dries up the soil and "steals" water meant for the crop. It is often better to plant indigenous tree varieties which are usually more naturally adapted to the dry climate and do not demand that much water. Ten years ago there were fewer trees and natural vegetation in areas around Hagere Selam, but now many are aware of the problem with deforestation and the inhabitants try to plant and reforest the area and also rehabilitate the land among other thing with tree planting. One respondent said: "*If flood or heavy rain occurs it would be positive if we have planted trees beforehand. Trees are also positive because they break the wind and give shade*". In this way trees and other green vegetation can contribute positively to mitigating the climate changes, and in areas with many trees, temperatures are often lower than in for example urban areas of Ethiopia with fewer trees.

Picture 4: Tree seedlings in nursery, Tigray Region

Source: Author (January 2011)

- Kofele

56 % of the respondents in Kofele have planted trees. They planted various tree species. Planting of eucalyptus was common, but it was often negative, because it takes up large

amounts of water. Sometimes eucalyptus planting has also a positive effect in Kofele because it contributes to the drying up of peat fields. If climate and eucalyptus trees dry up the soil further it will have negative impacts. Trees have many positive effects, for example they give shade and they can reduce air and soil temperatures this way. Having natural plants in the crop field can also have positive effects. Trees can also to some extent prevent flood and landslides, and they break the wind and make it less strong. Some farmers in some villages in Kofele sub-district have experience with landslides due to deforestation. Climate changes can possibly worsen these conditions because lack of rain or too heavy rain can both make the soil weaker and more vulnerable to landslides.

6.4.4 Off-Farm Activities

- Hagere Selam

43.3 % of the respondents in Hagere Selam said they took off-farm work sometimes; this could be anything from being a teacher or priest to being a daily laborer or working on other people's farms after finishing work on their own farm. Others had a shop and sold different products like milk, honey, clothes, or local beer. This income surely reduces their household's general vulnerability because they have different sources of income and do not have to completely rely only on agriculture for their livelihood. Two respondents said that they took jobs in other villages due to drought periods in previous years.

- Kofele

44 % of the respondents had off-farm income in Kofele. This could be anything from selling home made products or hot food to being a daily laborer or having a job like being a guard. There were no priests among the respondents in Kofele.

6.4.5 Soil and Water Conservation (SWC)

- Hagere Selam

The farmers in Hagere Selam practices soil and water conservation of many different kinds. 73.3 % of the respondents answered that they practiced activities in water and soil conservations. A few said they did not practice soil and water conservation because they were old. The farmers are encouraged by the government to do these activities, and especially in January each year they often practice this activity. This is probably done mainly due to soil degradation, but it is even more common practice to do soil and water conservation because climate changes makes the soil even drier and it is even more important than before to conserve the water in the soil as much as possible. They have different techniques, for example dig deep trenches, soil bends and stone bends. These techniques will keep the water in the field and also prevent the soil from being washed away when it rains. This will increase the field's fertility and make it better for the crop to grow properly. Soil and water conservation can also be seen mainly as a strategy to reduce general vulnerability, but it would be an extra advantage to have done this if drought or flood occurs. The climate is naturally dry in Hagere Selam, so it is always positive to try to save the water, even in a good year. One respondent said "*Drought ten years ago resulted in soil degradation. We did not have enough food during that time. We managed by eating plants we do not usually eat. At that time we did not actively adapt. Later the government encouraged us to plant trees and use soil and water conservation, and now conditions are much better*".

Picture 5: Farmers digging deep trenches in hillside, Hagere Selam
Source: Author (January 2011)

- Kofele

In Kofele, 4 % used soil and water conservation. Soil and water conservation activities are sparse in the area around Kofele because the land is often flat, so there is rarely any need to build terraces and it is not possible to make functional deep trenches like they do in Hagere Selam. The environment is also wetter so they do not have this much need for conserving water and soil. They however often have the knowledge and capacity to do so, and the farmers who have fields on a hillside often employs stone bends and other techniques to make the soil and water stay in the field and prevent drain-off during the rainy season.

6.4.6 Selling of Assets

- Hagere Selam

20 % of the respondents in Hagere Selam said they sometimes sold livestock to earn some money and then they could buy food and other things at the market. Some farmers also sold honey or bee colonies sometimes. Three respondents said that they used to sell livestock as a coping mechanism due to drought periods. One man said, "*When there was drought in previous years, I sold some livestock and bought food at the market because my harvest yield collapsed. I will do so again in the future if necessary*". Another respondent said, "*I do not fear drought because usually they are very short. If drought occurs I will have to sell livestock and get work in other villages*". One respondent said: "*After the harvest we usually get 6 to 10 quintals. We consume that in 6 to 7 months. After that we buy additional grain from the market up to next harvest*." This is the common situation for farmers in Hagere Selam. To be able to buy food the rest of the year, they usually need to sell assets, or have a job which gives them income.

