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THE IMPACTS OF CLIMATE CHANGE ON RURAL LIVELIHOOD AND THEIR ADAPTATION METHODS: THE CASE OF ALAMATA WOREDA, SOUTHERN TIGRAY.

By

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The Impacts of Climate Change on Rural Livelihood and Their Adaptation Methods: the case of Alamata woreda, Southern Tigray.

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Abstract

Climate change and variability is one of the greatest challenges facing the Ethiopian agrarians. Climate change has a drastic impact on agricultural output, with total crop failure and massive livestock deaths. Furthermore the capacity of the rural poor to cope with climate related shocks has declined due the increase frequency and intensity of droughts. This study looks on the impact of climate change on rural livelihood and their adaptation methods of Alamata woreda. The woreda or the study area is hotspot for the impact of climate change. Three tabias was selected by simple random sampling method and 131 persons were participated in the study. The general findings of the study shows that the climate of the woreda has show variability and in turn this climate change and variability has impact on the woredas livelihood sources like: crop production, cropping pattern, availability of long cycle crops, and availability of livestock feed and loss of livestock were the major ones. To minimize the impacts of climate change and variability the farmers of the woreda had adopted different coping strategies like; decrease on amount of meal, selling labor, food aid, selling livestock and other assets and eat less expensive foods. Beles feeding for livestock, migration, early maturing crop varieties, water and soil conservation, rehabilitation of gullies and area closure were long term adaptation practices applied by farmers and woreda office of agriculture. By considering the above facts the researcher recommends: there should collaboratively works of farmers and DA experts on rehabilitation of their environment. The woreda's office of agricultural should encourage farmers to use drought resistant crop seeds with commercial fertilize, compost and soil moisture management practices. In addition there should be focus on planting fodder trees and beles around irrigation dykes and area closures.

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Acronyms

BoH-	Bureau of Health
CFCs	Chlorofluorocarbons
CSA	Central Statistical Agency
ENMA	Ethiopian National Meteorological Agency
EWS	Early Warning System
FGDs	Focus Group Discussion
FTC	Farmers Training Center
GHG	Greenhouse Gas
HH	Household
MASL	Meter above Sea Level
MDGs	Millennium Development Goals
NGO	Non-Governmental Organizations
OoA	Office of Agriculture
REST	Relief Society of Tigray
SAERTA	Sustainable Agricultural and Environmental Rehabilitation in Tigray
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Developmen

Chapter One

Introduction

1.1 Background of the Study

There is no clear universal convention on whether there is climate change or not. Most of the time there is accepted agreement on the existence of climate variabilities. This climate variability is becoming a challenging factor for the millennium development goals of the developing countries. It is a recognized fact that Africa because of wide spread poverty and consequential limited adaptation and coping capabilities, it is one of the most vulnerable regions of the world to the current and projected impacts of climate change. It is also known fact that most of the Africa's disasters are caused at least in part by adverse weather, Allen.K (2003).

The climate related disasters pose a serious threat to the poverty reduction and sustainable development in Africa continent. As one of the most vulnerable regions in the world to the projected impact of climate change, Africa faces many challenges at the critical juncture. Traditionally, national development plan, poverty reduction strategy and sectoral strategies in climate sensitive sectors have paid little attention.

The impact of climate change will fall disproportionally on the world's poorest countries, many of them here in Africa. Poor people already live on the front lines of pollution, disaster, and the degradation of the resources and land. For them, adaptation is a matter of sheer survival.

Sufficient evidence shows that the average temperature rise in Africa is faster than the global average and is likely to persist in the future (Hassan et al. 2006). The warming is definitely hazardous for agricultural activities in the continent as many of the crops are grown close to the thermal tolerance limits (Collier et al. 2008). The warming of few degrees and increase in frequency of extreme weathers will consequently strongly

influence the agricultural production and makes the society victim of the events and decreases the future adaptive capacities.

Ethiopia is one of the horns of African countries which are highly vulnerable to climate variability. Recurring drought is the single most important climate related natural hazard impacting the country from time to time. Hulme et al., (2000) also showed that rainfall decreases 'significantly' in June-July-August (JJA) over parts of the Horn of Africa which is the main crop cultivation season in Ethiopia.

Ethiopia has experienced major droughts which resulted in famine. The last three decades have been marked by catastrophic and wide spread droughts and famines; and the magnitude, frequency and the effects of droughts have increased since the mid-1970s. According to a United States Agency for International Development (USAID) study, the frequency of nationwide droughts causing severe food shortage increased from once every 10 years in the 1970s and 1980s, to every two-three years now (Margaret 2003).

In general Ethiopian history is punctuated by drought and famine which affected large parts of the country covering hundreds of thousands of square kilometers, and millions of households, MCKeej. (2008). particularly the eastern and northern parts of the country are the most vulnerable and have the highest food insecurity.

1.2 Statement of the Problem

Alamata woreda has a narrow range of agro-ecological conditions, and it is ideal or representative for mid and lowland areas where mixed farming exists. Furthermore, according to the socio-economic activity and geo-ecological condition the woreda is categorized as one of drought prone woredas (districts) in Tigray region. The woreda was one of the agricultural surplus producer areas of the region. Nowadays crop and livestock production has decreased and the woreda has become a hotspot for impacts of climate change/variability. In addition to this there is change in the cropping pattern of the study area.

Therefore, this study has assessed the pattern of rainfall and temperature of the study area. At the same time impacts of climate change and variability on the livelihood of the rural population of the woreda is assessed. Last but not the least the adaptation and coping strategies practiced by the farmers are surveyed.

1.3 Research Questions

1. What are the local indicators of climate change?
2. What are the main impacts caused by climate change/variability on crop and livestock production of the woreda?
3. who are more vulnerable to the impacts of climate change
4. What are observed changes in the cropping systems/pattern of the farmers?
5. What are the coping strategies or adaptation methods practiced by the farmers?

1.4 Objectives

The main objective of the study is to assess the impacts of climate change/variability on livestock and crop production of the woreda and identify farmer's response/ adaptation strategies.

1.4.1 Specific Objectives

A. To apprise the pattern of rainfall and temperature pattern in the last two decades in the woreda;
B. To assess impacts of climate change and variability on livestock and crop production of the woreda;
C. To identify the responses and adaptation strategies being practiced by the people to climate change or variability;
D. To come up with suggestion (recommendation) that would enable the people better cope or adapt the situation.

1.5 Materials and Methods

1.5.1. Data Sources

***Primary Source*:** The data needed for the research were collected from both primary and secondary sources. Primary data was collected from household surveys using questionnaires, FGDs (focus group discussions), interviews and field observations.

***Secondary Source*:** In addition to above mentioned primary sources, secondary sources such as books, articles, internet sources, climate/meteorological data, and journals were used to collect all the necessary data. And from the woreda's agricultural office relevant reports and documents were collected and used as secondary sources of data, (see table 1.1)

Table 1.1: Secondary data collected

SN	Data Type	Year
1	Agricultural production of Alamata woreda	2001-2010
2	Livestock population of Alamata woreda	2001-2011
3	Demographic and area coverage of *Tabias (kebelles)* by square kilometer	2008
4	Rainfall data	1982-2007
5	Temperature data	1984-2009
Maps		
6	Alamata woreda *tabias*	2009
7	Annual temperature of Alamata woreda	2009

1.5.2. Methods of Data Collection

1.5.2.1 Interview

In-depth interview were carried out with a knowledgeable and experience-rich personality, particularly aged people who are believed to have good and long time experience in farming and livestock rearing were the targets. In addition, relevant researchers and officials were consulted specially regarding impacts of climate change on agricultural farming, livestock production, grazing land and water resources management.

The officials of the Alamata agricultural research center were considered in the interview session, because the center plays a great role in resource management and other development activities of the woreda.

1.5.2.2 Focus Group Discussion

Focus group discussion (FGD) or sometimes known as Focus group interview, as one data gathering tools, has various advantages. Firstly, it is a highly efficient technique for data collection since the amount and range of data increased by collecting from several people at the same time. Secondly, natural quality control on data collections operate, for example, participants tend to provide check and balance on each other's view. Thirdly, group dynamic help in focusing on the most important topics and it is fairly easy to assess the extent to which there is a consistent shared view.

Finally, people who cannot read and write or other who have other specific difficulties is discriminated against (Robson, 2002). Focus Group Interview were used to get general information in climate condition of the woreda whether it has changed or not, impacts of climate change on livelihood of the society, and their coping and adaptation methods. For this purpose 15 persons, 5 from each of the sample *tabias* were selected based on purposive sampling method.

1.5.2.3. Observation

Observation techniques are methods by which an individual or individuals gather first hand data on programs, processes, or behaviors being studied. They provide evaluators with an opportunity to openly explore the relevant topics. Mikkelsen Britha (2002) suggested that observation provides important information during all phases of study.

Thus, observation of the people's life, their assets and resources, the ups and downs to overcome their daily struggle, their activities for living, etc, would provide valuable and supportive information. Having a good look at physical and socio-economic infrastructures, the land use, housing conditions, the different economic activities people are involved with would provide valuable contributions to understand the existing real situations of the rural poor.

Thus in this study an attempt was made to carefully observe every situation and understood them fully. During observation, field notes and photographs of some important sites and practices were taken.

1.5.2.4. Informal Discussion

Informal discussions were carried out with some individuals. Informal discussions were accomplished while observation was going on, women, elders and youngsters were part of the discussion from *Garjalle* and *Selambkalsi tabias*. It is intended to get more information, from those with whom discussion carried out, in addition to other data gathering tools.

The discussion were conducted purposely because the researcher believes that it was when someone informally discuss with others that he/she can get more information; that is in case of informal discussion, people with which the researcher discussed about the issue under study freely narrate as usual without suspecting to tell truth.

1.5.3. Sampling Design and Selection of Case Study Area and households

The rationale for the choice of Alamata woreda for the study is based on its narrow range of agro-ecological conditions, and it is ideal or representative for mid and lowland areas where mixed farming exists. Furthermore, according to the socio-economic activity and geo-ecological location criteria of the woreda is categorized as a hotspot for climate change/variability impacts.

More than 75% of the woreda is lowland accordingly many of the *tabias* are located in the very extensive plain area and although most people of the areas are food insecure. Last but not least as the writer was grow up in the woreda there was no communication barrier either respondents to interact and deal with all matters related to the research activities.

Within the woreda there are 10 rural *tabias (kebelle)* and 2 towns. And the researcher was focused on rural *tabias* of the woreda. To make the research manageable in terms of financial and time constraints out of 10 rural *tabias* only 3 or 30% were selected namely *Garjalle, Timuga and Selambkalsi*. The 3 *tabias* were selected using simple random sampling method. From the 3 *tabias* 96 household heads were selected based on purposive proportional sampling method to fill/answer questionnaire.

The sampling system considered different wealth and age groups, male and female headed households. And another 15 persons (5 from each of the 3 *tabias*) were selected for FGD (Focus Group Discussion) and the focus group discussion was held once at each of the *tabias.* And finally another 15 household heads (5 from each), and 5 local DA officials of the woreda were selected purposively for interview.

Table 1.2: Sampling distribution

Tabias /Kebelles	Population(HHs) Size			Sample size		
	Male	Female	Total	Questionnaire	Interview and FGD	Interview (DAs)
Garjalle	696	189	885	31	5+5	5
Timuga	761	304	1065	37	5+5	
Selambkalsi	604	206	810	*28*	5+5	
Total	2071	699	2770	*96*	30	5

About 131 persons were participated while the research was held in the study area. This accounts for about five percent of the total household populations in the study *tabias*.

1.5.4. Data Analysis and presentation

1.5.4.1. Data Analysis Techniques

Qualitative data analysis was accomplished by developing and administering a series of analytical questions specially, during the administration of questions for interview and again by comparing data across sources. Quantitative data analysis was carried out using graphs, tables and percentages, descriptive statistics, time series regression analysis as necessary.

1.5.4.2. Presentation of Data

After collecting the expected data from sample households' qualitative data was presented in narrative form and percentages. And the quantitative data was presented

using graph, percentage, and time series regression analysis and table form. This is the form by which quantitative data such as human and animal population, rainfall and temperature pattern and trends were analysed.

1.6 Delimitation of the study

The area delimitation of this study was Alamata woreda. Rural *tabias* of the woreda were the concern of the study. And from the 10 rural *tabias* of the woreda only three of them were focus of study.

1.7 Limitation of the Study

This study had limitation in relation to number of sample size this is because of time and financial constraints. Some farmers were not willing to fill questionnaires and participate on FGD. Shortage of adequate secondary source of data was also another problem.

1.8 Significance of the Study

Climate change and variability in Ethiopia has become a challenging factor for its development strategies. And this study was assessed the impact of climate change on rural livelihood of Alamata woreda and farmers adaptation methods. Since this issue is the concern of the world especially developing countries who have limited capacity for adaptation of climate induced shocks, this study may contribute little about how to cop up and adapt the impacts of climate change.

In addition to the above point, this study can provide climate related information about the woreda and helps other researchers and policy makers.

Chapter Two

Review of Related Literature

2.1. Climate Change and variability

The Earth's climate has changed throughout history. Just in the last 650,000 years there have been seven cycles of glacial advance and retreat, with the abrupt end of the last ice age about 7,000 years ago marking the beginning of the modern climate era-and of human civilization. Most of these changes are attributed to very small changes in the Earth's orbit changing the amount of solar energy the Earth receives. The current warming trend is of particular significance because most of it is very likely human-induced and proceeding at a rate that is unprecedented in the past 1,300 years.

The climate of a place or region has changed over an extended period (typically decades or longer). There is a statistically significant change in measurements of either the mean state or variability of the climate for that place or region. Changes in climate may be due to natural processes or persistent anthropogenic factors that caused in atmosphere or in land use systems (UNFCCC, 2006). Climate change has the potential to undermine sustainable development, increase poverty, and delay or prevent the realization of the development goals proposed by every nation.

Climate change can influence humans directly, through impacts on health and the risk of extreme events on lives, livelihoods and human settlements, and indirectly, through impacts on food security and the viability of natural resource-based economic activity. Competition for scarce resources, such as fresh water, land or fishing grounds, brought about by changes in climate, has the added potential to cause conflict over resources with impacts on the achievement of the development goals, and on human migration. For example, in Africa increased pressure on resources related to food and water insecurity can deepen tensions between communities and ethnic groups resulting in violence and war (Oxfam 2006; Sachs 2007).

As cited in Aklilu A. and Alebache a. (2009), Erikson (2008) noted that, the direct effects of climate change include changes in rainfall, temperature, soil moisture, and sea level.these changes could have adverse effects on ecological system, human health, and the various social and economic sectors. The impacts on countries of the world may range from sea-level rise , melting ice capes and glaciers in the polar and coastal regions along with increased incidences of catastrophic drought, flooding and disease burdens in the tropics and sub-tropics. However, the most problematic impacts would occur in poor countries that are heavily dependent on climate sensitive economies and have least adaptive capacities to the changes.

When dealing with issues of climate change, it is important to understand the different terms used as "packages" in understanding the system. Accordingly, "climate variability" is the fluctuation in climatic parameters from the normal or baseline values, whereas "climate change" is a change in the long-term mean value of a particular climate parameter Olmens S. (2001). So generally Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales.

2.2. Causes and Evidences of Climate Change

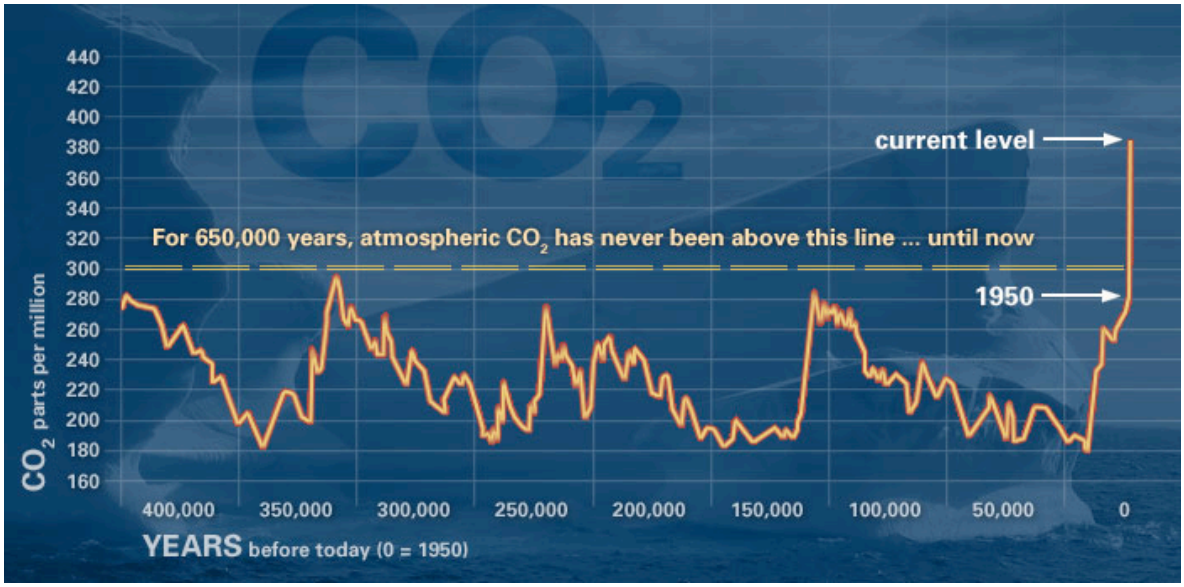
The world has approximately 100 years of climate records throughout the globe. These 100 years have witnessed an increased of GHGs and change in the climate system. Extreme weather events and longer term climatic change have both exerted substantial influences on economical and social history (Balling1997). Climate change, driven by fossil fuel combustion and deforestation, is a becoming threat to lives and livelihoods in every part of the world at this time (Ackerman**,** 2009**).** Evidence of climate change and variability has been presented both from empirical data and perception. In the light of incontrovertible evidences of a more fundamental shift in the climate, research in to how we could adapt to this would be paramount.

