Research Report 20

Characteristics of Climate Change Risk, Vulnerability and Adaptation in Cotton and Sugarcane Producing Regions of Ethiopia

Discussions from a household survey

By

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Executive summary

Climate change is a global concern mainly due to its effect on two parameters that affect the ecological setup particularly agriculture – increase in the average temperature and rainfall variability. Even though the agriculture sector as a whole is vulnerable to climate hazards including flood and drought, climate change poses a particular threat to certain agricultural commodities and social groups, due to difference in agro-ecology and heterogeneity in non – climate change drivers of vulnerability. This context specific nature of the impact of climate change calls for the need to identify adaptation options to build a climate resilient production of particular agricultural commodities and vulnerable groups.

In addition to coffee, the Agricultural Development Led Industrialization (ADLI) strategy and the Growth and Transformation Plan (GTP) clearly stipulate that sugar and textile are strategic export commodities in the industrial development strategy of Ethiopia. They are labour intensive, have broad linkages with the rest of the economy, use agricultural products as inputs, are export-oriented and import substituting, and contribute to rapid technological transfer. They are strategic commodities because they are crucial in transforming the country's economy from the agriculture – led into industry - led economy within the GTP period of 2011 - 2015.

Accordingly, the study focuses on two commodities including sugarcane and cotton. While sugarcane is key input in the production of sugar, cotton is key input in the production of textile. In addition to their economic importance, empirical evidence from other developing countries on the impact of CC on sugarcane and cotton commodities shows that CC poses risk on the two commodities. However, evidence on the impact of CC on these two commodities is absent in Ethiopia. As a result, not only that, the export earning of the country is also affected due to the impact of climate change on these two commodities, it is also that the different actors along the value chains of the two commodities are vulnerable to the anticipated climate change impacts. Therefore, it is imperative that urgent action is taken to build a climate resilient agriculture production

for these two agricultural commodities so as to reduce the negative impacts of climate change on the country's export earning or economic growth and reduce on vulnerable social groups.

Therefore, this research project is initiated by the Ethiopian Development Research Institute to identify adaptation options to build a climate resilient production of the two commodities. The research has different activity components including climate modelling, agronomy study, value chain analyses, welfare impact and economy wide impact of climate change. Across all these research activities, data generated using a household survey on 1200 randomly selected households in the cotton and sugarcane producing regions is key input. This report, therefore, contains the descriptive analyses of the characteristics of climate risk, vulnerability and adaptation mechanisms adopted by households in these regions of Ethiopia.

In characterizing the nature of climate risk, vulnerability and adaptation, the study adopted the notion that identifying adaptation needs requires an assessment of the factors that determine the nature of, and vulnerability to, climate risks and an assessment of adaptation options to reduce risks. This is mainly due to the fact that the ability to adapt and cope with climate related hazards depends on the economic resources, institutions, knowledge, social status, infrastructure, technology, and social safety nets. Accordingly, to characterize the nature of climate risk, vulnerability and adaptation in the sugarcane and cotton producing regions of Ethiopia, the study explores the climate and non-climate drivers that influence the vulnerability of households and communities. It also explores the adverse events that occurred due to climate change, associated impacts and adaptation mechanisms adopted by households to cope up with the adverse events. The key results of the study are summarized as follows.

The non-climate drivers of vulnerability including livelihood, asset holdings, institutional and access to infrastructure have been explored. The result indicated that households in the cotton and sugarcane producing regions mainly depend on crop production and