- Kofele

52 % of the respondents in Kofele said that they had sold livestock the last years. 46 % said no, and the last 2 % did not have any animals. Only a few farmers sold firewood, and some sold eucalyptus poles for house building. This can be seen as good coping mechanisms. Many farmers said that they had a shortage of firewood themselves and had nothing to sell.

During drought in Kofele in 2008, many sold livestock, and they could buy food at the market. It seems however difficult to sell livestock during a drought. Most likely, all the farmers in the area face the same types of problems and many want to sell some livestock. My general experience from Ethiopia is that many want to sell livestock, but it is difficult because there are not so many buyers, and the buyers usually choose the fat and healthy livestock only. During a drought, a farmer might have to walk long distances or even pay for transportation to another area to be able to sell his livestock.

Picture 6: Selling livestock is a common coping mechanism, Kofele
Source: Author (February 2011)

6.4.7 New or Suitable Seed Varieties

- Hagere Selam

23.3 % of the respondents in Hagere Selam said they had tried new varieties of seeds the last few years. The farmers usually sow crop types that are suited for their land and they sometimes introduce new types of crop. They are often innovative, but want to reduce risk at the same time. There are no crop types that are really drought resistant or drought tolerant. On the other hand they have many traditional crop types that grow fast and that they use for eating for example when they are waiting for the rest of the crop to ripen in September. Some farmers in Hagere Selam also have access to certified wheat which is drought resistant to some extent and tolerate dry conditions a bit better than local wheat. The farmers decide what to sow and when to sow according to when the rain starts. For example if the rain starts in May they can sow sorghum but if the rain starts later in June they can sow for example wheat which ripens faster. The farmers know which types that can be sowed before the rain starts and which types that must be sowed after the rain has started.

When I asked the respondents if they knew any seed varieties that were fast growing or drought tolerant, many respondents knew local varieties that had these qualities, but they did not grow them last year. Possibly, they did not have a need for these varieties last season. If the climate gets worse in the future, they might scale up their cultivation of crop varieties that they traditionally know are drought resistant or ripen just after three months, but this season they had no need for that and they usually prefer to grow cereals to make their *injerra* bread.

- Kofele

34 % of the respondents in Kofele said they had used new seed varieties the last few years. They had got access to certified wheat, and also improved varieties of barley, potatoes, and corn in Kofele. The respondents knew a few types of crop that grow and ripen fast, like potatoes, a special barley variety called *savin*, and corn. They usually did not know any drought resistant crop types because traditionally they have not had the problem with shortage of rainfall or drought in Kofele. Some said *enset* is drought resistant and during the drought in 2008 many farmers experienced that they could rely on it and that it did not die like other types of crop during the drought. The livestock can eat the leaves and people can eat the root of it. So *enset* has good potential and has proved its importance for the farmers in Kofele as a good and reliable coping mechanism. Moreover, if the trend with later *belg* rain continues, the farmers will need to adapt and grow varieties of potatoes that ripen faster than traditional types for the *belg* rain, so they have time to harvest the potatoes, plough and prepare for cereals before the *kiremti* rainy season starts in June. In Kofele, the farmers had an improved potato variety called *gudane* that mature faster than the traditional ones, but there might be a lack of access to it, it might be too expensive, or otherwise unsuitable, because most farmers did not use it.

Picture 7: Ploughed field, most likely suitable or new seed types will be sown this year
Source: Author (February 2011)

6.4.8 *Enset*

- Hagere Selam

Farmers in Hagere Selam do not grow *enset*.

- Kofele

72 % of the respondents in Kofele grew *enset*. *Enset*, also called false banana due to the look of the plant, is a bit drought resistant and can be used both for food and livestock fodder. *Enset* is valuable for a large part of the farmer population in Kofele, and the majority of the farmer population eats this for approximately half the year after the cereals have been consumed. This can save money, because they do not need to go to market and buy food. The production of *enset* is most favored within the altitude range of 2000-3000 meters (FAO 2003: 6). *Enset* is often grown together with large numbers of crops and trees (fruit and forest trees) and livestock rearing (FAO 2003: 6).

Picture 8: *Enset* plant

Source: http://ethiopia.limbo13.com/index.php/enset/ (2011)

6.4.9 Food Aid

- Hagere Selam

31.7 % of the respondents in Hagere Selam mentioned that it is possible to ask the government for help if a drought occurs and they sometimes give food aid. One of them said "*The government sometimes gives food aid if there is a bad drought in Hagere Selam*". I do not think food aid has been given recently in Hagere Selam because they do not need it, but in 1984, at least, they got food aid. Usually the farmers in Hagere Selam relied on the government and they thought they would get help if they needed it, because that was the trend in earlier years.

- Kofele

If a natural disaster happens in the future, 20 % of the respondents in Kofele think or hope the government might help them with food aid. Some said, however, that they had no confidence in government help, but many would report to them and hope for help. Others said they would not report because they did not believe that government would give any help anyway. Some also says that NGOs might help. They mainly referred to NGOs that were already working in the area.