At global scale, the main cause of climate change is growing concentration greenhouse gas (GHG) emissions of mainly carbon dioxide (70%), primarily coming from burning

of fossil fuel (petroleum) imported from industrialized countries, while other sources GHG are methane and nitrous oxide which are caused by deforestation and agricultural activities particularly, the use of pesticides. Most scientists agreed that, the main cause of the current global warming is human expansion of the "greenhouse effect". Accordingly the earth will be warmed when the atmosphere traps heat radiating from the earth to space and reradiating back to the ground. Gases that contribute to the greenhouse effect include: water vapor, carbon dioxide (co_2), methane, nitrous oxide and chlorofluorocarbons (CFCs).

The role of human activity; In its recently released Fourth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC), concluded there is more than 90 percent probability that human activities over the past 250 years have warmed our planet.

The industrial activities in the developed nations caused rise in atmospheric carbon dioxide levels from 280 parts per million to 379 parts per million in the last 150 years. The panel also concluded there's a better than 90 percent probability that human-produced greenhouse gases such as carbon dioxide, methane and nitrous oxide have caused much of the observed increase in Earth's temperatures over the past 50 years. **(http://www.ipcc.ch/pdf/assessmentreport/ar4/syr/ar4_syr_spm.pdf.)**



This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO_2 has increased since the Industrial Revolution. (Source: NOAA)

Scientists who support the global warming and climate change usually incorporate the challenges to develop a better hypothesis to explain the environmental data. Against the skeptics, IPCC and other scientists who support human induced climate change are presenting different evidences. Calvin, (2008), shares the idea of human induced climate change, he suggested that we cause our planet to run fever and now we have entered a period of consequences. The scientific evidence is clear: global climate change caused by human activities is occurring now, and it is a growing threat to society. American Geophysical Union stated that "Human activities are increasingly altering the Earth's climate. These effects add to natural influences that have been present over Earth's history. Scientific evidence strongly indicates that natural influences cannot explain the rapid increase in global near-surface temperatures observed during the second half of the 20th century (http://www.globalissues.org/issue/178/climate-change-and-global-warming).

Evidences of climate change: Some evidences of the rapid climate change are sea level rise, global temperature rise, shrinking ice sheets, warming oceans, declining Arctic sea ice, glacial retreat, ocean acidification and extreme events.

2.3. Vulnerability to Climate Change

Vulnerability to climate change refers to the magnitude of harm that would result from a particular hazardous event of climate on society over specific place and time. The concept recognizes, for example, that different sub-types of a receptor may differ in their sensitivity to a particular level of hazard. Therefore climate vulnerability defines the extent to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. It depends not only on a system's sensitivity but also on its adaptive capacity. Fussel (2007) and Fussel and Klein (2006) argued that the IPCC (2001) definition, which conceptualizes vulnerability to climate as a function of adaptive capacity, sensitivity, and exposure, accommodates the integrated approach to vulnerability analysis.

The term ‘vulnerability’ is used in many different ways by various scholarly communities. The ordinary use of the word ‘vulnerability’ refers to the capacity to be wounded, i.e., the degree to which a system is likely to experience harm due to exposure to a hazard (Fu¨ssel, 2006, as cited in Turner II et al., 2003). There is confusion arising from different usages of the term vulnerability. Brooks, (2003) has grouped the term vulnerability as “social vulnerability” and “biophysical vulnerability.

Kelly and Adger, (2000), defines social vulnerability in terms of the capacity of individuals and social groupings to respond to , to cope with, recover from or adapt to – any external stress placed on their livelihoods and well-being. The focus is on socioeconomic and institutional constraints that limit the ability to respond effectively.

Downing et al. (1996) also define vulnerability as the exposure to contingencies and stresses, and difficulty coping with them. In this definition vulnerability has two sides; an external side of risk, shocks and stresses which an individual or household is subject; and an internal side which is lack of means to cope without damaging loss. From this point of view the most vulnerable individuals, groups, classes, and regions are those most exposed to perturbations, who possess the most limited coping capacity and suffer from the impacts of climate change and who are endowed with tightly circumscribed potential recovery.

The African continent is more vulnerable to effects of climate change and variability. As a result of global warming, the climate in Africa is predicted to become more variable, and extreme weather events are expected to be more frequent and severe, with increasing risk to health and life. Arid and semi-arid regions are more vulnerable especially in Western and eastern part of the continent. This includes increasing risk of drought and flooding in new areas and inundation due to sea-level rise in the continent’s coastal areas Mironer . (2009).

Agricultural production relies mainly on rainfall for irrigation and will be severely compromised in many African countries, particularly for subsistence farmers and in sub-Saharan Africa. Under climate change much of agricultural land will be lost, because of shortening growing seasons and lowering yields. National communications report that

climate change has caused a general decline in yield of most of the subsistence crops, e.g. sorghum in Sudan, Ethiopia, Eritrea and Zambia; maize in Ghana; Millet in Sudan; and groundnuts in Gambia. Of the total additional people at risk of hunger due to climate change, although already a large proportion, Africa may well account for the majority in the future (UNEP 2006).

Africa is vulnerable to a number of climate sensitive diseases including malaria, tuberculosis and diarrhea Bohle, H., Downing T. and Watts, M. (1994). Under climate change, rising temperatures are changing the geographical distribution of disease vectors which are migrating to new areas and higher altitudes, for example, migration of malaria mosquito to higher altitudes will expose large numbers of previously unexposed people to infection in the densely populated east African highlands. Climate change is an added stress to already threatened habitats, ecosystems and species in Africa, and is likely to trigger species migration and lead to habitat reduction. Up to 50 per cent of Africa's total biodiversity is at risk due to reduced habitat and other human-induced pressures, Boko et al. (2007).

2. 4. Coping Strategies to Climate Change

Coping strategies to climate change are immediate response of a society to the happened hazards. As compared to adaptation strategies, coping strategies are strategies which are not well planned. The means by which people or organizations use available resources and abilities to face adverse consequences that could lead to disasters are the common coping strategies. The strengthening of coping capacities usually builds resilience to withstand the effects of natural and human-induced hazards (UN/ISDR, 2004).

In Africa there is a large body of knowledge and experience within local communities on coping with climatic variability and extreme weather events. Local communities have always aimed to adapt to variations in their climate. To do so, they have made preparations based on their resources and their knowledge accumulated through experience of past weather patterns. This includes times when they have also been forced to react to and recover from extreme events, such as floods, drought and hurricanes.

Coping strategies are an important element of planning for adaptation. Climate change is leading communities to experience climatic extremes more frequently, as well as new climate conditions. Traditional knowledge can help to provide efficient, appropriate and time-tested ways of advising and enabling adaptation to climate change in communities who are feeling the effects of climate changes (UNFCCC 2006).

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. These include intercropping and crop diversification; use of home gardens, diversification of herds and incomes, such as the introduction of sheep in place of goats in the Bara province in Western Sudan, pruning and fertilizing to double tree densities and prevent soil erosion in semi-arid areas, e.g. Senegal, Burkina Faso, Madagascar and Zimbabwe; manipulation of land use leading to land use conversion, e.g. a shift from livestock farming to game farming in Southern Africa; water conservation techniques to cope with arid conditions such as the *Zaï* technique in Burkina Faso, (UNFCCC 2006).

Farmers dig pits in the soil to collect organic material carried by the wind during the dry season, at the start of the rainy season farmers add organic matter from animals which attracts termite activity resulting in termite tunnels that can collect rain deep enough that it doesn't evaporate, and thus increasing soil fertility. In many locations especially in east African pastoralists/tribal and individual movements and migration are also identified as adaptation options, Mworia, & Kinyamario (2008).

2.5. Adaptation to Climate Change

Adaptation as applied to climate change is a very broad concept, and the concept is defined differently in the literature, as indicated below:

Adaptation to climate change 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). Adaptability refers to the degree,

to which adjustments are possible in practices, processes, or structures of systems to projected or actual change in climate.

Concerning the adaptation scenario, Tol *et al*. comment that former studies often assumed "limited capacities of farmers to adapt to changing circumstances". (Tol 2002). Perfect adaptation is less realistic as imperfect information, limited access to technology and institutional weaknesses reduce the extent and effectiveness of adaptation. There are two main types of adaptation, autonomous and planned adaptation. Autonomous adaptation is the reaction of, for example, a farmer to changing precipitation patterns, in that s/he changes crops or uses different harvest and planting/sowing dates. Planned adaptation measures are conscious policy options or response strategies, often multisectoral in nature, aimed at altering the adaptive capacity of the agricultural system or facilitating specific adaptations. For example, deliberate crops selection and distribution strategies across different agriclimatic zones, substitution of new crops for old ones and resource substitution induced by scarcity (Easterling 1996).

Adaptation to climate change in developing countries is vital and has been highlighted by them as having a high or urgent priority. Some countries are more able to adapt to climate change than others. Adaptive capacity is especially limited in less-developed countries. This is mainly due to a lack of financial resources, resulting in a local workforce that does not have the skills or technology to adapt to climate change efficiently and effectively. Countries with limited economic development and those who rely on rain-fed agriculture in the form of subsistence farming or fishing are the more vulnerable to the impacts of climate change. Drastic changes in ecosystems could have a rapid impact on the livelihoods of local communities that rely on poor livelihood standards. However, developing countries have limitations in capacity making adaptation difficult. Limitations include both human capacity and financial resources, Ellina L. and DennisT. (May 2006).

Outputs from the UNFCCC (2007) workshops and meeting highlighted that the most effective adaptation approaches for developing countries are those addressing a range of environmental stresses and factors. Strategies and programs that are more likely to succeed need to link with coordinated efforts aimed at poverty alleviation, enhancing

food security and water availability, combating land degradation and reducing loss of biological diversity and ecosystem services, as well as improving adaptive capacity. Sustainable development and the Millennium Development Goals (MDGs) are necessary backdrops to integrating adaptation into development policy.

Adaptation is recognized as a critical response to the impacts of climate change, because current agreements to limit emissions, even if implemented, will not stabilize atmospheric concentrations of greenhouse gases and climate change (NAPA, 2007). Adaptation is adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities whereas mitigation of climate change is a human intervention aimed at reducing the sources or enhancing the sinks of greenhouse gases (F¨ussel, 2000).

According to the IPCC Third Assessment Report, adaptation has the potential to reduce adverse impacts of climate change and to enhance beneficial impacts, but will incur costs and will not prevent all damages. Furthermore, it is argued that human and natural systems will, to some extent, adapt autonomously and that planned adaptation can supplement autonomous adaptation. However, options and incentives are greater for adaptation of human systems than for adaptation to protect natural systems (IPCC 2001, quoted in Olmes, 2001).

2. 6 Agriculture and Climate Change

Increased intensity and frequency of storms, drought and flooding, altered hydrological cycles and precipitation variance have implications for future food availability. The potential impacts on rain-fed agriculture irrigated systems are still not well understood. The developing world already contends with chronic food problems. Climate change presents yet another significant challenge to be met. While overall food production may not be threatened, those least able to cope will likely bear additional adverse impacts (WRI, 2005). The estimate for Africa is that 25–42 percent of species habitats could be lost, affecting both food and non-food crops.

Habitat change is already underway in some areas, leading to species range shifts, changes in plant diversity which includes indigenous foods and plant-based medicines (McClean, Colin *et al*., 2005). In developing countries, 11 percent of arable land could be affected by climate change, including a reduction of cereal production in up to 65 countries, about 16 percent of agricultural GDP (FAO Committee on Food Security, 2005).

The impact of climate change and variability in the agriculture sector of humid and sub-humid tropics has negative consequences. Agriculture, particularly in the sub-humid areas, is vulnerable to many environmental hazards including frequent floods, droughts, tropical cyclones, storm surges and high temperatures. Low-income rural populations that depend on traditional agricultural systems or on marginal lands are particularly more vulnerable. Agricultural vulnerability to, climate change will lead to unsteady crop production and food security will face great threat, FAO (2005).

Similar to agricultural farming the impact of climate change and variability in the livestock production is generally negative. Heat stress and its impact on seasonal water availability have a variety of detrimental effects on livestock, with significant effects on milk production and reproduction in dairy cows, and swine fertility. Pastures and rangelands are vulnerable to the climate variability particularly increased variability of precipitation. So generally livestock distribution and productivity could be indirectly influenced by the changes in the distribution of climate variability induced livestock diseases in Africa, (Pastoralism, 2010).

Agriculture is the basis for the livelihood of millions of people in the developing world. However, changes in the normal pattern of climate affects agricultural production (crops and livestock) by reducing the length of growing periods and forcing marginal areas out of production. According to reports of the (IPCC), the projected yield reduction due to climate change in some poor countries could be as much as 50% by 2020. As cited in A.Amsalu and A.Adem, (2009) an estimate by URT (2003) also showed that there would be a significant decline in the production of certain agricultural food crops in Africa (millet yields by 20 – 76% and sorghum by 13 – 82% in Sudan, maize yields by 33% in

Tanzania). NMSA (2001) predicted a reduction of wheat yield by 10.6% to 18.5% in central Ethiopia.

2. 7. Impact and adaptation of climate change in Ethiopia

In the past centuries and at present, there is a widespread cultural belief among the rural communities (farmers and pastoralists, Christians and Moslems) that drought and famine are acts of God against human sin (McKee 2008, Mesfin 1991, Pankhurst 1985). In this regard, in his famous work on famine and epidemics, Pankhurst underlined that "several subsequent epidemics and famines are mentioned in the literature of the thirteenth and fourteenth centuries which suggests that such outbreaks were regarded as punishments sent down by God" (Pankhurst 1985). And, it was acknowledged that the level of information and knowledge on climate change impacts in several sectors of East Africa is exceedingly patchy, generally poor to moderate only, Mironer S.M. (2009).

Ethiopian climate is characterized by a history of climate extremes, such as: droughts and floods; and increase and decreasing in temperature and precipitation, respectively. The history of climate extremes, especially drought, is not a new phenomena in Ethiopia. Recorded history of droughts in Ethiopia dates back to 250BC. Since then, droughts have occurred in different parts of the country different times (Webb and von Braun 1994). Even though there is a long history of droughts in ethiopia, studies show that the frequency of droughts has increased over the past few decades, especially in the lowlands (Lautze et al. 2003; NMS 2007).

Studies also indicate that mean temperature and precipitation have changed over time. According to NMSA (2001), the average annual minimum temperature over the country have increased by about 0.25 ^{O}c every 10 year, while the average annual maximum temperature has increased by about 0.1 ^{O}c every decade. The average annual rainfall of the country showed a very high level of variability over the past years, even though the trend remained more or less constant (NMS 2007). Drought in Ethiopia can shrink a household from production by up to 90% of a normal year output (World Bank 2003). Most often, many farmers of hunger or depend on foreign food aid during extreme

drought periods. For instance, during the 1983/84 drought periods, about one million people died due to drought that led to famine.

The vulnerability of Ethiopian farmers to climate change is attributed to their dependence on rain-fed agriculture and high poverty. Rain-fed agriculture, which supports the livelihood of the majority of the population, is highly sensitive to climate conditions. It is characterized by: highly erratic rainfall, frequent droughts that often cause the famines; and intensive rainfall that often cause floods. Given the dependence of the economy on agriculture and the dependence of agricultural sector on climate conditions, especially rainfall, the macroeconomic performance of the country follows rainfall patterns.

According to (Ringer 2008) as cited in (Yohannes, 2009), in Ethiopia, it is assumed that the temperature has been increasing annually at the rate of 0.2°c over the past five decades. This has already led to a decline in agricultural production, and cereal production is expected to decline still further (by 12%) under moderate global warming. Moreover, it has led to a decline in biodiversity, shortage of food and increase in human and livestock health problems, rural-urban migration and dependency on external support.

In countries like Ethiopia, where more than 85% of the people depend mainly on agriculture for their livelihoods, rendering them very vulnerable to climate variability and change. Accordingly, in recent times, a significant number of people in Ethiopia are being affected chronically by recurring droughts, leading to deaths and loss of assets and to an appeal for international support.