livestock production as their means of livelihood. Crop production accounts for the lion's share (93%) of the annual household income whereas non – farm income takes a very small proportion of their annual income. These livelihoods are very sensitive to climate change adverse events. The asset holding status of the households also indicated that land is the key asset. In addition, crop harvest and livestock are also assets that can easily be used at times of bad events. There are also durable assets owned by households that can be lost or easily converted to liquid income if bad events occurred. However, households vary with their level of income from all sources as well as with their level of asset holdings. So, the result shows the variation not only observed between sugarcane and cotton growing regions but also within a particular region, indicating that their vulnerability level also varies. Access to institutional services such as extension services and access to financial or credit has also been explored in the study areas since they are key determinants of vulnerability and adaptive capacity of the local community. In this respect, the survey result shows that there is low level of such services though some households respond that they have access to extension services in relation to crop and livestock productions. Similarly, households have very limited access to credit. Even those who had access to credit stated that they got very small amounts of loan. As a result, households usually get credit either from relatives or money lenders. This is especially true in cotton producing regions where households do not get access to credit for purchasing farm inputs such as fertilizer and harvesting machines. Access to infrastructure is also another key determinant of vulnerability and adaptive capacity. Our survey explored access to road transport, market, school, health and local government administrative services. The result also indicated that households especially in cotton growing regions had to travel long distance which takes hours to reach the nearest all weather road. The same is true for access to vehicle transport. Overall, access to infrastructure and basic social services such as energy, potable water and sanitation is relatively better in sugarcane producing regions. Communities in cotton growing regions have limited access to these services which are integral components of adaptive capacity.

Climate change parameters including long term change in mean temperature and rainfall have also been explored in the study areas from the local communities' point of view, which is aimed at understanding the local knowledge regarding climate change. Elderly people were asked to state their perception regarding change in temperature and rainfall in their locality within the last three decades. The result shows that the number of hot days has increased within the specified period. They also revealed that there have been changes in rainfall amount and pattern. For the majority, rainfall has decreased compared to the year before. In addition, its pattern has changed, which, for the majority, decreased and came late/delayed. There is some awareness about climate change among the growers whose main sources of information are their own experiences and mass media such as radio.

Regarding the occurrences of climate related hazards, drought and floods have been the two adverse events related to climate change observed in the study areas. As a result, households in cotton and sugarcane growing areas are vulnerable to climate change, and its impact has been observed in terms of decrease in income, food production and asset holdings. In many cases, growers could not do anything to adapt to shocks. Those who are better off use mainly their own savings to cope with the shocks related to climate change. However, these traditional adaptation mechanisms were not as effective as they should be as the adverse effects already resulted in the reduction of food production, income and loss of assets. This means that the increasingly erratic patterns of climate change will certainly further reduce their effectiveness, and thus, the vulnerability of households, unless effective adaptation strategies are planned and implemented. In sum, the climate change risks are characterized by increase in temperature and erratic pattern of rainfall as perceived by old people in the study regions. These features resulted in two climate hazards including flood and drought within the last three decades, to which communities in the study regions are vulnerable. On the other hand, these communities not only depend on climate sensitive livelihoods but also that their socioeconomic and other non – climate drivers exposed them to these climate related hazards. These two factors (climate and non – climate change) contributed to the low adaptive capacity of the communities. As a

result, the welfare of the households reduced. However, the result indicated that households vary in their characteristics of non – climate factors, which also resulted in different welfare effect. The heterogeneity of households not only varies between the cotton and sugarcane producing regions but also within specific commodity and by gender. Female – headed households are more vulnerable compared to male – headed households. Accordingly, the nature of climate risk, vulnerability and adaptations varies between and within regions.

1. Introduction

1.1. Context

Climate change is a global concern mainly due to its effect on two parameters that affect the ecological setup particularly agriculture – increase in the average temperature and rainfall variability (both in terms of quantity and pattern). The combination of rising average temperature and shifting rainfall volume and patterns negatively impact agriculture (IPCC, 2000; Muller, 2009). The fourth IPCC report released in 2007 explains that climate change (CC) has impact on crop and food production systems. The effect of climate change on agricultural yield varies by type of crop and spatially mainly with latitude levels. As a result of differences in predicted production capabilities, some regions will benefit from increases in yield while others will be left to importing an increasing amount of food to help meet demand. However, the fifth assessment report of IPCC reveals that the negative impacts of climate trends have been more common than positive ones (IPCC, 2013). In addition to this negative effect, the same report revealed that changes in temperature and precipitation, without considering the effects of CO_2 will contribute to increased global food prices by 2050, with estimated increases ranging from 3-84%. Without appropriate adaptation mechanisms, the effect can be alarming for developing countries given that their economies heavily rely on agriculture.