Some farmers around Kofele received food aid due to drought in 2008, but there were also many that did not get any, even though they reported livestock deaths to the government. Due to hail in Kofele in the autumn of 2009, some farmers received food aid because their entire crop yield was destroyed. Others did not get any food aid even though their crop was destroyed. Which households that got food aid and which households did not get any seemed area specific; all respondents from one village told that they got food aid, but respondents from a neighboring village told they did not get any. Some farmers received aid from relatives from other better off districts or regions due to the drought.

6.4.10 Irrigation and Diverting of Water

- Hagere Selam

16.7 % of the respondents in Hagere Selam had some form of irrigation. It is mainly the farmers that live close to a river, often in lowland areas, that can benefit from that water and construct irrigation canals or other types of irrigation. One farmer said "*I live in a higher lowland area and have access to irrigation from a river. This is especially valuable to feed the crop in field if there is shortage of rainfall or a drought period*". Mostly farmers living in Degua Tembien have no access to irrigation, especially in highland areas. Still, there were some special areas that had rich ground water not many meters down, so they could dig wells and pump up the water to grow vegetables to sell in the dry season. Irrigation can be seen as a strategy to reduce the general vulnerability. It is more likely that they will succeed in their agriculture if they have irrigation. Irrigation can also to some extent be seen as a strategy to prepare for drought. To some extent irrigation canals or other types of irrigation can feed the field with water and maybe keep the crop alive long enough for it to ripen. If there is a serious drought and there is no water to collect or to divert, there is no longer any help in irrigation. During drought one respondent said that they could perhaps dig to find water instead. Many farmers might do this. Some villages in Tigray Region and in the Degua Tembien sub-district have made ponds where they collect water in the rainy season and in this way they have water they can use for irrigation also a bit after the rainy season has finished if that is necessary. There were a few big ponds in Tigray, and in Hagere Selam there was at least one small one. It was already dried up when I was there in January 2011, but they might be valuable and important for the owners of the ponds before the harvesting season in September because they can use irrigated water to feed the crop if the rain stops before the crop has matured. One farmer said: "*If there is shortage of rainfall, we divert the water onto the farmland. If there is too much rain we make dikes to make the rainwater go another way*." This seemed to be common.

Picture 9: Water pump irrigation in Hagere Selam (left), and a water basin in Mekele used for irrigation canals (right)

Source: Author (January 2011, October 2010)

- Kofele

Most farmland in Kofele is rain-fed. 4 % of the respondents had some form of irrigation, and this was mainly water from hand dug wells that the farmers watered their vegetables with by hand. They usually sold the vegetables in the market. It is also possible to grow vegetables like this in the dry season which can be very valuable for the farmers because it gives them a small extra income. This was still very rare.

An adaptation strategy due to drier conditions and drought found in Kofele was to dig wells to get access to drinking water or irrigation water. It depends on the area how deep you have to dig before you find water, but in some special areas it is just a couple of meters, and then it is clearly possible to do this. Dikes and drainage can also be very helpful to mitigate flood and to prevent damages from flood in areas vulnerable to this kind of disaster. Rainwater can be diverted away from the most vulnerable areas in highland, midland and flat areas, but in the lowland, flood is common and diverting water away might not always be enough.

6.4.11 Migration

- Hagere Selam

None of the respondents actually said they used migration as a coping strategy, but if somebody had already migrated permanently, they would not been there anymore and thus not able to participate in the survey. One respondent said that earlier, some neighbors and others from the village were forced to migrate because of soil degradation. Now the inhabitants know how to handle soil degradation better, so is not any longer that pressing. None of the respondents mentioned migration due to climate changes other than possibly some who would have to migrate if a flood occurred in the future. Generally, the farmers are proud of being farmers and they want to continue their way of life. Agriculture is often the only work they know and they stay in their village because they like it there. In the younger generations more people are getting an education, and most of them have many brothers so it will be hard for them to get any farmland from their parents because their land is often already small, so there will not be sufficient land to divide up. Then they possibly move to a city and get a job there, or they wait for the government to give them land. 3.3 % of respondents in Hagere Selam mentioned migration, but it was not usually seen as a response to climate changes. People in Hagere Selam mainly moved because of other incentives. Migration was a bit less common in Hagere Selam than in Kofele. Actually I met several people that were from other areas of Tigray and newly settled in Hagere Selam because they had got a job there, so even though some are leaving, some are actually also coming.

- Kofele

None of the respondents mentioned migration as a general adaptation strategy, but 4 % of the respondents mentioned that you can rely on relatives from other districts during a drought. One of them said for example who people that have relatives in other areas which are not that badly affected by the drought, can possibly migrate to them for a limited period of time. Another one said that relatives from other areas can possibly share resources with those most badly affected without migration involved. 2 % of the respondents in Kofele said that if there is serious drought, some people having relatives in other areas or districts temporarily migrate to them and rely on them for a period of time. Some respondents knew people from Kofele who had migrated to the Bale area in drought periods. Migration is usually seen as the last possible option and also as a temporary option.