The problem is very serious in the arid and semi-arid areas, especially among the pastoralists. Poverty, limited resources, little alternative sources of income and livelihoods, lack of knowledge and expertise, and the absence of appropriate public administration and financing, increase vulnerability and decrease people's capacity to cope (Wondwossen 2008). Even relatively small shifts in the growing season, can spell disaster for the poorest farmers and pastoralists who are already struggling in poverty.

In Ethiopia, Deressa et al, (2008) have conducted an integrated quantitative vulnerability assessment for seven regional states of the total eleven regions by using biophysical and social vulnerability, the study has found that decline in precipitation and increase in temperature are both damaging to Ethiopian agriculture. The result of the study have further pointed out that some Regional States of Ethiopia like Afar, Somali ,Tigray, Oromiya and Amhara are the most vulnerable regions to climate change impacts.

Women and girls in particular are disproportionately affected by climate variability. In times of crisis, women tend to stay home with their children, while men move away to look for alternative means of survival. Women also have fewer options to find other ways of making a living, especially since women's literacy rate is not even half of that of men. The traditional systems in Ethiopia are also not given a say to women in household decisions and are frequently without cash savings or assets to sell to buy food and other basic items, Devereux, (2000).

Because of the long history of climate variability and change the local people have developed some deep-rooted adaptation mechanisms and competencies. In other words, adaptation to climatic variability is a way of life and not new to Ethiopians.

In the arid and semi-arid areas of Ethiopia, drought is part of a normal cycle. Small-scale farmers and pastoralists in Ethiopia are adopting a variety of coping mechanisms. In the farming areas, many are shifting to more drought tolerant crops and varieties, improved forest management practices, diversified energy sources, and alternative means of income from off-farm activities. Pastoralists have also divided pasture into wet and dry season grazing areas to better manage risk, while others have changed the composition of their heard from cattle to camels and goats, which can better tolerate dry or hot weather, Devereux, (2000). Both household and public level climate risk management through mitigation and coping practices are under taken to reduce the damages from climate change. Risk mitigation strategies at household level includes; selling productive assets, selling of livestock and agricultural products; reducing current investment and consumption, child labour; temporary or permanent mitigation; mortgaging of land, and use of inter-household transfers and loans. A country level study conducted by MoFED (2007) on the ability of farmers to cope with the shocks revealed that the main coping

strategies include, selling of animals, loans from relatives, selling of crop outputs and own cash.

Public level risk mitigation strategies include: water harvesting, resource conservation and management, irrigation, voluntary resettlement programs, and the newly pilot studies (namely weather-index drought insurance and commodity exchange programs). Coping strategies include; free food distributions (mainly from food aid), and food for work programmes (MoFED; Devereux and Guenther 2007). Food aid has become one of the most important coping strategies to fight drought and famine. For instance, Ethiopia required about 896,963metric tones of food aid during the 2000/2001 drought period and needed about 455 million dollat worth of food ain during the 2008/2009 drought period (GOE 2009).

Every though they are very important for reducing vulnerability, both the household and public level risk mitigations as coping strategies have not proven to be wholly effective. Household risk management strategies are ineffective mainly due to the fact that, they achieve partial insurance at a very high cost, they are localised, they are limited in scope, and informal insurances marginalize the most vulnerable and have very high hidden costs (World Bank 2003). The limitation of public risk management strategies include; limitation of coverage, weak institutional linkages among stakeholders dealing with the risk management, poor early warning mechanisms, and dependence on foreign source for food aid (World Bank 2003; Devereux and Guenther 2007).

Chapter Three

Description of the Study Area

This chapter describes the study area, Tigray region in general and Alamata woreda in particular. It provides the physical feature, resource basis, demographic characteristics and socioeconomic standards.

3.1 The Tigray National Regional State

The Tigray national regional state was established in 1993 as one of the nine regional states of Ethiopia. It is located in the north eastern part of the country between $12^0$15'N and $14^0$57'N latitude and 36^0 27'E and 39^0 59'E longitude. It covers 53000 square kilometers area (Solomon 2005). The region is bounded by Eritrea to the north, the Sudan to the west, and the Ethiopian regions of Amhara and Afar to the south and the east respectively.

Administratively it is divided in to 6 zones, 34 rural districts (woredas) and 12 town districts. Each district is subdivided in to *tabias* and each *tabia* is divided into *kushet*, which are the lowest administrative hierarchy. The delineation is made based on natural boundaries like rivers, escarpments and mountain peaks; settlement, population size, agro-ecology and convenience and proximity to administration centers.

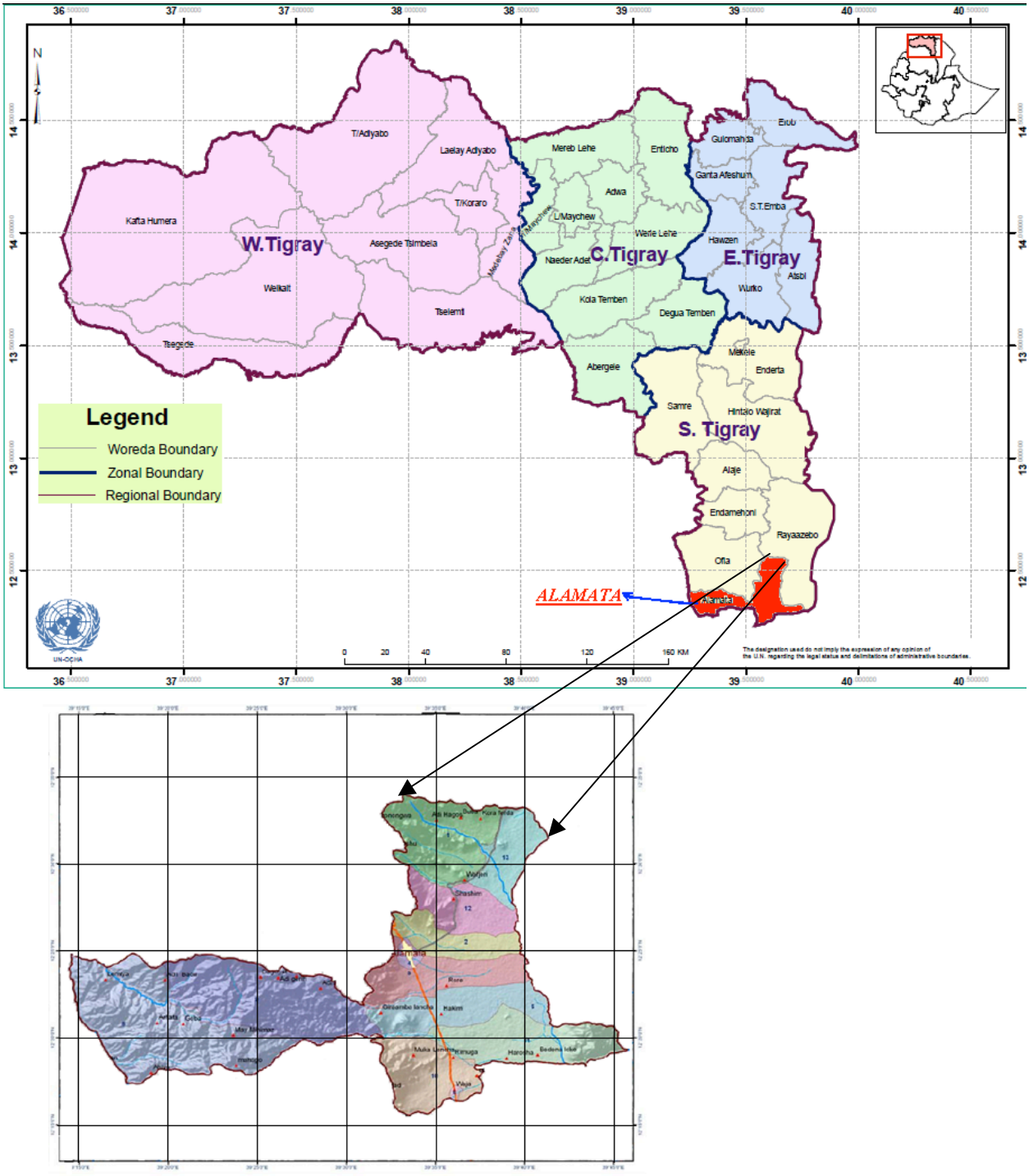


Figure 3.1: Administrative Map of Tigray Region and Alamata woreda

3.1.1 Agro-ecological Zones and Climate

The topography of Tigray region contains three main traditional divisions; kola-lowlands (1400-1800 meters above sea level) with relatively low rainfall and high temperature, woina dega -middle highlands (1800-2400) with moderate amount of rainfall and temperature, and dega -highlands (2400-3400) with somewhat higher rainfall and cool temperature. On the basis of altitude six major agro ecological zones are identified; upper dega, dega, weyna dega, upper kolla, lower kola and wurch (Bureau of Finance and Economic Development, 2007).

The climate condition of the region is direct reflection of its altitude. The recorded annual mean temperature of the region ranges from 12^0c in the highland to 37^0c in the lowlands of *Humera*, which is semi-arid kola. The annual mean temperature for most part of the region is between 15^0c - 21^0c.

The highest rainfall in the region occurs during summer season which starts in the middle of June and ends up in the early September. Rainfall distribution in the region is characterized by high temporal and spatial variability with annual precipitation ranging from 500-1000 mm (Ethiopian National Meteorology Agency, 2007)

3.1.2 Land use and land cover pattern

The main types of land use and land cover patterns in the region are bush and shrub land (36.2%) cultivated lands (28.2%), and grass lands (22.8%). Other forms of land use cover account for 10.81% of the land mass (Bureau of Finance and Economic Development, 2007). Cultivated land is dominant land use in areas of high population density. The natural forest resource of the region is overexploited and covers only about 0.2% of the total land area.

3.1.3 Demography and Socio-economic setting of the Region

The population of Tigray is 4.3 million, with an average family size of five persons per household (Central Statistical Agency 2008). According to the 2007 census, the population is growing at 2.5 per year and population density is 63 persons per square kilometer (CSA 2008). However, other studies indicate that in the highland areas the average density is 137 persons per square kilometer, showing that there is high population pressure in highlands (Pander and Gebremedhn 2004).

Eastern zone is relatively densely populated while western part of the region is sparsely populated zone. The proportion of population under age 15 years is 43.7 percent of the total population in the region. On the other hand the proportion of aged 65 and above is only 4.4 percent while the proportion of active labor force (16-64 years) is 51.9 percent.

Agriculture is the mainstay of the region's economy which contributes about 57 percent of the gross domestic product (GDP), of which 36% is from crop production and about 17% and 4% is from livestock and forestry respectively. Rain-fed crop production is the main economic activity for over 80% of the population. Major crops are sorghum, barley, teff, finger millet, wheat and maize accounting for 26%, 16%, 12%, 11%, 9% and 7% of the total area respectively (Girmay 2006).

3.2. Description of Alamata Woreda

Almata woreda is one of the 8 woredas of the Southern Zone of Tigray region. It is located 600 km north of Addis Ababa and about 180 km south of the Tigray Regional capital, Mekelle. It is farthest south woreda of the Region: It borders with Amhara region from the south and west and Afar region in the east and Ofla woreda in the north. Geographically the woreda is situated between 12° 15′ 0″ N and 12° 25′ 0″ N Latitude and 39° 15′ 0″ E and 39° 45′ 0″ E longitude. The total area of the woreda is estimated at 550 sq. km.

There are 10 Rural *Tabia (Kebele)* Administration units and 2 towns with in the woreda. The total population of the woreda was 132,059 in 2007. According to Table 3.1, the areas of 10 *tabias* range from 11 sq. km. (*Merewa*) to 87.29 sq. km. (*Selen Weha*).

Table 3.1: Name of *tabia* administration units and towns of Alamata Woreda

Number	Name of *Tabia*	Male HHs	Female HHs	Total	Area (km^2)
1	*Kulugize Lemlem*	401	198	599	37.2
2	*Selam Bekalsi*	604	206	810	68.855
3	*Limaat*	74	211	939	21.80
4	*Tumuga*	761	304	1065	50.86
5	*Selen Weha*	626	361	1187	87.29
6	*Tao*	699	196	895	37.945
7	*Laelay Dayu*	762	213	975	51.70
8	*Gerjelle*	696	189	885	54.295
9	*Merewa*	916	230	1146	11.125
10	*Tsetsera*	730	177	907	75.58
11	*Alamata* town*	9085	6094	15179	**
12	*Waja* town*	2515	1645	3650	**
Total		18869	9024	27893	496.35

** Missing data

Source: Alamata Woreda Office of Agriculture, 2010

Based on socio-economic profile of (Southern Zone of Tigray Regional State 2009) Alamata woreda is inhabited high population number, and from the woredas total population about 62% of the total population live in town and the remaining 38% of the total population live in the rural part of the woreda. The female population accounts for 47.41 of the urban and 48.59% of the rural population. According to the same census report the household size is 4.8 for rural and 3.2 for urban.

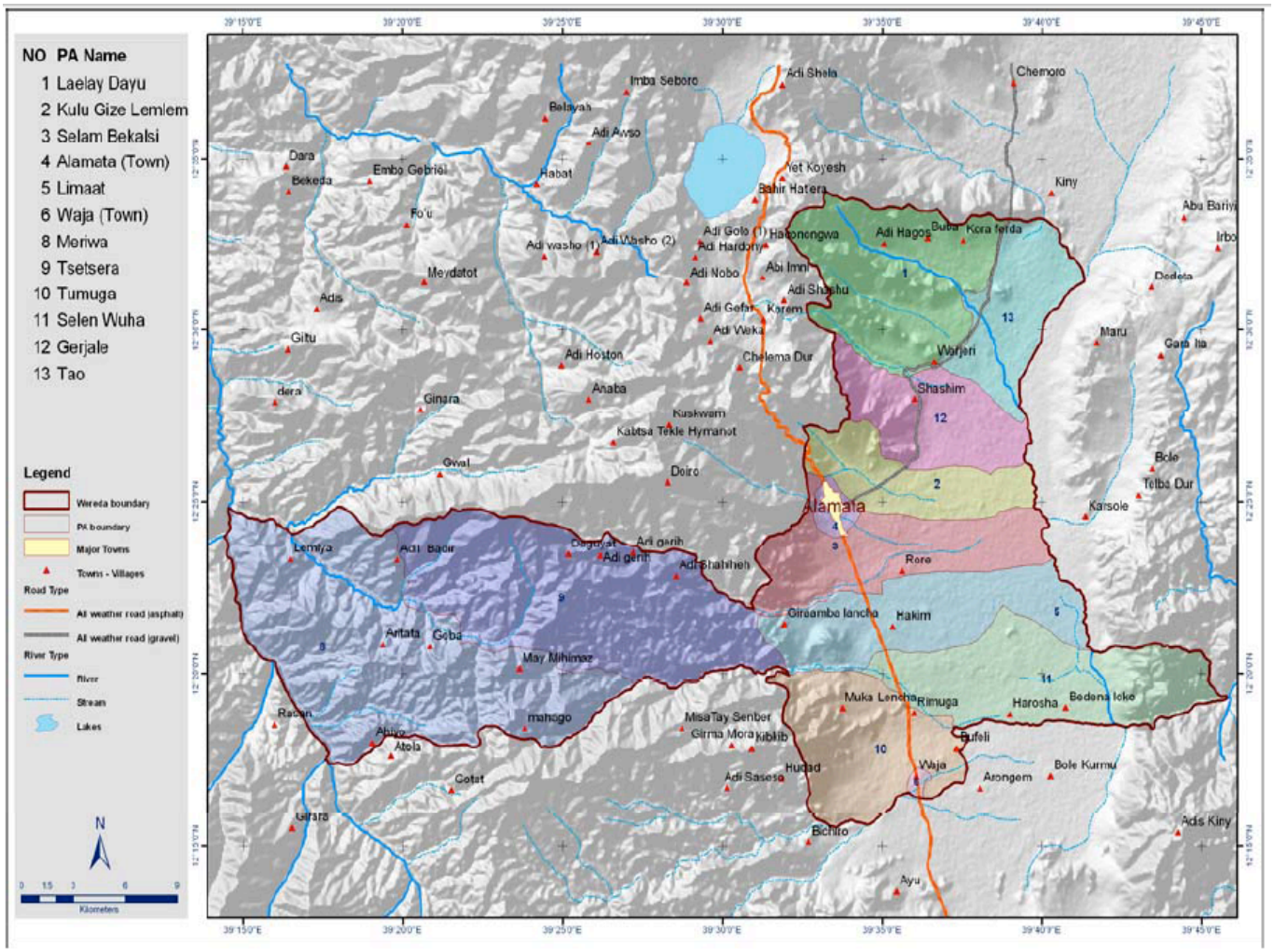


Figure 3.2: Alamata woreda *tabias*

3.2.1 Relief and Natural Resource of Alamata woreda

Altitude of Alamata woreda ranges from 1178 to 3148 masl (meter above sea level) and 75% of the woreda is lowland, 1500 masl or below, and only 25% is found in intermediate highlands between 1500 and 3148 masl.