Ethiopia's vision is to become a middle income economy by 2025 by achieving an average annual economic growth of 10% through building a modern and productive agricultural sector, strengthening the industrial base and growing exports (MoFED, 2010). However, evidence shows that the country is most vulnerable to climate change impacts. The current climate variability already leads to hazards such as flood, drought and soil erosion, and these impacts will be exacerbated by CC. The evidence shows that CC, if not well addressed, poses risk to achieving the country's vision. As a result, the country envisages achieving its vision through economic growth that is resilient to CC and in line with the global shift towards low carbon society that results in no increase in emissions. Towards this, it has launched the green economy (GE) strategy in 2011 (EPA, 211). However, the preparation of a national strategy for a resilient economy is not as simple as that of a low carbon development strategy for the following

reasons. Unlike low carbon development (as in GE strategy), which can be a response to the global burden, resilience is a response to local, regional and national level impacts. Thus, any benefits from resilience are sector, location and risk specific, and objectives for resilience are wider as opposed to the single goal of CO_2 reduction in the GE strategy. These features and the absence of universally agreed standards to appraise options for building resilience create challenges to identify adaptation options for the agriculture sector from a particular agricultural commodity or livelihood strategy. However, it is possible to address these issues and develop adaptation options for resilience from analysis made at individual commodity level.

1.2. Problem

In many developing countries including Ethiopia, agriculture is the largest employer and hence is the main source of livelihood. In this context, the impact of climate change on agriculture is an issue of great significance to the lives and livelihoods of millions of poor people who depend on agriculture for survival. Agriculture by its very nature is a low-capital sector, and hence is more climate-change sensitive than other sectors.

However, evidences show that the effect of CC varies from crop to crop, depending on its agro-ecological requirements for growth, as well as from community to community, depending on their vulnerability and adaptive capacity. As a result, CC poses a particular threat to certain agricultural commodities and social groups. Available information from CC risk analyses for one of the key agricultural commodities, coffee, explicitly indicated that CC impacts on this commodity is not only worrying for achieving a middle-income vision but the burden also falls on the most vulnerable of society. Hence, given the methodological challenges described above and the dependence of the country on few major agricultural commodities for its export sector, it is clear that Ethiopia needs to take early action to its key agricultural export commodities so as to prepare for the effects of CC on its export market and livelihoods of Ethiopians. The question is then, which agricultural commodities need urgent action for climate resilient development that results in minimum economy wide effects of CC and enhance the achievement of the country's vision.

In this respect, in addition to coffee, the Agricultural Development Led Industrialization (ADLI) strategy and the Growth and Transformation Plan (GTP) clearly stipulate that sugar and textile are strategic export commodities in the industrial development strategy of Ethiopia. They are labour intensive, have broad linkages with the rest of the economy, use agricultural products as inputs, are export-oriented and import substituting, and contribute to rapid technological transfer (MoFED, 2010). They are strategic commodities because they are crucial in transforming the country's economy from the agriculture – led into industry - led economy within the GTP period of 2011 - 2015.

Based on the GTP, in addition to the existing three sugar factories, the country will have ten sugar factories at the end of the plan period. This indicates that the sugar industry is one of the priority industries that are expected to contribute considerably to export diversification and foreign exchange earnings through greater value addition and productivity improvement (FDRE, 2010). The economic benefit of the sector can easily be seen from its main produce, sugar, which is an essential commodity that is consumed by everyone. Moreover, in addition to its benefits as a source of employment for many Ethiopians particularly for low and medium skilled labourers in the production process, it is a source of income for many small and middle traders that participate along its value chain. Ethiopia plans to raise annual production of sugar to 2.25 million tones by developing additional 200,000 ha of land for sugarcane; generate USD 661.7 Million foreign exchange earning and create additional direct employment opportunity for more than 200,000 citizens by the end of the GTP period. Sugarcane, major raw material for the industry in the production of sugar is currently growing using irrigation. Large scale irrigation schemes are also under construction in the ten sugar factories. It is produced by large scale state farms and smallholder out-growers.