In section 6.4 we found eleven coping strategies that were in use, and all of them are useful and valuable in some ways, and through for example sowing of carefully selected seed varieties, mixing of crop cultivation and livestock herding, and off-farm work, most farmers are successfully adapting to climate changes. Table 12 sums up the findings from chapter 6.4.

Table 12: Adaptation strategies in use in Hagere Selam and Kofele

Adaptation strategies in use				
	Hagere Selam		**Kofele**	
	Frequency	**%**	**Frequency**	**%**
Crop diversification	44	73.3 %	49	98 %
Mixing crop and pastoralism	16	39 %	19	70.4 %
Tree planting	30	50 %	28	56 %
Off-farm activities	26	43.3 %	22	44 %
Soil and water conservation	44	73.3 %	2	4 %
Selling of assets	12	20 %	26	52 %
New or suitable seed varieties	14	23.3 %	17	34 %
Enset	0	0 %	36	72 %
Food aid	19	31.7 %	10	20 %
Irrigation	10	16.7 %	2	4 %
Migration	0	0 %	0	0 %

Source: Fieldwork returns (2011)

6.5 What factors can explain various extents and forms of individual adaptations?

I will here present the relationships that I found between different factors, for example education, household size and wealth, and adaptive capacity. Wealth is in this research measured by three factors, namely size of livestock herds, size of farm, and the amount of crop yield from last harvest. Size of farm is measured in hectare, and crop is measured in quintal, which means hundred kilograms. 9 quintal is therefore 900 kilograms. Education is measured by how many years in school the head of household have. Age is also measured by the head of household. Access to information and weather forecasts is counted after how many sources to these facilities they have. The first factor to be assessed is wealth.

6.5.1 Wealth

Amount of crop yield, size of livestock herds, and farm size all contribute to explaining the level of wealth. First, it might look like a larger farm size is positive for coping strategies, and smaller farms seems to mean less adaptation strategies. Appendix 1 shows the correlation between farm size and numbers of coping strategies. We found a positive and significant correlation between farm size and coping ($r=0.38$, $p<0.00$). This can be seen in appendix 2. The government has an important role to play when it comes to farm size because most land in Ethiopia is communally owned and is distributed to farmers. The government has to decide if the best option is to give smaller plots of land to more numbers of farmers or give greater farm size to fewer farmers. The tendency now is that they give smaller plots of land to more farmers, because too many farmers apply. This tendency should maybe be changed, because it might be better to wait for a longer time to receive a proper sized farm than to receive land that is too small for making a living.

Secondly, it seems like those with larger size of livestock herds are more likely to adopt more coping strategies. These findings can be seen in the cross tabulation in appendix 3. There is a positive and significant correlation between number of animals and coping ($r=38$, $p<0.01$). This can be seen in appendix 4.

Thirdly, it also seems like those with larger crop yields do more adaptation strategies. This can be seen in appendix 5. Government can in many ways support the farmers to receive greater crop yields. They can amongst others investigate in new seed types and distribute these accordingly.

6.5.2 Gender of Headed of Households

There might also be a relationship between the gender of head of household and adaptive capacity. Some academic writers argues that male headed households are most likely to adopt adaptation strategies, while others argue that female headed households are most adaptive.

In per cent, there is no clear difference between the female headed and the male headed households that are doing most adaptation strategies. This can be seen in appendix 6.

6.5.3 Education

There seems to be a positive relationship between education and how active the farmers are in adaptation strategies, and those households where the head of household has 10 years or more in school are most likely to adopt more numbers of adaptation strategies. This can be seen in appendix 7. We find a positive and significant correlation between education and coping ($r=0.21$, $p<0.05$). This can be seen in appendix 8. Therefore it is clear that education is important, and education of farmers is not in vain. The government should enhance education and give proper education facilities, also in rural areas.

6.5.4 Age

Age might contribute to explaining various extents of individual adaptations, but there seems to be no clear relationship between the two variables. Those over 69 years old seems however to be less adaptive. Younger people seem to some extent to be more likely to adopt adaptation strategies. This can be seen in appendix 9.

6.5.5 Household Size

Household size might also be a factor that can contribute to explaining the extent of adaptations. From appendix 10 it seems like larger household size is related to higher adaptive capacity. We find a positive and significant correlation between education and coping ($r=0.33$, $p<0.05$). This can be seen in appendix 11. The average household size amongst the respondents is 5.6 in Hagere Selam and 9.2 in Kofele. Households in this survey from Hagere Selam had from one to ten members, and households in Kofele had from two to 20 members.

6.5.6 Access to Information

Some farmers has a radio, some has not. Some hear information from the development agents from the agricultural office in their sub-districts. Some hear information when they meet friends in market or in other places. A weak relationship can be seen between more sources of information available and adaptive capacity. Appendix 12 shows this. The government has a responsibility when it is coming to give information about climate changes and adaptation options to the farmer population. Radio programs and development agents at agricultural and rural development offices around the country should not be reduced, but they should keep up their work.