The small undulating mountains surrounding the woreda are very steep and have low vegetation cover. The mountains and hills cover a large area and slope toward Alamata

valley. The mountains surrounding Alamata cover a large area and have a series of dissected gullies which serve as a source of runoff water to the Alamata valley.

The gullies join together and form rainy season rivers down the foot of the mountains. The dissected gullies slowly spread over the valley depositing silts and water brought down in to the valley.

The fine silt is relatively fertile and the water becomes a source of supplementary irrigation. The Alamata valley is one of the most agriculturally productive and high areas in Tigray region. Farmers in the woreda extensively cultivate cereals and vegetable; and raise mainly goat, sheep and cattle in the valley.

3.2.2 Alamata Woreda Land Cover and Soil Types

Eutric Vertisols, Lithic Leptosols (Cambic) and Lithic Leptosols (Orthic) are the soil types covering nearly 90% of the land in the woreda. Soil pH for profiles tested by Relief Society of Tigray (REST) from the valley bottoms indicate that it ranges from 7.4 to 8.5 and was reported to increase with depth. This characteristic is also believed to render phosphorus and micronutrients unavailable. The soil for majority of the valley bottom is Vertisols.

Traditionally, fertility of the soils on the plains is believed to be fertile because of the silt coming from the adjacent mountains. The mountains in the western and northern parts of the valley are believed to be the major sources of alluvial soil because of relatively higher rainfall in these areas. However, previous studies by the Raya Valley Project indicate that soil fertility is low. However, it is obvious that soil fertility is very poor as could be seen from the performance of crop production.

3.2.3 Water Resource of the Woreda

The lowlands of Alamata woreda are surrounded by a chain of mountains from the east, west and partly north. As a result of this even if sufficient rainfall is not received in the

valley, rainfall from the surrounding mountains become the main sources of water for supplementary irrigation. Therefore rain from the surrounding areas, especially the western and northern highlands are the major sources of supplementary irrigation and enable farmers harvest a reasonable production.

Tigray Commission of Water Resources and REST have developed a series of 30 ponds that could enable supplementary irrigation of 133 ha in the woreda. In addition, primary, secondary and tertiary irrigation canals have also been developed by REST for trapping flood waters that comes from the northern highlands for supplementary irrigation. Spate irrigation is used for crop grown in the area

There are as many as 8 major sources of flood water; one of it was coming from as far away from *Eda Mokeni* (*Maichew*). Farmers are accustomed to directing flood water for supplementing their crops (spate irrigation).

3.2.4 Rainfall and Temperature Condition of Alamata Woreda

The *belg* (short rains) is from January to February and *Meher* (long rains) from July to August. Rainfall is usually intense and short duration. The average annual rainfall of Alamata woreda is 831 mm (REST). The average annual temperature of the woreda varies from 16 °C to 27 °C.

3.2.5 Livelihood Strategies and Classification

Like in most part of Ethiopia, mixed farming dominates the livelihood of the woreda. The empirical data shows that livestock number of the woreda are the second important source of livelihood in the woreda level.

Land is an important asset of households for production of crops and rearing of livestock. Livestock serves as a source of manure and fuel, pay land tax, buy fertilizers and as a saving to buffer bleak seasons of food/seed shortage. Oxen are the major ploughing engines. Donkeys, horses and mules play a significant role in the transportation of people,

water, and goods. Due to the high complexity and strong inter-linkage between crop production and livestock tending, it is difficult to consider the two livelihoods separately.

Mixed farming is the dominant livelihood system of the woreda farmers. Crop production practiced both in the lowland and midlands. Teff, sorghum, maize and livestock farming system is dominant in the lowland (8 *tabias*). While in the remaining 2 midland *tabias* barley is the dominant crop followed by wheat and pulses. The average land holding size ranges from 0.75-1.25 ha.

The wealth classification criteria for the woreda were not clearly set. But, as in all other rural parts of Ethiopia, livestock (especially camel) ownership and land holding size are the two most important criteria for ones wealth and status measure in the society. The household size is also included in wealth ranking criteria; small family households are considered as better-offs. However, the agricultural production is predominantly subsistent and it is difficult to estimate the household yearly income.

Nevertheless, it is clear that most of the produced crops and livestock or livestock products are used for household consumption. The remaining used for seed and sold to pay credits, government obligations, purchase of fertilizer, household financial expenses and others (CSA 2008).

3.2.6 Livestock Production

Animal resource is one of the potential resources that is not yet exploited in Alamata woreda. The performance (milk, meat, egg and honey production) and contribution to the regional and national economy is very low mainly due to poor management, inadequate and low quality feed supply, and the prevalence of various animal diseases. Animal species reared in the woreda are entirely local breeds except few crosses in one dairy farm in Alamata town. Local breeds popularly known as Raya breed, have high milk yield in good seasons or in areas having good pasture or feed sources.

Table 3.2: Livestock Population of Alamata Woreda

Livestock Species	Population In number 2011
Cows	31442
Oxen	29664
Sheep	45358
Goats	44122
Camel	6308
Donkeys	44122
Mules	426
Horses	31

Source: Alamata Woreda office of agriculture (2010)

Chapter Four

Analysis and Discussions of the Findings

4.1 General Background of Respondents

This section provides the descriptive results of the surveyed households' profile of sex, age, marital status, household size, educational level and means of livelihood.

4.1.1 Household Composition of Age, Sex, Marital Status and Family Size

Demographic variables such as population size and sex composition are important inputs in the process of socioeconomic development planning where its ultimate goal is to improve the welfare of the people.

From the survey, age composition distributions indicated that the percentage of age 40-49, 30-39 and 50-59 were 49%, 25% and 16% respectively. The remaining 6% and 5% of age groups were belonging to greater than 60 and less than 29 ages respectively. The population distribution was such that most of the sample household heads were between the age group of 40 and 49 years followed by 30-39 years, and the average age of respondents was 38.20.

In the survey, demographic information was collected for 71 men and 25 women, with men being more than women. So the sex composition of the sample population covered was 74% male and 26% female. Whilst the survey results indicate that *Garjalle* has 25% male sample population, *Timuga* 27% and *Selambkalsi* 22%. *Timuga* had the highest female headed household population accounted for 12%. And from the surveyed households, about 76% of household heads were married, 21% widowed and divorced, and 3% single or not married.

The result of the study showed that the average household size was 5.4. There is minimal difference in the mean household size across the three *tabias* studied, the smallest being for *Garjalle* (5.1), *Selambkalsi* (5.2) and the biggest for *Timuga* (5.7). Table 4.1 indicates majority of the households' had 5 to 6 members.

Table 4.1: Sex, Marital status and Age structure of the respondent

Tabias	Sex			HH size		Marital status			Age group				
	Male	Female	Total	Total HH size	Average HH size	Single	Married	Divorced & widowed	20-29	30-39	40-49	50-59	>60
	Respondents in %					Respondents in %			Respondents in %				
Garjalle	25	7	32	161	5.1	1	22	10	2	10	16	4	1
Timuga	27	12	39	214	5.7	2	29	7	2	9	18	6	3
Selambkalsi	22	7	29	146	5.2	-	25	4	1	6	15	5	2
Total	74	26	100	521	5.3	3	76	21	5	25	49	15	6

Source; Field survey, 2011

4.1.2 Education Level of Sample Household

The level of education (years of schooling) of a rural household plays an important role in improving the productivity (both at individual and community level) by equipping people with the skills and knowledge to actively participate in the economic endeavors of the society, and in promoting entrepreneurship (Phillips 1994).

Especially level of education in drought prone areas has indispensable contribution to understand the lessons and training given by agricultural experts to adapt the impacts of climate variability.

Therefore an attempt was made to assess the educational level of the respondents. It was found that approximately 81% of the households in the study sites could not read or write and were therefore illiterate, while about 13.5% of the respondents able to read and write only and 5.5% attained primary school education (see table 4.2 below). When education levels were compared with sexes, who were able to read and write and attend primary school, there were higher numbers of men (83%) literate than women (17%).

Table 4.2: Educational characteristics of the sampled households

Tabia	Sex	Level of education					
		Illiterate	Read & write only	Primary	Junior	Secondary	Graduate
		Respondents in %					
Garjalle	Male	20	4	1	-	-	-
	Female	6	1	-	-	-	-
Timuga	Male	21	4	2.5	-	-	-
	Female	9	2.5	-	-	-	-
Selambkalsi	Male	18	2	2	-	-	-
	Female	7	-	-	-	-	-
Total	Male	59	10	5.5	-	-	-
	Female	22	3.5	-	-	-	-
Grand total		81	13.5	5.5			

Source: Field survey 2011

4.1.3 Focus Group Discussion Participants and Key Informants Characteristics

The selection of the focus group and key informant participants sought a balance between males and females, with 55% being male respondents and 45% were females. With regard to age group of participants, all of them were between 40 and 60 years old.

The economic profiles of group interview participants showed that all were farmers but their livelihood depended on different way of life included agricultural farming (43), land renting (29%), oxen rent and livestock keeping (21%), daily laborers' and others (7%). In general, the study took advantage from persons who were prominent (influential persons) who were considered as knowledgeable about the woreda general characteristics especially climate condition of their woreda since they have lived longer years in the study woreda.

4.1.4 Means of Respondents' Livelihood and Farmland Holding

In an agrarian society like Ethiopia, ownership of land, particularly cultivated land as well as ownership of livestock is referred to as productive assets. These assets are a prerequisite in the productive activities for agricultural production. As participants in the focus group noted, land size and land fertility were the most important factors for differences in agricultural production and wealth disparities and difference in coping mechanisms. The research then sought to examine whether land holding per household varied among the samples including household land holding size.

The study indicated that the average household land holding size was 0.88 hectare, which is below to the national average land holding of 1.02 hectare. The study attempted also to compare the overall land holding size among the study groups. The survey showed slight /little variation of land holding per household amongst the surveyed group. However, about half of the households had land holding size less than the average, 54% of them between 0.76 and 1.0 ha and the rest (20%) more than 1.0 ha (see table 4.3)

Table 4.3: Household land holding size (in Hectare)

Land holding (ha)	Frequency	Percent (%)	Cumulative %
Landless	4	4	4
0.25-0.50	6	6	10
0.51-0.75	15	16	26
0.76-1.0	52	54	80
1.1-1.5	13	14	94
1.6-2.0	6	6	100
Total	96	100	

Households were asked to state up to their most important sources of livelihood, and based on this livelihood groups were constructed using principal components analysis and clustering techniques where a majority of the surveyed households were dependent on agriculture (50%), land renting (17%), livestock (16%). A small percentage of households relied on daily labor (6%), selling of firewood (7%) and petty trade (4%). (See figure 4.1)

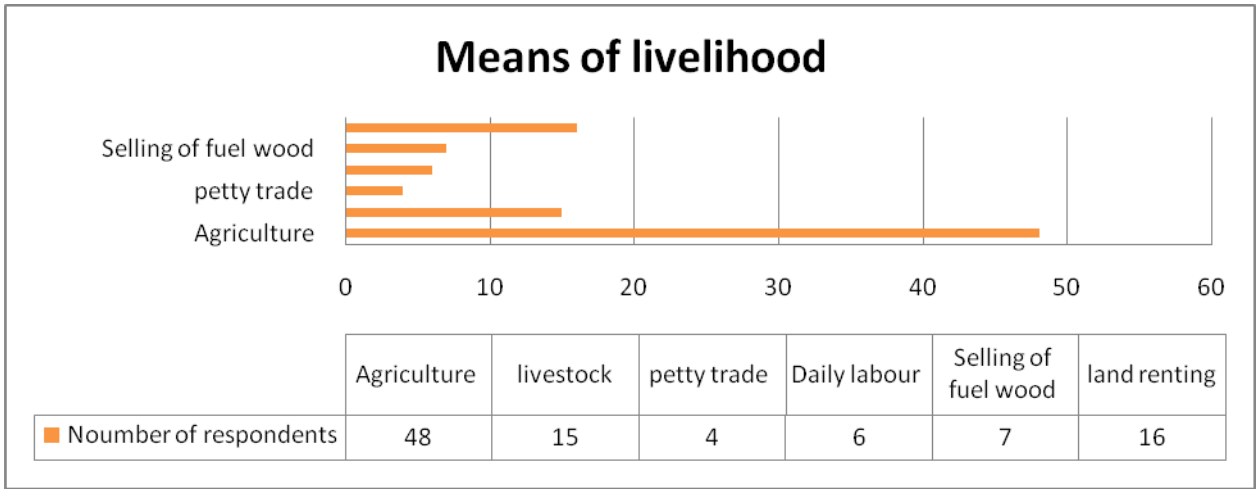


Figure 4.1: Means of farmer's livelihood

4.1.5 Current Situation of Livestock Possession by Respondents

Asset wealth was established by counting the number of different types of assets a household owned and then created categories: asset ownership (<=3, 4-7, 8-11, 12-15, >=16. Before 8 year the highest percent of livestock ownership for Garjalle, Timuga and Selambkalsi was, 42%, 35 %(4-7), and 32% (4-7) , while for the year 2011 it is 61%, 54% and 50% owned asset <=3 respectively. The average livestock ownership at a household level for the year 2003 was 6.41 while in 2011 it has decreased to 4.5.

Table 4.4: Distribution of livestock ownership in 2003 and 2011

N^{o}. of livestock frequency	Year	*Tabias*						Total	
		Garjalle		*Timuga*		*Selambkalsi*			
		Count	%	Count	%	Count	%	Count	%
<=3	2003	11	36	10	27	8	29	29	30
	2011	19	61	20	54	14	50	53	55
4-7	2003	13	42	13	35	9	32	35	37
	2011	7	23	7	19	9	32	23	24
8-11	2003	5	16	7	19	6	21	18	19
	2011	3	10	5	14	2	7	10	11
12-15	2003	1	3	4	11	4	14	9	9
	2011	1	3	3	8	3	11	7	7
>=16	2003	1	3	3	8	1	4	5	5
	2011	1	3	2	5	0	0	3	3

Source: Field survey 2011

4.2 Rainfall and Temperature Pattern of Alamata Woreda

In Tigray region severe and long lasting droughts have occurred, and also some events of flooding in relation to intense rainfall. The community recognizes changes from the past towards more serious droughts and shorter and more erratic rainy seasons. Tigray region

is one of the regions repeatedly affected by recurrent drought and food security problems in the country.

Alamata woreda is one of 8 woredas in southern zone of Tigray region. And it is one of the drought prone and chronic food deficient woredas in the region. In Alamata woreda the number of people vulnerable to acute and chronic food insecurity has been always increasing as a result of dependence on rain-fed agriculture and increased frequency and intensity of droughts or unreliable rainfall pattern.

4.2.1 Rainfall Pattern of Alamata Woreda

According to the data from Alamata woreda office of agriculture, in the past recent years Alamata woreda was experienced bimodal rainfall distribution. But nowadays the rainfall pattern has changed. Even the main rains of *kiremt* start at about mid July and ceceeds/discontinue soon after and the small rains *belg* is very uncertain. So generally reliability of rainfall has increasingly becoming so low, year after year and as a result crop production is affected significantly.

The observations are supported by historical records of weather data, showing that the rainfall amount and pattern has declined numerically. This change is not as such exaggerated but its impact has a great influence on crop growing, surface water availability for irrigation as well as watering of livestock.

As shown in figure 4.2 the rainfall pattern of Alamata station has declined. Based on the time series anlysis, the average yearly rainfall pattern for the past 26 years the amount of rainfall has decreased and it is expected to decrease more in the future.

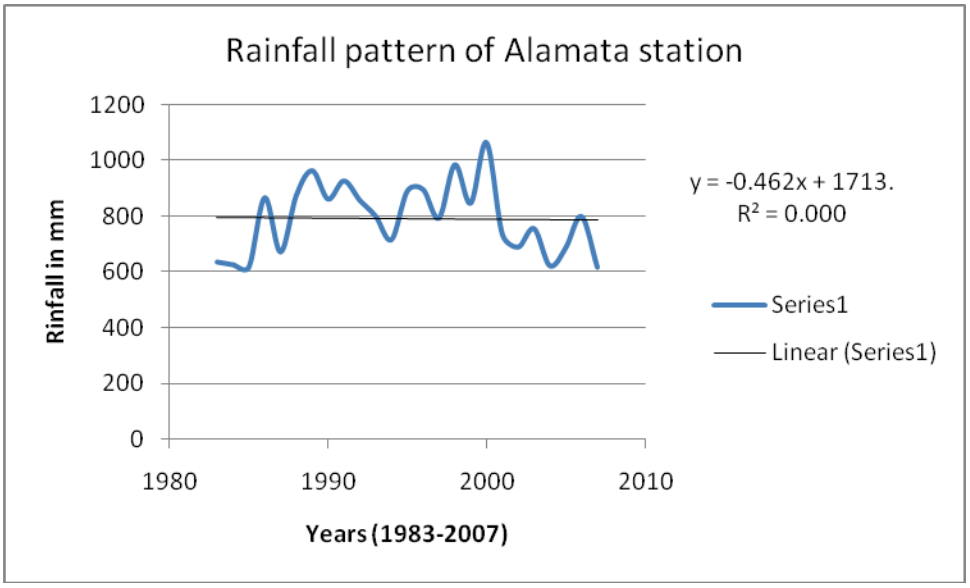


Figure 4.2 Rainfall trend of Alamata station

Figure 4.2 shows that the rainfall pattern over 26 years for Alamata stations. Alamata station has experienced both below (dry) and above (wet) the average rainfall over the last 25 years. In years like 1983, 1984, 1985, 1987, 1994, 2001, 2002, 2003, 2004, 2005, and 2007 recorded below the average amount of rainfall while1986, 1988, 1989, 1990, 1991, 1992, 1993, 1995, 1996, 1997, 1998, 1999, 2000 and 2006 were wetter years. And as the rainfall pattern in figure 4.2 shows annually it has decreased by 0.5 mm yearly. The average annual rainfall for 25 years (1983 to 2007) was 790.64 mm. The variability is very high that the annual rainfall for these years ranged from 615.30 mm (1985) to 1063.10 mm (2000), with a standard deviation value of 128.01 and 16.2% of CV.