Similarly, the textile sector is the other strategic sector that plays a key role in the economic growth and poverty reduction in Ethiopia. It is major a source of foreign exchange earning and employment. The sector is expected to earn US$ 1.0 Billion,

generate 40,000 new direct employment opportunities and raise its gross value of production to US$2.5 Billion at the end of the GTP period (MoFED, 2010). The sector uses cotton as raw input. Available information shows that more than 850,000 quintals of cotton is produced per year from 40,000 ha of land in Ethiopia (CSA, 2010/11). Anecdotal evidence indicated that 40% and 60% of the total production comes from smallholder and private commercial farms, respectively. Afar is the major production region, followed by SNNP and Gambela regions. Overall, in addition to their contribution as sources of foreign exchange earning for the country, these commodities are major sources of livelihood for many poor Ethiopians. Higher proportions of rural and urban poor depend on these commodities for their livelihoods through the production, consumption and labor linkages to these commodities.

From the climate change perspective, empirical evidences on the impact of CC on sugarcane and cotton commodities are absent in Ethiopia. However, empirical evidences from other countries show that CC poses risk on the two commodities. The direction of the impact on sugarcane is mixed. A study in Central American/Carebean shows that sugarcane production increased with an average of about 15% while in Brazil and South Asia almost no change; a decrease of 5% in Southern Africa and an increase of about 5% in Southeast Asia. No estimation is carried out for East Africa on yield changes of sugarcane. The result of the study on the effect of climate change on sugarcane production in South Africa by Deressa et al (2013) showed that climate change has significant nonlinear impacts on net revenue per hectare of sugarcane in South Africa with higher sensitivity to future increases in temperature than precipitation. Chandiposha's (2013) research on potential impact of climate change on sugarcane production finds that production is likely to be affected by climate change due to projected increase in temperature and changing rainfall patterns. The result of a similar study by Knox et al (2010) in Swaziland showed that with climate change, the current peak capacity of existing irrigation schemes could fail to meet the predicted increases in irrigation demand in nearly 50% of years assuming unconstrained water availability.

Similarly, the impact of climate change on cotton production is substantial when there is a combination of decrease in rainfall and increase in temperature. This is reflected in various studies carried out at global, regional and country level. A research that was carried out in Gokwe district in Zimbabwe, which is a major cotton producing area, indicates that there is a direct correlation between mean rainfall and mean temperature and cotton production yield "When comparing cotton production output against the mean annual rainfall, the coefficient of determination (r^2) was 0.64. This analysis showed that 64% of the variation in cotton output could be explained by the rainfall trend pattern in the district. The correlation coefficient between the cotton output and the mean rainfall was positive and statistically significant ($r = 0.8$, $p<0.05$)" (Gwimbi and Mundoga, 2010). The effect of climate change in cotton yield is not the same at the various stages of its growth. This shows, not only the issue of increase or decrease of temperature but also its variability during the various periods of growing season is important. The paper summarizes that climate change may impact cotton growth and development through increases in atmospheric carbon dioxide (CO_2) concentration, reduced water availability, increased atmospheric evaporative demand (lower humidity), and increases in temperature.

The above discussions clearly show that the two commodities are not only strategic commodities for the Ethiopian economy but also that there is risk from climate change on their production, and thus, on the economy of the country. The textile and sugar commodities are the two key strategic export commodities. Thus, the impact of climate change on the production of cotton and sugarcane is expected to jeopardise the export earning of the country. The fact that the livelihood of rural community in the growing region of the two commodities depend on the production of the two commodities which implies that these communities are vulnerable to climate change impact. In addition, as discussed previously, all actors along the value chain of the textile and sugar commodities are vulnerable to CC directly or indirectly though the impact could not be the same depending on their level of dependency and their adaptive capacity. Therefore, it is imperative that urgent action is taken to build a climate resilient agriculture development for these two commodities so as to reduce the negative

impacts of CC on the country's economic growth and on vulnerable social groups. The key policy question is then, "what are the adaptation strategy options that, if implemented, will build a climate resilient production of sugarcane and cotton in Ethiopia?"