6.5.7 Access to Weather Forecasts

Some farmers have access to weather forecasts on the radio or they heard weather forecasts in the market, at meetings, or they hear from their children's teachers or from neighbors. Local governmental workers and workers in the agricultural and rural development office also give such information informally. This is important work and this work should be scaled up. Weather forecasts might be especially valuable for the farmers in sowing and harvesting time. When the rain becomes more unreliable than before and the traditional wisdom about forecasting rain and seasons not always works anymore, modern forecasts seem to be of increasing importance. Still, there are some farmers that do not believe in modern forecasts, and the weather forecasts might sometimes be wrong. From appendix 13 it can be seen a weak relationship between access to forecasts and better adaptive capacity. The government should also scale up their work with local weather forecasts and the distribution of these. A drought warning system would also have been valuable for the farmers, and is a task that the government might take initiative to develop.

6.5.8 Access to Credit

Access to credit seems to have no clear relationship with adaptive capacity. This can be seen in appendix 14. Both private and governmental agencies have a role to play in giving access to credit. Even credit should be given with caution, it is positive for many farmers to have access to credit.

6.4.9 Agricultural Education or Training

40 % of the respondents in Hagere Selam have got some training or education in agriculture, while 28 % of the respondents in Kofele have got the same. This education is mainly informal advice and training from the development agents working in Agriculture and Rural Development Office in their sub-districts. Social workers working in a local NGO, Rural Organization for Betterment of Agro-pastoralists (ROBA) is also advising many farmers in Kofele sub-district. From appendix 15, it seems like there is no clear relationship between agricultural training and adaptive capacity. Even this research shows that agricultural training has no effect, the quality and access to agricultural training and education should be

improved. With a changing climate, it is important that the farmers are innovative and have access to knowledge about for instance the newest technologies and seed varieties.

6.5.10 Social Capital

Most of the respondents told that they had good and strong social capital. This can be very important of many reasons, and it can possibly also have positive effects on their adaptive capacity. However, it is difficult to measure social capital, because even if for example some respondents were lonely or had bad relations with their neighbors, they would most likely not have told it. Generally, it looked like the farmers encouraged and helped each other in many different ways, and they also had traditions of working together, borrowing and renting work and for example oxen from each other. At the same time, they often had to think about themselves first, to get the largest crop yield possible. Many surely prioritized work within family first before helping anybody else. The sharing and helping people other than family within a community, is probably mostly about giving advice, and sharing experience and knowledge, and not that much about physical or material help. Because it is difficult to measure social capital, and all respondents who answered this question said that they had good social capital, it is impossible to draw any further conclusions or comparisons between social capital and adaptive capacity.

6.5.11 Distance to Market

Access to a market might among other things mean better social capital and access to information. There might be several external benefits to living close to a town or market, but according to this research, it seems to be no clear relationship between distance to market and adaptive capacity. This can be seen in appendix 16. The government has the main responsibility for facilitating of infrastructure in Ethiopia, and they are doing quite well. It is however potential for improvement of for example roads in rural areas. Better roads would possibly give positive externality effects on amongst others coping strategies.

6.5.12 Agro-ecological Settings

Agro-ecological settings might contribute to explaining different forms and extent of adaptation. For example some coping strategies might be suitable in Kofele, but not in Hagere Selam, such as *enset*. Other crops might be suitable in Hagere Selam but not in Kofele, such as *teff*. Appendix 17 shows the relationship between agro-ecological settings and coping, and no clear relationship were found. Picture 10 shows that Kofele is green in February, while Hagere Selam is drier in February.

Picture 10: Landscape in Kofele (left) and Hagere Selam (right)

Source: Author (February 2011)

6.6 Discussion and Comparisons

Section 6.6 is a discussion of the empirical findings and also a comparison between Hagere Selam and Kofele. Connection between the reviewed literature and the empirical investigation will also be shown. Most people in both Hagere Selam and Kofele said they had experienced climatic changes the last twenty years. This is not surprising since climate changes can be experienced in almost all parts of the world. Generally, Rosell (2010), states that rainfall during the *belg* rainy season has declined to some extent in Ethiopia during the last 30 years. In addition, the National Meteorological Agency states that Hagere Selam received in general less annual rainfall than Kofele, and rainfall in Hagere Selam has also decreased more than in Kofele. Rainfall during the main *kiremti* season has changed drastically in Hagere Selam and less in Kofele, while the shorter *belg* rainfall has decreased in Kofele. The majority of respondents in both Hagere Selam and Kofele think rainfall has declined or become more irregular. Climate changes leads to different impacts, such as reduced crop yield, decreased animal yield, and animal deaths. However, impacts of climate changes are usually not leading to increased poverty or worsened health conditions. This can mean that farmers know how to adapt to climate changes, and that most farmers are not as vulnerable as many thought.