4.2.2 Temperature Pattern of Alamata Woreda

The Alamata woreda is located in a valley in between *Ofla* north and northwest of Alamata and *Charcher* highlands east of Alamata. As a result of this the woreda has hotter temperature condition than its neighboring woredas.

As figure 4.3, indicates that most of the woreda areas have relatively similar temperature condition. Especially the areas which are located in the extensive plain areas of the woreda are has hotter temperature condition even as compared to the midland areas of the

woreda. People have experienced increased surface temperature, which is partly due to, deforestation and lack of shade from trees.

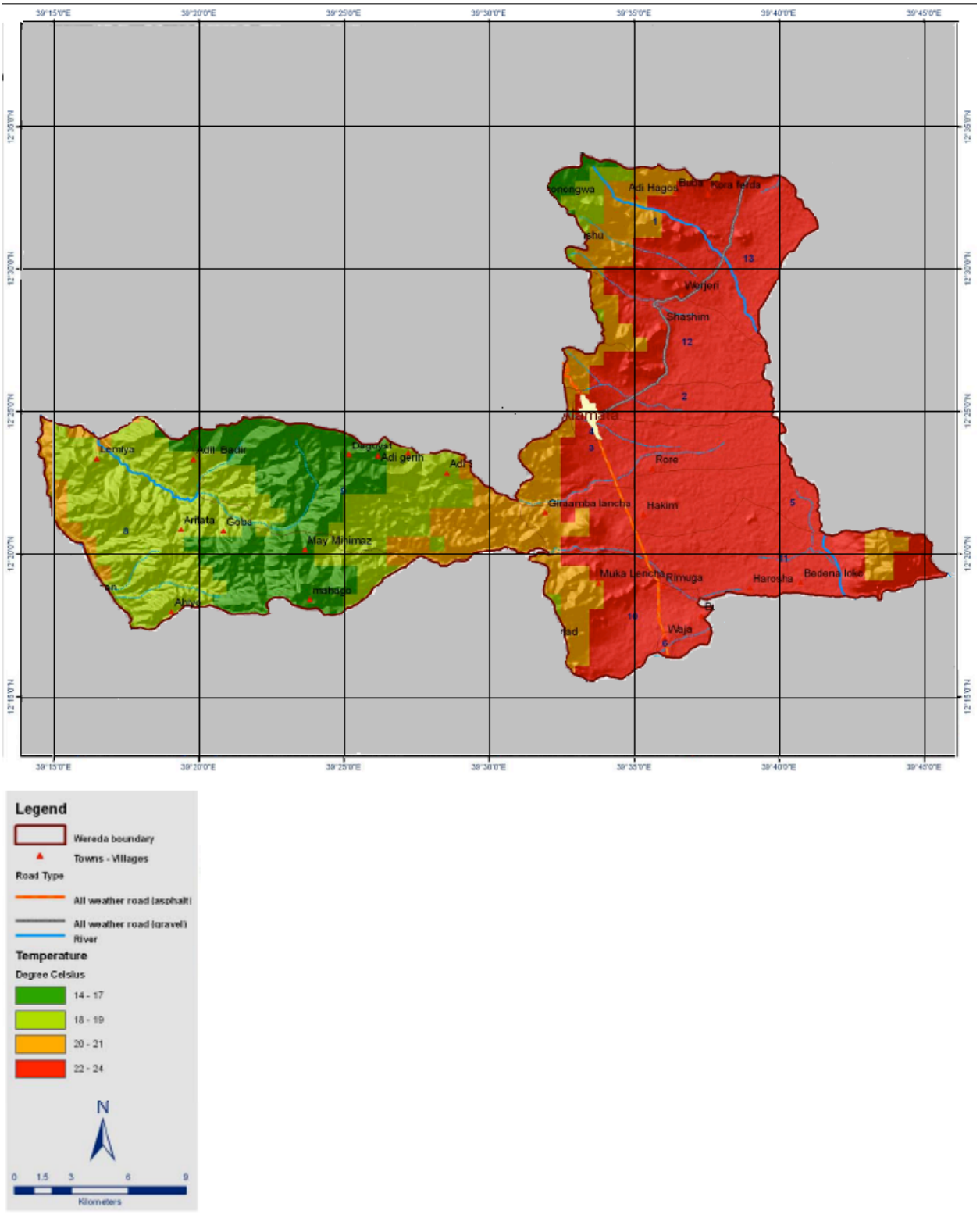


Figure 4.3: Alamata woreda annual temperature 2009

The average yearly maximum temperature of the past 24 years of Alamata was 30.1^0c, while the average for minimum yearly temperature of same years was 14.8^0c, as figure 4.4 indicates, the average yearly maximum temperature of Alamata station over the past 24 years has increased by about 0.014^0c annually, while the minimum temperature has decreased by -0.02^0c. The trend shows that, the maximum temperature of the woreda will continue rising in the future.

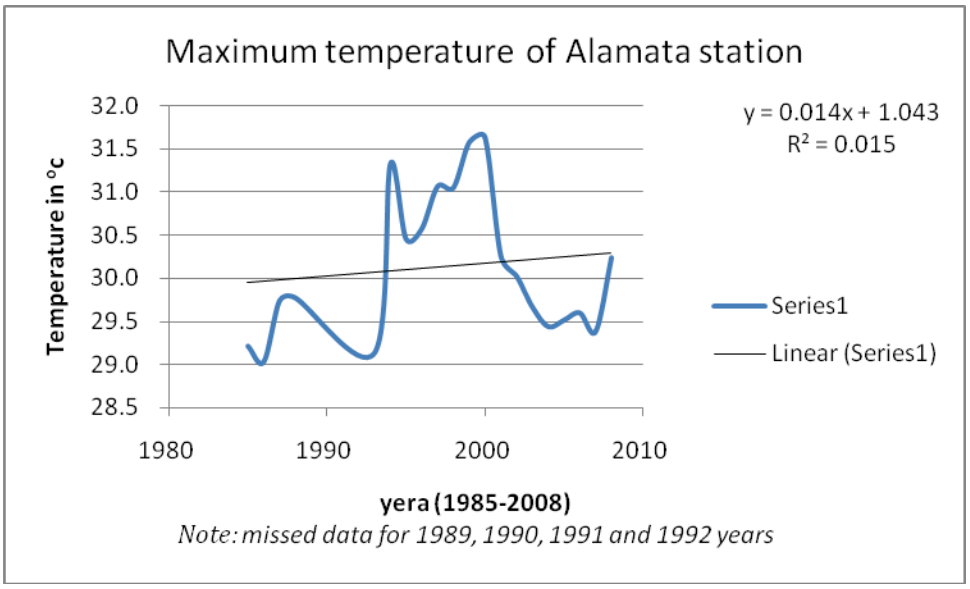


Figure 4.4: Average yearly maximum temperature of Alamata station

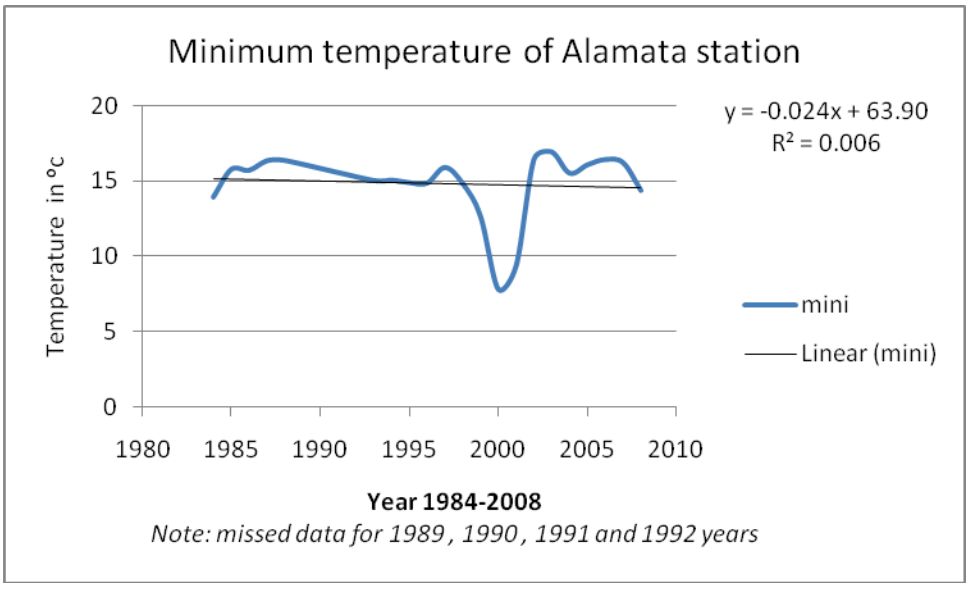


Figure 4.5: Average yearly minimum temperature of Alamata station

Figure 4.4 and figure 4.5, indicate the trend of maximum temperature is expected to increase, and decrease in minimum temperature respectively. Variability of annual average temperature is expected to increase.

The statistical result (Figure 4.2 and Figure 4.4) shows decline in amount of precipitation and increase in average annual maximum temperature. So overall of the analysis of rainfall and temperature from the stations indicates that, rainfall will be expected to decrease and temperature on the contrary expected to increase. Together with temperature variability and shortening rainfall seasons amount, these changes pose major challenges on the rural populations' livelihood.

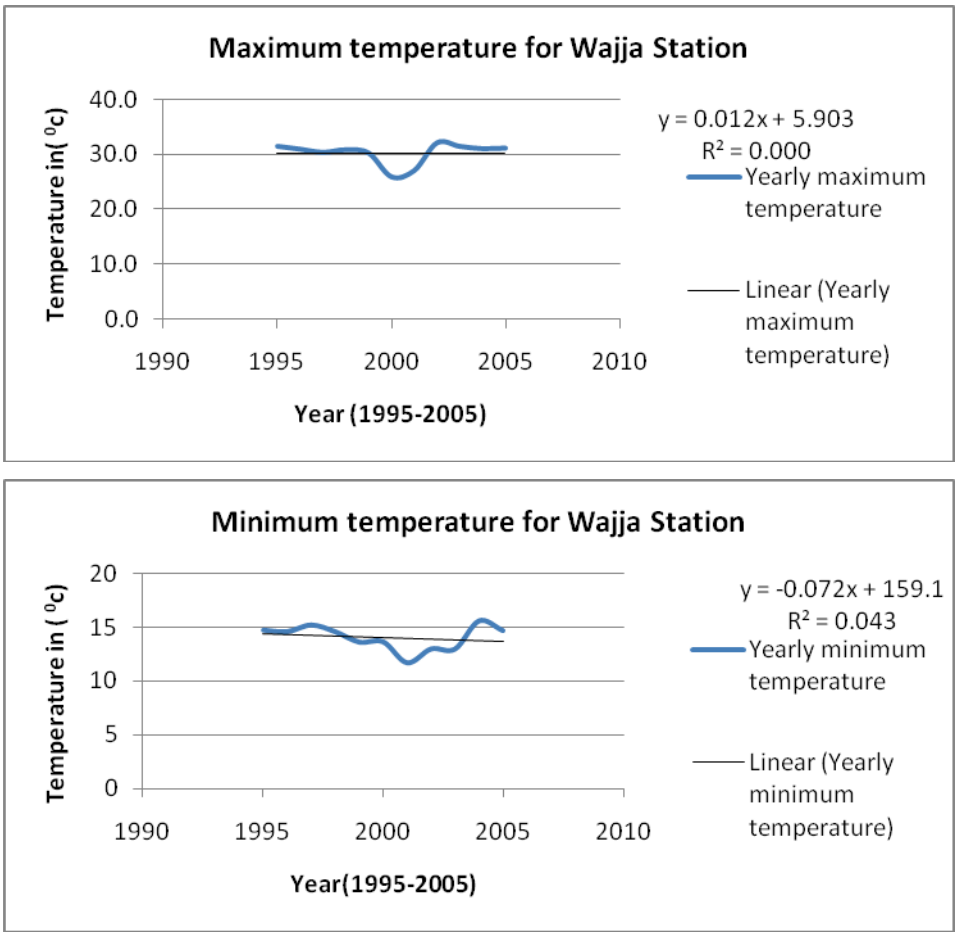


Figure 4.6: Maximum and minimum temperature of *Wajja* station

Wajja is one of the *tabias* which founds in the lowland part of the woreda. The average yearly maximum temperature of the past 11 years for *wajja* station was 30.0 ^{0}c. While the average minimum temperature for this station was 14.0^{0}c which is very closer temperature records of Alamata town. The temperature pattern of this *tabia* also indicates an increase by 0.012 maximum temperature and decrease in 0.072 minimum temperatures annually.

4.3 Perception of Farmers on Climate Change/Variability

The perception of farmers in that rainfall amount and pattern has changed for the worst especially in the recent years. Rainfall decreasing in amount and its pattern and distribution has become variable or irregular and more unpredictable. In FGD, farmers in the sample *tabia* reported that:

> *"In the previous times we were counting months and dates to know when the rains will start, but nowadays we are always looking at the sky and the main rainy season starts early July and withdraws mid to late August unlike in the previous times when it was starting early June and stop early September".*

Farmers are aware that the variations are due to climate change/variability. The farmers in the sample *tabias* have relatively similar perception regarding to climate change and climate variability. It was noted that about 17% of the respondents told that the climate of the woreda has not changed. However 59% of the respondents established there was climate variability while the remaining 24% reported the climate condition of the woreda has totally changed.

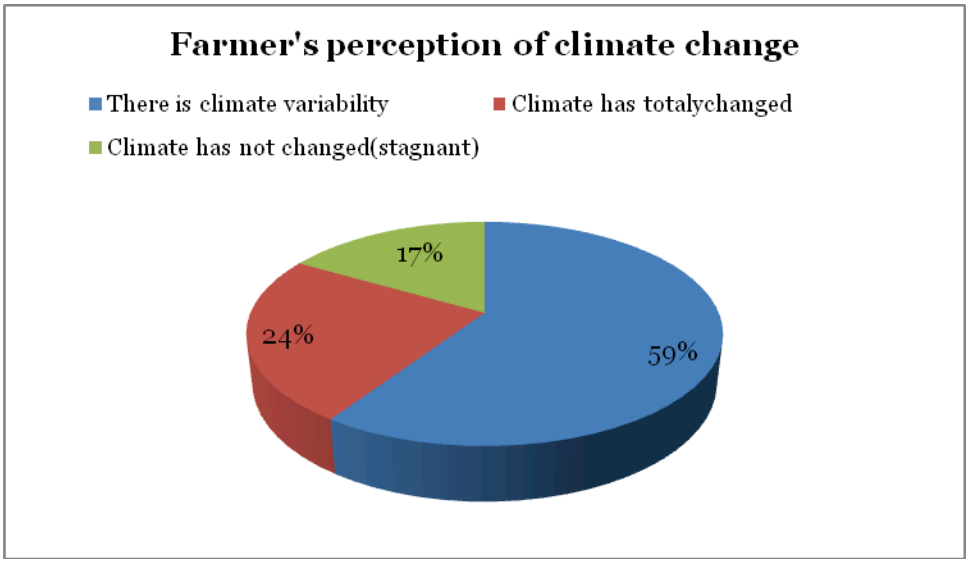


Figure 4.7: Farmer's perception of climate change

4.3.1 Rainfall Timing and Climate Change

Shortage of rainfall (moisture stress) is a major constraint of agricultural production in the woreda. In the old days, the big rain usually used to start in April at which, farmers used to cultivate sorghum, which lasts for 8 months and harvested it in November.

Reliability of rainfall increasingly become so low year after year that crop production has been affected significantly. And farmers in the area still exercise cultivation of crops which harvested in short time and drought resistant ones, for example, (*Amarica* sorghum, *emawaysh* maize and *bunign* teff species which harvested even in 1-4 months) but with difficulties of obtaining good harvest. Even if the crop does not fail totally because of the crop's drought tolerance, yield is substantially very low.