1.3. Objective of the report

To respond to the above key policy question associated with the impact of climate change on sugarcane and cotton, a research project is initiated by the Ethiopian Development Research Institute. The key objective of the project is to identify adaptation options to build the resilience of the two commodities to the anticipated climate change impacts. The project has different components[1]. As part of the project, a study is conducted to explore and characterize the nature of the risk associated with climate change, vulnerability and autonomous adaptation mechanisms adopted in the sugarcane and cotton producing regions of Ethiopia. This explorative work helps to identify the local capacity in terms of knowledge, resource as well as institutional services that are vital for adaptation and to build the resilience of the producers as well as the production of the two commodities to climate change impact. Therefore, this report presents the result from a descriptive analyses made on the household survey conducted in the sugarcane and cotton producing regions of Ethiopia.

1.4. Organization of the report

The report is organized in seven sections including the introduction section. The next section discusses the conceptual framework within which the study used to explore and characterize the nature of climate change risk, vulnerability and adaptation in the cotton and sugarcane growing regions. The third section presents the methodology in which the dataset is discussed. The fourth section discusses in detail the climate and non-

[1] The different research components of the project are climate modelling, agronomic study, value chain analyses, productivity impact of CC, welfare impact and the economy wide impact of CC on sugarcane and cotton production. Each component has its own report published as EDRI research report. The assessment made on the institutional aspects of the two commodities is published as EDRI research report 17. Readers can access this and the other forthcoming reports at www.edri-eth.org

climate drivers of vulnerability. Section five and six discuss the result on the impact of climate related adverse events or hazards that occurred in the study regions and the adaptation mechanisms adopted by the community respectively, the last section summarises the key findings of the study and presents the conclusions.

2. Conceptual framework

Identifying adaptation options requires understanding the nature of climate change risk and vulnerability. Thus, at the outset, it is important to briefly discuss the conceptual framework used in this study to describe the characteristic features of climate change risk, vulnerability and adaptation from a microeconomic perspective in cotton and sugarcane growing regions of Ethiopia. The fifth assessment report of the IPCC discussed how current impacts of climate change, projected impacts, and responses to climate change affect livelihoods and poverty. The report indicated that assessment of the impacts of climate change on a particular society or system requires understanding the complex nature of poverty and livelihood as well as the dynamic nature of the interaction among climate change, livelihood and poverty. As stated in the report, the multifaceted nature of poverty and the livelihood of community need to be explored to understand the impact of climate change[2]. The report indicated that climate related adverse events (hazards) such as flood and drought affect the lives of people through their impact on livelihood such as agricultural productivity, loss of assets or making people food in-secured[3]. Its effect is also manifested through increase in food prices.

[2] Livelihoods can be understood as the ensemble or opportunity set of capabilities, assets, and activities that are required to make a living (Chambers and Conway, 1992; Ellis *et al.*, 2003). They depend on. Livelihoods are dynamic and people adapt and change their livelihoods with internal and external stressors. Ultimately, successful livelihoods transform assets into income, dignity, and agency, to improve living conditions, a prerequisite for poverty alleviation (Sen, 1981).

[3] In the conceptual framework, the core concepts used are Climate hazard, vulnerability and adaptation and adaptation capacity. we used definition for these terminologies as defined in AR4 (Adger *et al.*, 2007). We refer to the characteristics of climate change and its effects on geophysical systems, such as floods, droughts, deglaciation, sea level rise, increasing temperature and frequency of heat waves, as *hazards*. In contrast, *vulnerability* refers primarily to characteristics of human or social-ecological systems exposed to hazardous climatic (droughts, floods etc.) or non-climatic events and trends (increasing temperature, sea-level rise) Vulnerability is dynamic and context specific, determined by human behavior and societal organization, which influences for example the susceptibility of people (e.g. by marginalization) and their coping and adaptive capacities to hazards (see IPCC, 2012a). Perceptions and cognitive constructs about risks and adaptation options as well as cultural contexts influence adaptive capacities and thus vulnerability (Grothmann and Patt 2005; Rhomberg, 2009; Kuruppu and Liverman 2011; see section 19.6.1.4). SREX stressed that the consideration of multiple dimensions (e.g., social, economic,

Climate change can also shift livelihood. As a result of reduction in any of these impacts, households can fall below poverty. However, the effect of climate change on people's livelihood depends on their vulnerability and adaptive capacity which depend on a number of factors. Thus, climate change is not the only stressor of livelihood. Its effect interacts with a multitude of non-climate factors that affect livelihood, and exacerbates poverty either by creating new poor people or making poor people poorer. The interaction of climate change with these non–climate drivers in a complex way also shapes vulnerabilities. Thus, the complex nature of the interaction arises from the fact that the vulnerability of households to climate related hazards depends on their adaptation capacity, which in turn can be affected by a multitude of factors that also affect livelihood and poverty including geographical, physical, social, economic, institutional, information, etc.