To cope with impacts of climate changes, farmers make use of various adaptation activities. Some do nothing while others do up to seven different activities. The average respondent in Hagere Selam uses 2.8 adaptation strategies or coping mechanisms, while the average respondent in Kofele uses 4.4 adaptation strategies. This might among others be because impacts of climate changes seem to be most severe in Kofele, and they also usually have more education, and larger farms, livestock herds, and households than in Hagere Selam, so the adaptive capacity of the farmers in Kofele might be higher. Many farmers in Hagere Selam and Kofele both reduce their general vulnerability to climate changes and also prepare for specific hazards. Adaptation strategies can also be divided between long-term general adaptation strategies and more short-term coping mechanisms related to one specific natural disaster. Off-farm activities, selling of assets, *enset*, food aid, and migration are the most solid coping strategies that might be increasingly used if climate is changing drastically in the future. If the climate is still good in the future and changes only moderately, many on-farm adaptations might be used to make it possible for farmers to continue with agriculture. This includes crop diversification, mixing of crop cultivation and livestock herding, tree planting, soil and water conservations, new or suitable seed varieties, and irrigation. The government is enhancing tree planting and soil and water conservation in Tigray. This is positive, and should be scaled up both in Tigray and also in other regions of Ethiopia. To have more education, to be young, to be part of a large household, and to have some standard of wealth seems to have positive effects on adaptive capacity.

The most common adaptation strategies and coping mechanisms today are valuable and successful, but they will possibly not be enough in the future. Development of adaptation strategies and coping mechanisms should not stop at the level where they are today. I will especially argue that it will be important to find improved on-farm coping mechanisms and adaptation strategies, because it seems that most of the farmers prefer their own life style and want to continue with it. Therefore, it is important to make it possible for them to continue to live as crop-farmers or pastoralists and to come up with new and better solutions to the problems they experiences because of climate changes. For example new improved technologies and seed types are needed, and new types of irrigation and collecting of water can be useful and maybe also vital for some households. The government can enhance investigation and distribution of new improved seed varieties and also give information and support to those that want to invest in irrigation.

In contrary, off-farm adaptation strategies may seem easier, and more effective than on-farm adaptation strategies. When former farmers get a job and a monthly salary, they are not longer so dependent on the natural resources and the climate. If the climate changes badly, the last alternative is to leave the farm temporarily or permanently and move for example to a city or to an area less affected by climate changes and probably look for a job there. If they find a job, it will most likely be very positive for them and their family. On the other hand it is difficult to find jobs. An alternative to a paid job is to create your own job, for instance if a family invests in a small shop. It might however be hard to find customers and they will probably not earn much from this shop. Every household in the village cannot invest in their own staple food shop; it will create neither income nor development. Consequently, there is a risk involved with both in remaining in the village and continuing farming, and in migrating.

Chapter 7: Conclusion

Climate changes have become a current global issue during the last few decades, in small rural communities in developing countries just as much as in big conferences and international politics. Whether the climate is changing faster than before, and whether it is created by humans or not, is still in dispute, but most scientists now agree that the climate is changing and that the world will see more change before stabilization can be reached (Feenstra et al. 1998: 119). Climate changes is one of the main challenges Ethiopian farmers are facing today and will possibly face more often in the future. It is important to map impacts of the various climate changes and also to map how the farmers respond to climate changes, to see how different kinds of institutions and agencies can support the farmers better in further adaptations.

This research has first of all shown that climate is changing in Hagere Selam and Kofele, and we also have learned that most respondents have experienced different impacts of climate changes. Secondly, various adaptation strategies were identified, and these are usually sustainable and functioning. Farmers are often successful in adaptation, and even climate changes create several impacts, it does not usually lead to increased poverty. Finally, there are many facilitators and barriers to adaptations, and this research shows that the factors most likely to explain different forms and extent of adaptations are education, age, household size, and wealth.

7.1 Impacts of Climate Changes

The main impact of climate changes is that crop yield has generally decreased from year to year, and so are also animal products and animal fertility. Moreover, climate changes to some extent accelerates the process of soil degradation; and heavy rain, hailstorms, strong wind, and flood can in different ways lead to soil erosion. Because of climate changes, farmers get less income from the animals and from the crop fields and they might in drought- or flood periods face extensive shortage of food, water, or other necessities. Therefore especially children’s health might be at risk during these periods. These impacts are partly serious and must be mitigated and prevented. Therefore, I will argue that it is important to map the possible action the farmers have to take against climate changes and natural disasters such as flood and drought.

7.2 Critical Factors Making Adaptations Successful

Adaptation strategies in rural areas are vital factors for development. Senbeta (2009: 2) and Smith et al. (2003:11) state that adaptive capacity in Africa is often low. This research has found partly conflicting results. Findings of this study have demonstrated that the impacts of climate changes can be mitigated to some extent, and that many farmers are doing successful adaptation strategies. There are several coping mechanisms and adaptation strategies that governments, NGOs, and individual farmer households can do to mitigate the impacts of climate changes. In addition, it is positive to see that many of the adaptation mechanisms found in the literature is functioning also in Hagere Selam and Kofele. On the other hand, I will argue that most of these coping strategies only can mitigate moderate impacts of climate changes. If for instance extreme and long-lasting floods or droughts occur, there is no longer any help in tree planting or irrigation. Then scaling up of off-farm activities or temporary or permanent migration might be the outcome. Therefore, I will argue that even some of the farmers do adaptation activities there are limitations for how great the outcomes of these adaptation strategies are. For example planting of trees and soil and water conservation can create better soil fertility and protect the soil for example during moderate flood and drought periods. Consequently, all adaptation strategies in use have some benefits and they serve a purpose, but they are to some extent limited and will not always be suitable. It is however positive to have a selection of adaptation strategies available, because some are suited to some conditions while others are more suitable in another situation.