The perception of 69% of the respondents showed that in all parts of the woreda rain started very late, sometimes toward the end of August and it only rained for a few days. Under normal conditions, rain commonly start toward the end of June and ends toward the end of September. About 18% of the respondents replied that rain starts this days late and ends early, while the remaining 13% of the respondents reported that rainfall has started early and ends late.

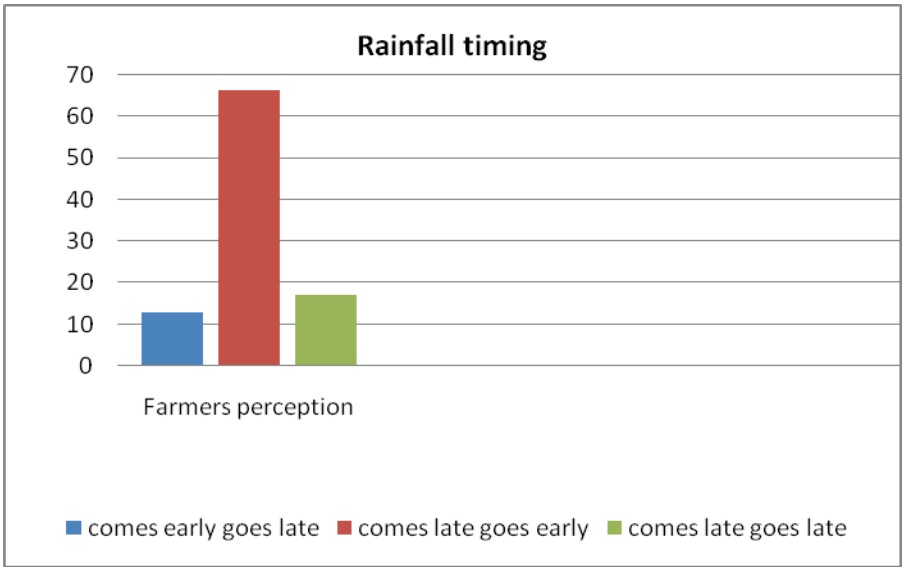


Figure 4.8: Perception of farmers' on rainfall timing

About 72% of respondent reported that *belg* rainfall has show high seasonal variability/change as compared to *kremt* season in terms of amount, time rain started, time rain ceceeded. While the remaining 19% and 9% of the respondents said, both seasons has show almost the same variability and *Kremt* season has show the highest variability respectively.

4.3.1.1 Rainfall Timing and Its Impact on Cropping Pattern

As the information from focus group discussion short cycle crops (particularly teff) in all areas of Alamata woreda have replaced long cycle crops (maize and sorghum). It is also important to note that these short maturing varieties of crops are local varieties, which of lower yields.

In the woreda, for instance a local variety teff, called *bunign,* is planted. While normal teff would have given about 6 qt/hectare, *bunign* gives 3 qt/hectare. The same is true for sorghum. In South Tigray, rains have been non-existent in the month of September. This has lead to large expanses of land to be not cultivated.

And according to the sample households responses and FGD, before 10-15 years in the woreda, *belg* rains were used for the production of short cycle crops such as teff and planting of long cycle crops such as maize and sorghum, especially *degalit* sorghum, which attain maturity during the main *meher* season. But nowadays since the *belg* rain becomes not reliable; it does not last long enough to support crop growth. They also told that the importance of *belg* rain is just only for the replenishment of pasture and water resources and land preparation for the main rainy season.

4.4. Indicators of Climate Change

The sample respondents have identified the major indicators of climate change and variability as follows: increased uncertainity in climate (20%), decrease in rainfall amount (19%), deminishe the rate of indigenious vegetation and crops (14%), temperature rise (10%), decreased crop and livestock production (9%), deforestation (8%), decrease in river discharge volume (6%), decrease (drop) in grond water table (4%), and others (3%), (see figure 4.9).

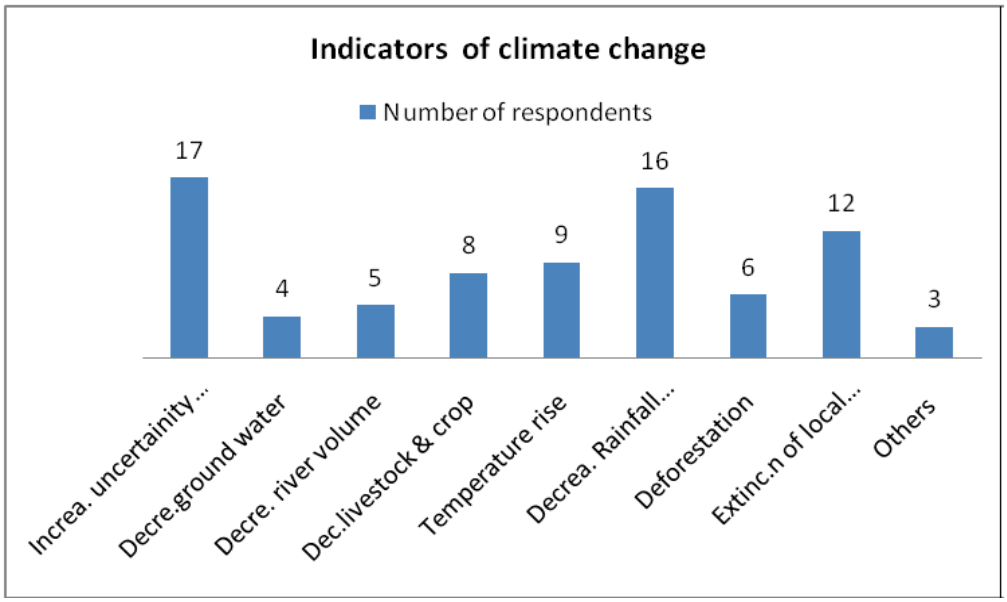


Figure 4.9: Indicators of climate change

In connection with the extent of forest degradation as a result of climate change during the 1980's and the role of trees, one of the elders in the area reported that:

> *"The whole field you see here was covered by trees like this! They used to keep us cool and have pleasant weather. Now the trees cut, forest cleared, hence the air condition has become hotter since the sun hits the ground directly and as a result the climate of our area has changed. And Some people especially women, lost the traditional practice of making handcrafts due to disappearance of special grasses like sindedo and edini they used for that purpose, and the reason for the disappearance of these grasses is because of degradation of natural vegetation and climate change.''*

4.4.1 Decrease of Long Season Crops

According to the perception of respondents' noted from the FGD, loss/decrease of crops has considered as indicator of climate change and variability. Increase in uncertainty of the climate especially temperature and the uneven rainfall distribution have resulted in decline of crop production, decrease in number of livestock and livestock products (e.g. honey, meat, milk).

While the respondent's perception is focused on unavailability of especially long season crops (*Degalit* sorghum*)* which needs about 8 months for harvest. The respondents said, since the climate has changed the *Raya* valley gets difficulties to grow *degalit* sorghum for the last 13 years. In addition to *degalit* there are other crops which are not available today like, *abuyi*-teff, *dengele* and *jamuye* –sorghums.

Figure 4.10: Photo showing *Degalit* sorghum

4.5 Impacts of Climate Variability on Rural Livelihood of Alamata Woreda

One of the objectives of this study is to validate the impact of climate change based on the opinions and responses of farm households of Alamata woreda. In order to attain this specific objective, household data were generated and analyzed to assess household's perceptions and responses, and impacts of climate change and climate variability on the livelihood of the communities. Accordingly, to meet this objective primary data from sample households was collected. Results and discussions of the studied households are presented below.

Owing to the abnormalities in precipitation in terms of both spatial and temporal distribution, climate variability was a frequent phenomenon over many parts of Alamata woreda. An abnormality in precipitation is one of the utmost important disasters which cause instability in food production in the woreda as a result of drought induced crop failure. Recurring drought disasters have multiple impacts on rural communities of the woreda. Populations engaged in agriculture (livestock production and farming) are particularly at risk from drought as agriculture is the main stay of the rural poor. The impact on crops and animals was the most important.

4.5.1 Impact on Cropping Pattern

The Raya valley was known for its production of sorghum, maize, and teff which takes the lion share in cereal production of the woreda (OoA 2010). But nowadays according to the sample respondents the cropping pattern of Alamata woreda has changed. Before 10 - 15 years sorghum, teff maize and wheat used to cover 48%, 26%, 18%, and 8% of cropped area respectively. These were the dominant crop according to their decreasing importance. While nowadays, according to the sample households' response the share of cereals account for individually as follows: teff (*bunign*) 51%, wheat 5%, sorghum *(wedi-arba*)11%, maize *(emewaysh*) 26% and pepper 7% mentioned as dominant crops across the rural areas of the woreda. So generally the major crops currently grown as present are teff, maize, sorghum wheat and pepper in order of their decreasing importance.

4.5.2 Impact on Crop Production

Climate variability affects virtually all aspects of agricultural and other water-intensive activities and has impact on a large proportion of households, with far-reaching consequences throughout the economy. The recent drought episodes experienced reveal that droughts are not once-off disasters. They are frequented phenomena that can be forecasted, and they will reoccur at least in the foreseeable future. Results for impacts on production are generally simulated in two different ways. Either climate-induced yield changes are projected without agronomic (farm-level) and economic (sector-level) adjustment (Harrison *et al.*, 2000; Adams *et al*., 1999) or different static cases are compared, with a given level of climatic change and a fixed adaptation factor (Darwin *et al*., 1999; Parry *et al*., 2004).

Climate variability/change entail loss of assets in the form of crops, livestock, and productive capital damaged as a direct consequence of water shortages or related factors. Some of the droughts had a drastic impact on agricultural out-put, with total crop failure and massive livestock deaths being recorded in many parts of the country and Tigray

region. Since high percentage of the population is rural and depends on farmland for subsistence, a variation in the weather has powerful negative consequences.

The climate anomalies over the past years have significantly impacted the economy of study area by affecting the households' income from agricultural products. Years of drought 1983, 1984, 1985, 1987, 1994, 2001, 2002, 2003, 2004, 2005, and 2007, are associated with very low yield contributions. The recent drought of 2009/10 damaged crop production in the woreda. Due to the severe drought event, total crop yield in 2009/10 was ever lower compared to the past 9 years. Total output decreased by 73.72% percent from the average production of past 9 years. Table.4.5 shows, the total area cultivated for cereal production was reduced by 3.7 km^2 as compared to the average past 9 years cultivated areas.

Table 4.5: Crop production in Alamata woreda

Production year	cultivated area in hectare	Production in quintals
2001/2	35138	415729.5
2002/3	32699.72	79530.5
2003/4	36131.75	199994.75
2004/5	34280.5	136111.5
2005/6	33754	553529
2006/7	34051.5	524375.5
2007/8	34503	399162
2008/9	34503	260823
2009/10	33201	77276
Total	308226.2	2646531
Average	34251.38 SD=1015	294059.08 SD= 185114

Source: Alamata woreda office of agriculture, 2011

As table 4.5 shows there is gradual drop in the crop production of the woreda. Generally as the information replied by respondents, the reasons for poor crop production in the

woreda were erratic rainfall during the main season (62%), poor (traditional) farming system (24%) and infertile farmland (14%).

4.5.3 Economic and Social Impacts

Rural outmigration, due to frequented drought occurrence, disrupted normal way of living and has also resulted in family disintegration. Moreover, the demand for child labors increased when the households were short of subsistence. During group discussions it was revealed that some people are migrating to nearest towns to sell their labor. Particularly young people are migrating to Humera and to Sudan for seasonal employment.

4.5.4 Impacts on Vegetation Pattern and Land Use

According to the respondents, the vegetation cover of the study area has changed. Opinion survey made showed that about 71% of the respondents attributed the change for degradation of natural resources base, particularly through intensified land use of ecologically fragile land by and rapid population growth together with overgrazing and deforestation. The rest of the respondents told the change was due to climate change and variability 16% and soil erosion 7% and 6% attributed to other factors (See Table 4.6).

Table 4.6: Factors responsible for vegetation change

Reasons for vegetation change	Respondents in number			Total	
	Garjalle	*Timuga*	*Selambkalsi*	Frequency	%
Climate change and variability	5	6	4	15	16
Deforestation	12	15	8	35	37
Overgrazing	9	11	13	33	34
Soil erosion	3	2	2	7	7
Others	2	3	1	6	6
Total	31	37	28	96	100

Source: Field survey 2011

According to the information obtained from FGD respondents, the vegetation types which were very dominant in the woreda before 15-20 years were *badano, kunkura, karwera, oda, sabansa, wancho, karwera* and *agam.* But nowadays because of high rate of deforestation vegetation cover of the areas decreased and trees become very few in numbers.

Currently, the woreda's vegetation cover is characterized by desert shrubs, cactus and other invasive plants like *kinche*, *Medafe, biru* and *chigagot*. *Kinche* is the most dangerous invasive plant and it has spread very rapidly in the whole valley in the last 10-11 years (see figure 4.11). These weeds have also been identified as invasive weeds in the adjacent Kobo woreda of the "Amhara regional state". And it was mentioned that the weed has suppressed the growth and production of capacity to decrease sorghum, maize and especially teff.

Figure 4.11: Photo showing *kinche* an invasive plant in the woreda

Vegetation and land use change are significant to a range of themes and issues central to global environmental change. Alterations in the earth's surface hold major implications for energy fluxes and global radiation balance, contribute to in biogeochemical effects alter hydrological cycle & influence ecological balance and complexity so land use and

land cover change is one of the possible reasons for the occurrence climate change at global, regional & local contexts.

As to the perception of respondents the land use and land cover of Alamata woreda has changed as compared to the land use pattern of the area before 10 year. The changes were attributed to rapid population growth and redistribution of grazing lands to new couples, deforestation and over grazing, climate change and unwise use of resources.

4.6 Vulnerability of Peoples and Their Concern Shocks

The impact of climate variability has different impacts on a society. A given portion of a society could be more vulnerable to the impacts of climate related shocks. As the result, study shows female headed households were found the more vulnerable.

4.6.1 Vulnerability by Age, Sex and Land Ownership

Almost majority of the respondents agreed that climate related disasters have differential impacts on different parts of the society, like males and female headed households, different age group and wealthy and poor households. (See Table 4.7)

Accordingly, 52 percent of the respondents believed that female headed households were more severely affected by climate variability than other parts of the society. And respondents listed the following ideas to say female headed household were more vulnerable. The differential impacts of the climate variability were due to the differing needs for social activities at household level. A woman has to collect water from the nearest water source. Furthermore, a woman engages in works such as cooking and cleaning, rearing of children, and collecting firewood. They also work in farms to grow crops and earn income for their family.

According to the respondents, the situation worsens during drought seasons, with fewer water sources left near the dwelling, they have to walk long distances on average 5-7k.m to fetch drinking water and collect firewood. Moreover, female headed households

cannot keep their livestock by moving (migrating), neither to the nearest pasture areas nor to feed cactus (by burning its thorns).

Figure 4.12: Photo showing woman collecting firewood

34% of the respondents indicated older members of the society and children are much more vulnerable next to female headed households. The recurrent drought has disrupted children from attending their education. Students drop out from their schools to support their individual family during severe drought event. And respondents replied that students are vulnerable to climate induced impacts, because they are used as adaptation mechanisms to the impact of climate change by sending them to work areas. The last but not least, about 14% of the respondents considered landless persons were reported vulnerable group to the impacts of climate change. (See table 4.7)

Table 4.7: Vulnerability to climate change

Vulnerability to climate change	Respondents in number			Total	
	Garjalle	*Timuga*	*Selambkalsi*	Number	%
Female headed households	14	20	16	50	52
Elders and children	12	12	9	33	34
Land lass persons	5	5	3	13	14
Total	31	37	28	96	100

Source: Field survey 2011

4.6.1.1 Importance of Shocks by Farmers' Perception

The main shocks listed by households were: drought/ irregular rains, prolonged dry spell (27%), denial to participate safety net program (18%), shortage of animal feed (17%), death of working HH member (13%), unusually high food prices (10%), temperature rise (8%), unusually high level of crop pests and disease (5%) and others (2%).(see table 4.8)

Table 4.8: Shocks experienced by *tabias*

Shocks	Respondents in number			Total	
	Garjalle	*Timuga*	*Selambkalsi*	*Total*	Percent
Drought/ irregular rains	8	11	7	26	27
Temperature rise	3	3	2	8	8
Shortage of animal feed	5	6	5	16	17
Prohibiting/exclusion from safety net program	6	6	5	17	18
Death of working HH member	4	5	3	12	13
Unusually high food prices	3	4	3	10	10
Unusually high level of crop pests and disease	2	1	2	5	5
Others	0	1	1	2	2
Total	31	37	28	96	100

Source: Field survey 2011.

Households were asked to prioritize the shocks/difficulties faced over the past 10-15 years. They were allowed to name as many they can and then to identify the top three shocks. Accordingly, the main shocks reported by female and male household respondents were drought/irregular rainfall and elder households replied to prohibition from safety net program and death of working household member as major shocks for their livelihood. The landless households were also reported unusually high food prices as their concern.