Hence, identifying adaptation needs requires an assessment of the factors that determine the nature of, and vulnerability to, climate risks and an assessment of adaptation options to reduce risks IPCC (2013). As stated in the AR5 of IPCC, structural features of farm households and communities affect their vulnerability to climate change in complex ways (*AR5, IPCC, 2013*). The ability to adapt and cope with weather hazards depends on economic resources, institutions, knowledge, social status, infrastructure, technology, and social safety nets (IPCC 2013). Thus, any assessment of CC impact on the livelihood of households should take into consideration the fact that behind higher vulnerability to poverty resulting from adverse climate events, there is a range of factors that reveal the weaknesses of households to cope with ex post or manage ex ante events. Accordingly, in this study an explicit attention is given to the non-climate and climate change drivers to explore and characterize the nature of climate risk, vulnerability and adaptation in the sugarcane and cotton producing regions of Ethiopia. These factors reflect households' lower adaptive capacity and higher susceptibility to the impacts of the events and refer to low levels of human and physical capital, insufficient access to assets and services (public or private), weak institutional

environmental, institutional, cultural), as well as different causal factors of vulnerability can improve strategies to reduce risks to climate change (see IPCC 2012c, p.17 and Cardona *et al*., 2012, p. 17, 67-106).

structures, inexistent or inefficient social protection programmes and greater exposure to uncertainty in the physical and economic environment (Skoufias et al., 2011). While economic resources such as access to land and natural resources, ownership to livestock etc are key for adaptation, institutions can decrease or increase vulnerability by determining the incentive structures for adaptation responses, and by mediating external interventions (e.g. finances, knowledge and information, skills training) into local contexts. On the other hand, while access to information alone is not a guarantee for success, one has to have the skill or knowledge to access, process and manage disseminated information within the formal institutional structure to address vulnerability issues. Gender inequalities such as difference in access to resources between men and women, also determine vulnerability. Besides, access to infrastructure such as road, market, electricity, communication technology, etc is important in determining the sensitivity of people to the exposed climate change impact. This study describes the characteristics of climate risk, vulnerability and adaptation using the conceptual framework discussed above. After a brief description of the data and survey method, the report presents the study result on the climate and non-climate drivers of vulnerability, as well as the features of climate risk and adaptation mechanisms from the survey data.

3. Methodology

This report is based on the household survey conducted in the sugarcane and cotton producing regions of Ethiopia. The survey is made with the aim of analysing the impact of climate change on vulnerable groups. As this study focuses on cotton and sugarcane commodities, our target population is smallholder farmers in cotton and sugarcane growing regions of Ethiopia. In the subsequent sub-sections, we will describe the target population and the sampling strategy in detail.

3.1. Target population

Cotton is produced by three groups of farmers, namely, private commercial farmers, state farms and smallholder farmers. The report will focus on the vulnerability of smallholder farm households. According to the data obtained from the Ministry of

Agriculture (MoA), 18,085 hectares of land is cultivated with cotton by smallholders in the year 2005 E.C. and the share from each region is given below. Smallholder farm households producing cotton are located in Amhara, Tigray and Afar. **Error! Reference source not found.** shows that Metema district in Amhara regional state accounts for 62 per cent of the cultivated area by smallholder farmers in the country. There are small areas in Tigray and Afar regional states where cotton is cultivated by smallholder farmers.