Referring to table 1, it is indicated that both Hagere Selam and Kofele are "*vulnerable communities"* because they have experienced quite high impacts of climate changes, such as reduced rainfall and higher temperatures, and their adaptive capacity is often of medium level. If they improve or scale up their adaptive capacity they can hopefully become "*development opportunities"*, and some households already are in this category. According to matrix 1, it is difficult for these communities to achieve "*sustainability"*, because most likely the impacts will remain high. If they manage to mitigate the impacts, and at the same time adapt to the impacts that occur, they might be sustainable.

7.3 Lessons Learned and Policy Recommendations

Constraints on time and resources limited the ability to do a larger sample size and a larger in-depth study of Hagere Selam and Kofele. Nevertheless, the justification for the chosen sample enhances the validity of the findings and aims to provide a representative picture of the farmer's situations in these two communities. I think my sample size and research answered the research questions well, and all research questions have been investigated and clarified during the research. However, to talk about a time period of twenty years is not much when it is coming to measuring of climate changes. I will still argue that it is enough to figure out a tendency, and it is also difficult for the respondents to remember longer than that. The respondents for example in their 80s might have talked about weather changes in a longer time period than 20 years even I did not asked for it, and many compared climate in their childhood and today. Therefore, I think the time specter in this research is good enough to make some conclusions about the respondents' perceptions about climate changes.

The investigation carried out for this thesis has been two case studies of how farmers perceive- and react to climate changes. The conclusions of the study are therefore mainly limited to these two communities only, but the research is also aiming to say something about climate changes and small scale sub-Saharan farmers in general, and can be seen as an example of this. The findings can however not be generalized because impacts of climate changes and adaptation possibilities are to a large extent area specific and dependent upon amongst others agro-ecological settings, type of climate, and extent of climate changes.

Moreover, adapting rural livelihoods will require a responsible government, and investments, policies, planning, and information are wanted (Pettengell 2010: 28). It will also be a need for access to appropriate technology (Pettengell 2010: 28). The Ethiopian government should preferably enhance adaptation through amongst others giving education, distribute food aid when necessary, and infrastructure facilities. They should also invest more in investigation of new suitable seed varieties and distribute this to farmers. Investigation in a drought warning system would also be positive, and if such a system are put in place in the future this would be very valuable for the farmers.

Picture 11: Farmer plowing his field, Kofele

Source: Author (February 2011)

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Appendices

Appendix 1

Farmsize * coping Crosstabulation

Count

		Coping			Total
		0-2	3-4	5-7	
Farmsize		2	3	0	5
	0-0,25	2	1	1	4
	0,26-0,70	12	18	5	35
	0,71-1,20	7	16	6	29
	1,21-2	4	9	10	23
	2,1-	1	3	10	14
Total		28	50	32	110

Appendix 1: Cross tabulation showing the relationship between farm-size and coping

Source: Fieldwork returns (2011)

Appendix 2

Correlations

		coping	Farmsize
coping	Pearson Correlation	1	.377**
	Sig. (2-tailed)		.000
	N	110	105
Farmsize	Pearson Correlation	.377**	1
	Sig. (2-tailed)	.000	
	N	105	105

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

Appendix 2: Matrix showing the correlation and significance between farm-size and coping

Source: Fieldwork returns (2011)

Appendix 3

Animals * coping Crosstabulation

Count

		coping			Total
		0-2	3-4	5-7	
Animals		15	15	11	41
	0-5	10	18	6	34
	6-10	3	8	6	17
	11-16	0	6	3	9
	17-	0	3	6	9
Total		28	50	32	110

Appendix 3: Cross tabulation showing the relationship between number of animals and coping

Source: Fieldwork returns (2011)

Appendix 4

Correlations

		coping	Animals
coping	Pearson Correlation	1	.384**
	Sig. (2-tailed)		.001
	N	110	69
Animals	Pearson Correlation	.384**	1
	Sig. (2-tailed)	.001	
	N	69	69

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

Appendix 4: Matrix showing correlation and significance between numbers of animals and coping

Source: Fieldwork returns (2011)

Appendix 5

Cropyield * coping Crosstabulation

Count

		coping			Total
		0-2	3-4	5-7	
Cropyield		1	0	0	1
	0-5	11	11	8	30
	5.5-9	10	19	9	38
	9.5-15	6	18	9	33
	16-	0	2	6	8
Total		28	50	32	110

Appendix 5: Cross tabulation showing the relationship between amount of crop yield and coping

Source: Fieldwork returns (2011)