4.7 Climate Change and Livestock Production

4.7.1 Livestock Composition

Major livestock in the area are oxen, cows, sheep, goats, donkey and camel. Camels are owned by very few better off farmers. Because of recurrent droughts in recent years however, household composition of livestock has considerably changed. For this analysis primary data was collected during the field work and respondents were asked about their livestock composition before 10 years and now .

According to the sample households' responses, before 10 years the woredas livestock was composed of cattle (53%), small ruminants (35.5%) and equines (12.5%). But nowadays according to the sample respondents the composition changed, and small ruminants, cattle and equines accounted for (40.5%), (40.5%) and (19%) respectively (See Table 4.9). So according to the respondents, in the lowland part of the woreda where animal feed shortage are more serious farmers, preferred small ruminants especially goats.

Table 4.9: Farmers estimation on livestock composition (befor 10 yaers and now)

Year	Livestock composition	*Tabias*						Total	
		Garjalle		*Timuga*		*Selambkalsi*			
		Count	%	Count	%	Count	%	Count	%
Before 10 year	Cattle	17	55	20	54	14	50	51	53
	Small ruminants	11	35	12	32	11	39	34	35.5
	Equines	3	10	5	14	3	11	11	12.5
Now 2011	Cattle	12	39	16	43	11	39	39	40.5
	Small ruminants	13	42	14	38	12	47	39	40.5
	Equines	6	19	7	19	5	14	18	19

Source: Field survey 2011

4.7.2 Livestock Number

Because of recurrent droughts in recent years the total number of livestock has decreased by 20.2%. The highest rate of decreasing rate on livestock has shown on oxen, cow, and sheep. However there is positive rate of change on goat, camel and donkey number of livestock per household has significantly reduced.

Table 4.10: livestock composition and rate of change

Livestock species	Years		Rate of change (%)
	2001	2011	
Oxen	44242	29664	-32.95
Cow	65911	31442	-52.35
Goat	33929	44122	30.04
Sheep	51108	45358	-11.25
Camel	4401	6308	43.33
Donkey	33929	44122	25.60
Mule	488	426	-12.70
Horse	38	38	No change
Sum	205186	163725	
Average	45596.88889	36383.33	

Source: Alamata office of agriculture(2011)

As it is shown in table 4.10 there is positive and negative rate of change in the livestock composition of the woreda. There is a negative change in oxen, cow, sheep and mule by -32.95, -52.35, -11.25 & -12.70 respectively. On the other hand there is a positive change in the population of goat, camel and donkey by 30.04, 43.33 & 25.60% respectively with no change in number of horses. In general the livestock number found in the woreda has decreased by 20.2 %.

As the information collected from FGD showed, the livestock population of Alamata woreda decreased as compared to the past 10-15 years. According to office of agriculture

(OoA) sector, experts of the office, attribute the situation to: Lack feed resources, lack of large body sized bulls, and no practice of urban cattle fattening, transhumance during drought conditions/seasons, and lack of proper castration technique and uncontrolled movement of animals from Afar and Amhara regions and poor knowledge on improved feeding systems.

Similarly the respondents said a huge number of livestock death has occurred in the recent past years. According to them the loss of livestock was associated with the fragile nature of grazing lands and frequent and erratic rainfall seasons.

4.7.3 Livestock Feeding Water Source and Climate Change

In some parts of Alamata woreda there is cultural trend of cattle rearing with no intention to increase meat productivity or economic benefit rather their intention is to get a cultural prestige. The focus number than quality (size). Nowadays the respondents noted that because of recurrent drought and degradation of grazing lands, livestock feed resource considered as the major limiting factor of livestock production. Continuous grazing of fragile pasture areas with animal number more than carrying capacity of the lands has accentuated shortage of livestock feed in the woreda. As a consequence, many of the dry land areas are now characterized by feed and fuel wood deficits.

Table 4.11: Feed resource before 10 years

Feed resource	*Tabias*						*Total*	
	Garjalle		*Timuga*		*Selambkalsi*			
	Count	%	Count	%	count	%	Count	%
Grass	12	36	16	33	11	39	39	41
Crop residues	9	29	10	24	8	29	27	28
Tela	1	3	1	3	0	0	2	2
Beles	7	26	8	35	8	29	23	24
Others	2	6	2	5	1	3	5	5

Total	31	100	37	100	28	100	96	100

Before 10 years the main source of animal feed was grass 41%, crop residue 28% (especially Sorghum, teff and maize) and *beles* 24% were the major source of animal feed. The remaining (7%) are belonging to feed resources like, *tela* 2% and 5% belong to other source of animal feed.

As to the 28% of respondents, crop residues like sorghum, maize and teff stalks were major sources of animal feed during the dry season, so the performance of the long cycle crops has implications for availability of animal feed in the woreda even with crop failure. But nowadays because of recurrent drought there is a serious shortage of grass and crop residues. And this shortage of animal feed has led to loss of animals and decreased number of livestock population.

The farmers of the Alamata lowlands traditionally take their animals to grazing land in the Afar Region and North Wollo during the dry seasons. According to the respondents, these practices have been partially disrupted in recent years as the grazing areas of Afar Region and as well as the Raya plain of North Wollo were affected by similar drought.

Then Alamata woreda farmers have coped up the climate variability (recurrent drought), which caused shortage of animal feed, with a very nice indigenous knowledge based local means by feeding cattle with plant called cactus/*Beles*. According to the respondents the *beles* which is found in the woreda has too many thorns, so the farmer burn it with fire to remove the thorns,(Figure 4.13a) then after, the *beles* will be chopped in to pieces, to make it easily feed by the cattle population, (Figure 4.13b). Here the youngsters of rural Alamata (herders) have suffered in search of fire wood. According to them in order to feed beles for their cattle, the beles should be burned unless otherwise the cattle populations can't feed (*beles*) as it is. To make this they have to collect firewood weekly and to search firewood they have to travel not less than 7Km.

a

b

Figure 4.13: Photo showing livestock feeding *beles* in the woreda

Generally cattle population in the woreda has feed grass for a few months when there is rainfall but during the long dry season they use with crop residues and beles feeding. Farmers who do not own animals store hay and straw and then sell it to livestock owners. However, the poor harvest of last year greatly reduced available amount of crop residues.

Water (watering) problem in the woreda has become more acute in recent years; some rivers have dried up and the existing ponds become empty. The water sources of many ponds connected to small irrigation schemes and watering of animals, has depleted even faster. And in *Garjalle* animals have to travel up to half day to reach a water source and may only get water every other day locally known as *tabso*. According to the elders

perception this kind of long travel in search of water consumes the energy of productive animals and consequently reduces their performance and showed loss of weight.

4.7.4 Climate Change Impact on Livestock

Since changes in climate are relatively slow, there is need to rely more on continuous observations and experience of farmers and their local knowledge. Climate changes will also affect nomadic and transhumant livestock keepers. New routes and pastures will have to be found. The negative impact of ruminants on greenhouse gases emissions can be addressed through changes in animal husbandry including ruminant diets and animal stocking ratios to avoid nitrous oxides emissions. Larger changes in climate can increase costs exponentially (Hahn and Morgan 1999, cited in IPCC 2001).

Climate change/variability has wide range of impact on availability of grass, crop residues and water which is dominant factors for the existence of animals. Poor grazing area and frequent drought caused shortage of animal feeds and loss of livestock in the study area was reported. Population of cattle in the woreda has showed negative growth rate -32.85 and -52.35 for oxen and cow respectively (Table4.10) onwards from the past10 years. The respondents reported that communites showed preferences to drought resistant animals especially small ruminants and camel to decrase the impact of reccurent drought.

4.7.4.1 Loss of Livestock

Climate change has direct effects on livestock productivity as well as indirectly through changes on the availability of fodder and pastures. Climate determines the type of livestock most adapted to different agro-ecological zones and therefore the animals that are able to sustain rural communities. Climate change is expected to affect livestock at the species level. For example, if the Himalayas turn warmer, the yak could be restricted to higher altitudes where grass and fodder is less available. Communities will seek other species for production, relying on their own knowledge.

As it is shown in Table 4.12 on the past 10 years 47%, 21%, and 4% of the sample households lost on average of 1-3, 4-6, and >=7 livestock respectively. And the average loss of livestock at household level were 2.1. The respondents replied that decrease in livestock ownership in their *tabia* is credited to frequent droughts and shortage of livestock feed.

Table 4.12: Livestock loss within 10 years

Loss of animal in number	Respondents in number			Total	
	Garjalle	*Timuga*	*Selambkalsi*		
	Frequency	Frequency	Frequency	Frequency	%
No	9	10	8	27	28
1-3	14	18	13	45	47
4-6	7	8	5	20	21
>=7	1	1	2	4	4
Total	31	37	28	96	100

4.8 Coping and Adaptation Methods to Climate Change and Variability

4.8.1 Farmers Coping Methods to Climate Change and Variability

One of the intended objectives of this study was to identify some of coping and adaptation methods practiced by farmers, in response to impacts of climate change and variability.

The sample households were asked what "coping strategies" they had adopted to cope up the impacts of climate change and variability. The most widely adopted strategies were those that have little cost to the household and are relatively easily reversible, such as

cutting the number of meals two rather than in a day. This is by far the most commonly reported coping strategies in the study area, being adopted by almost three-quarter of the households.

Generally, there was not much difference in the proportion of households adopting other coping strategies. Accordingly the respondents replied the following coping methods; some households are more inclined to eat less preferred or less expensive foods (33%), selling livestock and other assets (23%), reducing the number of meals (20%), food aid (19%), withdrawal children from school (2%), daily labor (3)% (see table 4.13).

Table 4.13: Coping strategies to impacts of climate change

Coping mechanisms to climate change and variability	*Tabia*						Total	
	Garjalle		*Timuga*		*Selambkalsi*			
	Count	%	Count	%	Count	%	Count	%
Food aid	4	13	5	13	9	32	18	19
Selling livestock	7	23	9	24	6	21	22	23
Reducing the number of meals eaten per day	6	19	6	16	7	25	19	20
Eat less preferred or less expensive foods	12	39	15	41	5	18	32	33
Withdrawal children from school	1	3	1	3	0	0	2	2
Daily labor	1	3	1	3	1	4	3	3
Total	31	100	37	100	28	100	96	100

Source: Field survey 2011

4.8.2 Adaptation Strategies to Climate Change

Adaptation vary not only with respect to their climate stimuli but also with respect to other, non-climatic conditions sometimes called intervening conditions, which serve to influence the sensitivity of the systems and the nature of their adjustments. For example, a serious of droughts may have similar impacts in crop yields in two regions, but differing economic and institutional arrangements in the two regions may well result in quite different impacts on farmers and hence in quite difference adaptive responses, both in the short and long terms. (Smit et al.2000).

Adaptation is well thought one and planned to be applied for long term while coping strategies are immediate or short time responses to climate induced shocks. Coping strategies to climate induced shocks are considered to have low cost. On the contrary, strategies that involve adaptation to impacts of climate change incur high cost in terms of asset stripping, or lost future income, or loss of social status. A classic case in point is renting land, which requires the farming household to give up its most basic and indispensable productive resource. In the sample survey, a small number of households especially young people, were forced to out migrate to towns to sell their labor so as to earn some amount of money to be remitted home and used to secure food for households.

4.8.2.1 Farmers Initiated Adaptation Strategies

The most commonly cited adaptation strategies used first by households when dealing with climate change shocks are noted in the next section.

The respondents identified that communities are the first to respond to disasters induced by climate change shocks. Planting early maturing crops appears to be the major adaptation mechanism of communities (23%), followed by preservation of food and seed storage (20%), petty trade (18%), diversifying livestock composition (13%), and migration (12%). (See table 4.14).

Table 4.14: Farmers adaptation strategies

Adaptation mechanisms to climate change and variability	*Tabia*			Total	
	Garjalle	*Timuga*	*Selambkalsi*		
	Freq.	Freq.	Freq.	Freq.	%
Migration	2	4	6	12	12
Petty trade	6	7	3	17	18
Diversifying livestock composition	4	5	3	12	13
Growing cactus for own and livestock feed	2	5	2	9	9
Food and seed storage	8	6	5	19	20
Use early maturing crop varieties	6	9	7	22	23
Renting land	2	1	0	3	3
Others	1	0	1	2	2
Total	31	37	28	96	100

4.8.2.2. Obstacles of Farmers' Adaptation

As cited in Santiago (2001), IPCC (2000) report noted that, it is clear that the climate change will, in many parts of the world, adversely affect socioeconomic sectors, including water sources, agriculture, forestry, fisheries and human health with developing countries the most vulnerable. Because of deep rooted poverty developing countries have lesser capacity to adapt and more vulnerable to climate changes, just as they are to other stresses. This condition is most extreme among the poorest people.

The information revealed from respondents the major limiting factors for farmers' climate change adaptation strategies were, poor means of livelihood 34%, poor infrastructural development (road, farmers training center, and veterinary center) 22%, poor farming system (without fertilizer and irrigation) 16%, lack of access to credit14%,

lack of labor force for elders and female headed households 9%, and low educational level of farmers 6%.

4.8.2.3 Government /Woreda Initiated Adaptation Strategies

Adaptation strategies designed and promoted by the government and accepted and implemented by the community are massive soil and water conservation and afforestation activities. Percolation ponds are constructed to reduce run off and raise ground water level. Gullies are treated using gabion check dams and reclaimed to use them productive.

Productive Safety Net Program is also one of government induced adaptation strategies. The main objective is to fill food gap of the chronically food insecure farmers by assist crop (wheat) so that the farmers may not to sell their remaining assets. Introduction of early maturing crop varieties is another government strategy. Many varieties are being introduced out of which wheat varieties are widely accepted.

4.8.2.3.1 Environmental Rehabilitation

Soil and water conservation activities are crucial for stabilizing the equilibrium of the environment, preventing run-off and reversing the considerable loss of soil fertility in the watersheds. This in turn gives rise to agricultural productivity in treated areas. Massive natural resources rehabilitation on degraded farmland and grazing areas has been implemented using different Soil and Water Conservation (SWC) techniques to reduce soil erosion and increase vegetation cover.

Some of the interventions made by the Woredas Office of Agriculture to cope with the climate change and variability were:

a) Construction of water-harvesting check dams, construction of fords and different type of terraces
b) SWC on farms, in back yards and on communal land.
c) Enclosure of degraded communal areas in order to rehabilitate the land and regenerate the natural forest. The area enclosure aims at stabilizing the soil,

natural regeneration of the vegetation, and reduces erosion which damages the farmland. Especially vegetation rehabilitation program is taken on *Gra-kasu* Millennium Park.

4.8.2.3.2 Adaptation with Water/Rain Water Harvesting

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). A key element to respond to both problems is soil organic matter, which improves and stabilizes the soil structure so that the soils can absorb higher amounts of water without causing surface run off, which could result in soil erosion and, further downstream, in flooding. Soil organic matter also improves the water absorption capacity of the soil for during extended drought.

At present almost all of the rural people rely entirely on rain-fed agriculture (crop and livestock production). Rain water harvesting is necessary and it is good adaptation method or option in alleviating effects of recurrent drought and food crisis in the region.

As adaptation alternatives to address the impacts of climate change in the woreda use of available rain water through different harvesting techniques including flood water diversion, on farm runoff retention, soil moisture conservation and impounding in storage structures were implemented by the woredas office of agriculture. This option focuses on harvesting and utilizing as much rainwater as possible and making maximum use of it to increase production and productivity of the land. The woreda office of agriculture believes small scale irrigation intervention to be a climate variability proofing/adaptation strategy in the study woreda.

Accordingly in an effort to address the problems of recurring climate variability conditions and food insecurity, the woredas office of agriculture engaged in variety of water harvesting programs to supplement the rainfed agriculture and there by address drought and food shortages.

Notable among these implementation of an extensive small dam-based irrigation program known as *Golgol-raya*, within a major rural development program called Sustainable Agricultural and Environmental Rehabilitation in Tigray (SAERT).These dams, which are generally small and constructed with stone and earth, built with active participation of the communities. Extensive ponds (*Horeye*) construction and digging of water wells has been in progress in the woreda. There are two major rivers that are of great economic importance to the Woreda. These rivers are *Gereb-hara*, and *Gereb-etu,* mainly used for irrigation during the dry season for the production of horticultural crops and vegetables.

At the time of this field survey what was observed was involving irrigation activities at *Gereb-etu,* runoff diversion to farm lands and run off storage for supplementary irrigation was also part of the adaptation strategy in areas of moisture deficit. Some farmers also use water pumps to produce vegetables, cereals and pulses.

Figure 4.14: Small scale irrigation in *Gereb-etu*

Water harvesting is considered as a single most important means to increase productivity and adapt the impacts of climate change.

4.8.2.3.3 Adaptation with Livestock Feed

The Office of agriculture (OoA) is trying to protect pasture land from overgrazing through a variety of management measures. They try to introduce a rotation system whereby while one part of the pasture is used; another part is closed to grazing to allow the grass to recover. Attempts have also been made to introduce high yielding varieties of grass like pijenpi, alpha-alpha and lab-lab.

Another measure introduced is by the office of agriculture is closure of the grazing land to all animals during the dry season but farmers are allowed to cut the grass and feed it to their animals at the homestead. In this way the roots of grass are not damaged and the grass will recover quickly after cutting. And it has economic benefit by serving as a source of livestock feed through cut and feed system and honey production.

Chapter Five

Conclusion and Recommendation

5.1 Summary and Conclusions

A large segment of population in Ethiopia are chronically and seasonally food insecure because of recurrent drought. Ethiopia's vulnerability to climate change goes hand-in-hand with poverty, although some regions of the country are more vulnerable than others namely Afar, Somali region, Oromia and Tigray.

Tigray region is more affected by drought due to unreliable rainfall conditions or climate variability. The complex nature of climate in the region took many lives; which also entails loss of assets in the form of crops, livestock, and productive capacity damaged as a direct consequence of water shortages and pasture degradation the lives of thousands of people has threatened.

This study employed was targeted to assess the impact of climate change on rural livelihood and their adaptation methods in Alamata woreda. The main findings of the research are summarized below.

Climate change and variability: As to the statistical results and farmers perception on climate condition, the study area has had shown changes in rainfall and temperature patterns. The rainfall amount of the woreda has decreased through time and expected to continue decreasing in the future. On the contrary, temperature pattern has shown an increasing trend and expected to increase in the coming future also. In the coming decades, climate change will have a major impact on crop and livestock production and on biophysical and human environments.

Indicators on climate changes and variability: The findings of the study revealed that uncertainty in climate, decrease in rainfall amount, and decrease the availability of indigenous crops and vegetation as the major indicators of climate change and variability.

Vulnerability to climate change: The magnitude of vulnerability to climate change is quite different at household level, different age group, and wealth and education status of the community. Thus, the analysis/ the results of the study indicates, female headed households, elders and children and landless peoples were found more vulnerable to climate change and variability. As to the respondents justification females headed households' vulnerability to climate change was found higher. This is because women were engaged in too many tasks as compared to other segments of the society.

Impact of climate change: According to the findings from the study climate change and variability has resulted in impact on different sectors. The major impacts were on crop and livestock production. Because of the variability in rainfall amount in the past 10 years, higher rate of variation in crop yields has recorded, with maximum 553,529 quintals in 2005/6 and minimum of 77,276 quintals in 2009/10 production years. Because of climate change and variability the cropping pattern has change especially long cycle crops like *Degalit (sorghum)* were replaced by short cycle crops like, *Bunign* (teff).

Livestock production of 2001 and 2011 years was decrease by 32.5%, and 52.35%, respectively for oxen and cows livestock species. Contrary to the cattle population, positive rate of change was observed for goats, camels and donkeys. From this it is possible to conclude that, the climate change condition, warming of climate, favored by goats and camels than cattle population due their capability to with stand shortage of feed and long dry seasons.

Coping Mechanisms: The most commonly cited coping strategies was used first by households when dealing with shocks were: eat less preferred or less expensive foods, reducing the number of meals, food aid and selling labor.

Adaptation to climate change induced shocks: The research shows that Alamata farm farmers were more likely to adapt if they had access to non-farm income, owned livestock, had more farming experience and education/training, and were economically better off. Access to credit, agricultural extension, information on climate change, and other rural services was important as well.

Obstacles to Adapting to Climate Change: Alamata farmers identified shortage/poor means of livelihood as the single most important constraint to adapting to climate change, followed closely by poor distribution of infrastructure. They also noted that poor (traditional) farming system, access to credit, lack of labor, as well as their educational level, prevented them from adaptation. Water and soil conservation, rain water harvesting, construction of dams, rehabilitation of guiles, and expansion of spate irrigation were some of the major strategies initiated by office of agriculture to adapt the impacts of climate change and variability.

Conclusion:

Climate variability is a major driver of vulnerability in the woreda. Since the livelihood of the rural Alamata is dependent of crop and livestock production irregular annual rainfall was highly affect the livelihood of the population. But it is difficult to say the climate of the study area has changed, since climate change is a total change of the climate condition of a given area from hot to cold or the reverse. But this is not the reality in Alamata woreda; rather it is possible to say there is climate variability on the past two decades, with different range of impacts over the local livelihood of the peoples.

Because of climate variability induced shocks and population growth the vegetation cover and grazing areas of the woreda has deteriorated and finally it caused livestock feed shortage and decrease in cattle production. There is irregularity in rainfall timing in turn which affects the cropping pattern and crop production of farmers.

Generally the farmers of the woreda are highly vulnerable to the impacts of climate variability and almost about 80% of the farmers were food insecure. NGOs were very much supporting the Safety Net Program, programs that support a good number of the poor and the affected population. Even though Female headed households were more vulnerable to the impacts of climate change.

Last but not least the farmers have practiced different types of coping and adaptation strategies to cope up with the impacts of climate change. *Beles* feeding to livestock (cattle) and feed less expensive crops for own feed consumption were the common ones. Poor source of livelihood hinders the farmers not to cope up the impacts of climate

change. While the woreda office of agriculture has tried to minimize the impacts of climate change by work on soil and water conservation, rehabilitation of gullies and degraded and deforested areas.

5.2 Recommendations

Given the nature of the data and based on the findings and results of the study the following policy oriented recommendations are suggested to minimize the impacts of climate change and variability on rural livelihood communities of Alamata woreda.

- The government (development agents and extension supervisors) should encourage farmers to use drought resistant crop seeds together with commercial fertilizer, chemicals and soil moisture management practices

- The governmental officials should train farmers on rainwater harvesting technologies

- Strengthen the existing water and soil conservation and expand the area cultivated with irrigation schemes,

- The Raya valley is one of the area considered as suitable for cotton plantation and sesame production so government should start developing the valley as part of this scheme by training farmers and invite investors for cotton production, which can have an enormous adaptation effect by promoting resilience to impacts of climate change,

- In relation to shortage of livestock feeding, there should be possible interventions by plating fodder trees around enclosure areas and irrigation dike. Train farmers on cut and carry so as to decrease overgrazing,

- There should be collaborative farmers effort on preventing and controlling the expansion of invasive plant species, especially *kinche* which adversely damages livestock and crop production (teff) and over all of natural environment,

- Protecting the environment from restless cutting down of trees and deforestation, and promote reforestation and afforestation activities,

- To minimize the impacts of climate change young people should get access to credit, and invested in farm and off farm activities like poultry, dairy farm, getting involved in petty trade etc. Others, who were not able to get credit facilities especially the young people, did casual labor like loading and unloading, and employed in construction sites.
- Moreover, farmers were wise in the long dry seasons by feed *beles* for their cattle, and government should encourage them to plant *beles* in their backyards for cattle and own their own feed/consumptions.

- Investments, policies, and extension services should explicitly target (address) those groups who are most vulnerable to climate change-including, female headed household, elders and children and landless and less educated to ensure that the right information gets to the right people.

- The Early Warning Systems (EWS) were highly effective in preventing the repeated occurrence of famines that struck Tigray in general and the study area in particular by providing food crops to the more affected peoples of the woreda. Similarly the EWS should strengthen providing climate and cropping pattern related information

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Appendices

Appendix A

Introduction;

My name is Nigus G/medhn. I am studying Geography and Environmental studies in Addis Ababa University. I am doing my Masters thesis on: *The impacts of climate change on rural livelihood and their adaptation methods the case of Alamata woreda*. Thus I appreciate you cooperation to give me your time for the success of this work.

- Writing your name is not compulsory.

Thank you!

Households and socio economic issues

1. Name _____
2. Sex M_____ F_____ Age _____
3. Marital status;

   A. Single B. Married C. Divorce/Widowed
4. What is your educational level?

   A. Illiterate B. Capable to read and write

   C. Primary school D. Junior

   E. Secondary School F. Graduate
5. Do you have children? Yes/no If yes, put the appropriate number in the table;

Age	<5 years	5-10 years	10-15 years	>15 years
Number of children				

6. How do you make your life (means of livelihood)?

   A. Livestock rearing B. Agriculture (Crop production)

   C. Renting out land D. petty trade

   E. Daily laborer F. Selling firewood

   G. Other (specify)
7. Do you or your family member have another source of livelihood other than agriculture (off farm activity)? Yes _____No _____

8. If your answer to **Q 7** is 'yes', what kind of activity is it?

   ……..

9. Do you hold land? Yes _____ No _____

10. If your answer to **Q 9** is 'yes', how much hectare?

    A. 0.25-0.50 B. 0.51-0.75

    C. 0.76-1.0 D. 1.1-1.5

    E. 1.6-2.0 G. Other please specify

11. Do you have livestock? Yes _____ No _____if yes, how many livestock do you own?

Animal type	Number of animals	
	Before 10 year	2003(E.C)
Oxen		
Cow		
Camel		
Donkey		
Sheep		
Goat		
Others (specify)		

Climate variability and vulnerability

1. What is your perception on climate condition of your woreda?
   A. There is climate variability
   B. The climate has totally changed
   C. The climate has not changed (it is stagnant)
2. If your answer to **Q1** is 'the climate has changed/ show variability', what are the local indicators of climate change/variability?
   A. Increased uncertainity in climate
   B. Decrease crop and livestock production
   C. Extinction of indigenious and crops
   D. Decrease river volume
   E. Decrease in rainfall amount
   F. Decrease (drop) in grond water
   G. Temperature rise
   I. Deforestation (deteriorated vegetation cover)
   H. Others
3. How do you characterize the weather of your area in terms of temperature?
   A. Increased B. Decreased C. No change
4. Is there change in the timing (duration) of the rain? Yes_____ No_____
5. If your answer to **Q4** is 'yes', how do you characterize it?
   A. Comes early and goes late
   B. Comes late and goes late
   C. Comes late and goes early
6. If your answer to **Q5** is comes late and goes early, what changes you have seen in your crop production?
   A. Decrease in crop yield B. Increase in crop yield
   C. No change in production D. Decrease of long cycle crops
   E. Others

7. Have you ever faced any climate related (serious) impact in your life time?
   Yes_____ No_____
8. If your answer to **Q7** is 'yes', what type of climatic shock is your concern?
   A. Drought/ irregular rains B. Shortage of animal feed
   C. Death of working HH member D. Unusually high food prices
   E. Temperature rise F. Prohibition/exclusion from safety net program
   G. Unusually high level of crop pests and disease
   H. Others
9. Who do you think the more vulnerable to the above shocks?
   A. Female headed household B. Male headed household
   C. Landless D. Elders
10. If your answer to **Q7** is 'yes', did it affect your cattle or/and crop? Yes _____No _____If yes how much?
   A. Very high(with animal disease and death) B. Moderate
   C. Low D. Very low
11. Why do you think, you are more vulnerable to the impact of climate variability?
   A. Lack of information on climate conditions/weather
   B. Poor administration system
   C. Poor livelihood /source of income
   D. Other (specify)
12. What are the major constraints you have that hinders for your coping mechanisms
   A. Poverty B. Poor infrastructure
   C. Lack of access to service D. Livestock disease
   E. Poor administration F. Other (specify)
13. Is there any change in your cropping system? Yes _____No _____
14. If your answer to **Q13** is 'Yes', please specify
   ……..…….……..…….
15. Is your crop productivity increased or decreased? Increased ____ Decreased ____

16. If your answer is decreased what do you think the cause?

A. Erratic rainfall during the main season B. Poor farming system

C. Infertile farm Land D. Other constraints

17. Which do you estimate, the highest composition of livestock on the past 10 years?

A. Cattle B. Small ruminants

C. Equines D. Others

18. And which livestock composition do you think have the highest composition nowadays?

19. Is there any change on livestock number, composition and feeding of your area?

Yes_____ no_____

20. If your answer to Q19 is 'Yes', please explain it

……...……

21. Do you think livestock production has increased or decreased in your village?

Increased_____ Decreased_____

22. If your answer is decreased please specify the reasons;

A. Livestock disease B. Shortage of pasture (animal feed)

C. Shortage of water D. Others (specify)

23. How many livestock you have loss because of climate change related shocks in the past 10 years.

A. no B. 4-6

C.1-3 D. >=7

24. What was the source of feed for your livestock before 10 year? (multiple answer is possible)

A. Grass B. Crop residues

C. *Tela* D. *Beles*

E. Others

25. What is your main source of animal feed at present time?

.....

26. What do you think the possible ways to minimize the impacts of climate variability or change on your livelihood?

A. Applying new cropping system and irrigation

B. Make diversification on crop and livestock production

C. Safety net program

D. Other (specify)

27. What do you think the responsible factors for change on vegetation pattern and land use type of your area?

A. Climate change and variability B. Soil erosion

C. Deforestation D. Others

28. Do you have access to get credit from any institution? Yes _____ No____

29. How did the government, GOs and NGO's responded to reduce the impact?

A. Providing credit B. Safety net programs

C. Improving infrastructures D. No one gives attention to the problem

E. Other (specify)

30. What crops you used to grow before 10-15 years?

_____, _____, _____, _____, _____

31. What are the main crops you product now?

_____, _____, _____, _____, _____

Adaptation practices

1. Are there any adaptation practices that you have used? Yes _____ No____
2. What kind of coping mechanisms you practiced to minimize climate related shocks? A. Selling labor B. Selling livestock

C. Reducing the number of meals eaten per day D. Petty trade

E. Withdrawal children from school

F. Eat less preferred or less expensive foods G. Others please specify

3. How do you adapt the impacts of climate change?

A. Diversifying and dividing livestock composition B. Migration

D. Food and seed storage C. Use of early maturing crop varieties

E. Growing cactus for own and animal feed F. Renting out land

4. What are the major coping/adaptation strategies you used related to livestock production?

   A. Increase livestock diversification

   B. Sale weak and old animals before the outbreak of long dry season.

   C. Moving with livestock in search of pastures and water

   D. Decreasing number of livestock

   E. Cattle fattening

   F. Food aid

   G. Others (specify)

5. Adaptation strategies related crop production.

   A. Expand cultivation of food crops B. Using new and variety of crops

   C. Storage and wise use of food crops D. Inter cropping system

   E. Aid from safety net program F. Others (specify)

6. Adaptation related to water and other natural resources?

   A. Water harvesting B. water and soil conservation

   C. Expand irrigable farm lands D. Others (specify)

7. What are the major constraints that hinder you to adapt the impact of climate change?(multiple answer is possible)

   A. Poor market accessibility in the area B. Poverty

   C. lack of accessibility infrastructures (road, veterinary center, FTC)

   D. Others (specify)

8. Is there any locally accepted coping mechanisms? Yes_____ No_____

9. If your answer for **Q8** is 'yes', please explain

   ……..……

10. What do you think the right way to adapt (minimize) the impact of climate variability in your village?

    .....

Appendix C

Interview questions and FGD

1. Is there any change in climate condition of your village? Yes_____ No____
2. If your answer for **Q1** is 'yes', is it climate change or climate variability that occurs in your village?
3. What are the observed local indicators of climate change?
4. How do you understand the impact of climate change/variability on your livelihood?
5. What are the more vulnerable livelihood sectors in your village?
6. Is there any change on livestock number, composition and feeding of your area?
7. Is there any change (decreasing) in crop and livestock production in your village? Yes_____ No____
8. If your answer for **Q6** is 'yes', how do you respond to the change?
9. How do you cop up or adapt the impact of climate variability on your livelihood?
10. What kind of trees was had the highest share in the vegetation pattern of your woreda
11. Which trees are common at the present time?
12. What are your major challenges in alleviation of the problem and what should be done?

Thank you!

Agriculture and rural development office officials, development agents and other experts

1. Name _____ Position/profession _____
2. Is there any form of climate change or variability in your woreda or *tabia*? If your answer is yes, please can you explain?

3. If the answer to Q2 is yes, please would you like to explain the extent of climate change and variability impact on crop and livestock of your woreda/district/peasant association?

4.
5. Who is more vulnerable to the impacts? Why?
6. Is there any change on livestock number, composition and feeding of your area?
7. What are the local coping mechanisms used to reduce the impacts?
8. What is the institutions effort to reduce future impacts?
9. What are the main challenges and how do you think they can be improved?

Focus Group Discussion (FGD)

Checklist for focus group discussion; the following points are bench marks for the discussions that will be taken place with purposively selected persons.

- ✓ Do you think there is change in climate condition of your area?
- ✓ What do you think the local indicators of climate change?
- ✓ What are the major livelihood activities practiced in your area? And how much they are vulnerable to the effects of climate variabilities and change?
- ✓ Who is more vulnerable from your society?
- ✓ What do you think the social impacts of climate change/variability?
- ✓ What are the major climate variability induced shocks and effects?
- ✓ Is there change in the timing (duration) of the rain? If yes what do you think the impacts?
- ✓ Is there any change on copping pattern of your area?
- ✓ What are the best copping strategies employed in your village?
- ✓ What are the adaptation strategies employed by the local community?
- ✓ What do you think the possible ways to minimize the impact of climate variability? Thank you

Declaration

This thesis is my original work and has not been presented for a degree in any university. All sources of the materials used for this thesis has been fully acknowledged.

Name: _____

Signature: _____

Date: _____

This thesis has been submitted for examination with my approval as a university advisor.

Name: _____

Signature: _____

Date: _____