Appendix 6

Femaleormaleheaded * coping Crosstabulation

Count

		Coping			Total
		0-2	3-4	5-7	
Femaleormaleheaded	Female	2	3	2	7
	Male	26	47	30	103
Total		28	50	32	110

Appendix 6: Cross tabulation showing the relationship between gender of head of household and adaptive capacity

Source: Fieldwork returns (2011)

Appendix 7

Educationheadhousehold * coping Crosstabulation

Count

		Coping			Total
		0-2	3-4	5-7	
Educationheadhousehold		1	0	2	3
	Illiterate	17	30	16	63
	1-5	6	6	2	14
	6-9	3	11	3	17
	10-	0	3	6	9
	Bible school	1	0	3	4
Total		28	50	32	110

Appendix 7: Cross tabulation showing the relationship between education and coping

Source: Fieldwork returns (2011)

Appendix 8

Correlations

		Educationheadhousehold	coping
Educationheadhousehold	Pearson Correlation	1	.211*
	Sig. (2-tailed)		.029
	N	107	107
Coping	Pearson Correlation	.211*	1
	Sig. (2-tailed)	.029	
	N	107	110

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 8: Matrix showing the correlation and significance between education and coping

Source: Fieldwork returns (2011)

Appendix 9

Age * coping Crosstabulation

Count

		coping			Total
		0-2	3-4	5-7	
Age	20-29	4	15	10	29
	30-39	9	14	9	32
	40-49	4	11	8	23
	50-59	7	8	2	17
	60-69	1	0	3	4
	70-79	3	1	0	4
	80-85	0	1	0	1
Total		28	50	32	110

Appendix 9: Cross tabulation showing the relationship between age and coping

Source: Fieldwork returns (2011)

Appendix 10

Householdsize * coping Crosstabulation

Count

		coping			Total
		0-2	3-4	5-7	
Householdsize		2	0	1	3
	1-3	5	6	1	12
	4-6	13	16	9	38
	7-11	8	23	14	45
	12-20	0	5	7	12
Total		28	50	32	110

Appendix 10: Cross tabulation showing the relationship between household size and coping

Source: Fieldwork returns (2011)

Appendix 11

Correlations

		coping	Householdsize
Coping	Pearson Correlation	1	.328**
	Sig. (2-tailed)		.001
	N	110	107
Householdsize	Pearson Correlation	.328**	1
	Sig. (2-tailed)	.001	
	N	107	107

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

Appendix 11: Matrix showing the correlation and significance between household size and coping

Source: Fieldwork returns (2011)

Appendix 12

Accesstoinformation * coping Crosstabulation

Count

		coping			Total
		0-2	3-4	5-7	
Accesstoinformation		18	17	14	49
	0	1	4	1	6
	1	8	12	8	28
	2	0	14	6	20
	3	0	3	2	5
	4	1	0	1	2
Total		28	50	32	110

Appendix 12: Cross tabulation showing the relationship between access to information and coping

Source: Fieldwork returns (2011)

Appendix 13

Accessforecast * coping Crosstabulation

Count

		Coping			Total
		0-2	3-4	5-7	
Accessforecast		18	17	14	49
	No	5	5	1	11
	Radio	3	22	9	32
	Newspaper, TV	0	0	2	2
	Through others	2	8	6	16
Total		28	50	32	110

Appendix 13: Cross tabulation showing the relationship between access to weather forecasts and coping

Source: Fieldwork returns (2011)

Appendix 14

Accesscredit * coping Crosstabulation

Count

		coping			Total
		0-2	3-4	5-7	
Accesscredit		18	18	14	50
	no	1	8	4	13
	yes	9	24	14	47
Total		28	50	32	110

Appendix 14: Cross tabulation showing the relationship between access to credit and coping

Source: Fieldwork returns (2011)

Appendix 15

Agriculturaltraining * coping Crosstabulation

Count

		coping			Total
		0-2	3-4	5-7	
Agriculturaltraining		19	20	14	53
	no	2	11	6	19
	yes	7	19	12	38
Total		28	50	32	110

Appendix 15: Cross tabulation showing the relationship between agricultural training and coping

Source: Fieldwork returns (2011)

Appendix 16

distancetomarket * coping Crosstabulation

Count

		Coping				Total
			0-2	3-4	5-7	
Distancetomarket		3	15	9	5	32
	0-20	0	2	5	1	8
	21-45	0	1	12	5	18
	46-90	0	8	16	17	41
	91-250	0	2	8	4	14
Total		3	28	50	32	113

Appendix 16: Cross tabulation showing the relationship between distance to market and coping

Source: Fieldwork returns (2011)

Appendix 17

agroecologicalzone * coping Crosstabulation

Count

		Coping				Total
			0-2	3-4	5-7	
agroecologicalzone		3	0	1	0	4
	Highland	0	23	43	28	94
	Lowland	0	2	3	2	7
	Midland	0	3	3	2	8
Total		3	28	50	32	113

Appendix 17: Cross tabulation showing the relationship between agro-ecological settings and coping

Source: Fieldwork returns (2011)