Table 1: Smallholder Cotton Producing Districts in 2005 E.C

Region	Zone	District	Area cultivated with cotton (Ha.)	Share in the region %	Share in the country %
Amhara	Northen Gonder	Metema	11062	62	62
		Kuwaraj	4944	28	27
		Tegede	945	5	5.2
		Armacho	261	1	1
Tigray	Western Tigray	Humera	110	72	0.6
		Welkayt	43	28	0.2
Afar		Amibara	85	76	0.5
		Buremedetu	10	9	0.06
		Gewande	12	11	0.07
		Asayta	5	4	0.03
Total			18085		

Sugarcane for the production of sugar is produced by state owned farms or out-growers. The focus of the vulnerability study will be farm households supplying sugarcane for the factories as out-growers. Currently, there are three state owned enterprises producing sugar, namely, Metahara, Wonji and Fincha and only Wonji is served by out-growers. In total, there are 11,2451 out-growers supplying sugarcane to the Wonji sugar factory. They are organized into 36 out-grower associations (OAs). The 36 out-grower associations (OAs) are distributed in three Woredas and two zones (East Shoa and Arsi).

3.2. Sampling

For cotton, we have focused in two zones where the majority of smallholder cotton production takes place (1 zone in Amhara and 1 zone in Tigray) and we have used stratified two stage cluster sampling. Zones are the strata for the sampling, namely, North Gonder and Western Tigray constitute the study area. All districts with the potential to produce cotton are covered in the study. The primary sampling units are *Kebeles* and forty *Kebeles* are randomly sampled from North Gonder and Western Tigray (i.e. twenty from each zone). From each *Kebeles*, 20 households are selected in North Gonder and 10 households in western Tigray. Hence, there are 400 households sampled from North Gonder and 200 households from Western Tigray.

For sugar, we have covered two zones where there are out-grower associations and we have used two-stage stratified cluster sampling. The stratification is done on zones, namely, East Shoa and Arsi. The primary sampling units are the 36 organization associations. Out of the 36 organizational associations, a total of ten associations were sampled (four OAs from Arsi and six organizational associations are from Arsi). In the second stage, households are randomly sampled from the sample organizational associations. We have sampled 75 and 50 households from organizational associations in Arsi and East Shoa, respectively. **Error! Reference source not found.**shows the survey regions.

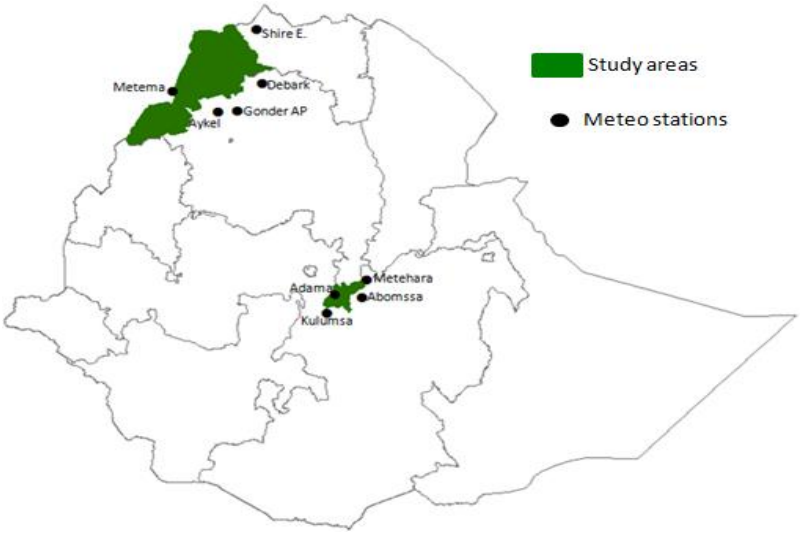

Figure 1 Sample Zones in Sugar and Cotton Producing Areas

4. Characteristics of vulnerability

As discussed in the section on conceptual framework, the climate and non-climate drivers of vulnerability to climate change risk are assessed in this section. Thus, the result is presented in two subsections. The first subsection presents the non-climate change drivers of vulnerability and the second subsection presents trends in climate change parameters as perceived by the community.

4.1. Non climate drivers of vulnerability

The vulnerability of households or community to climate change risk depends not only on the extent/degree of the adverse events that may occur due to change in climate variables but also their adaptive capacity which varies from community to community and region to region. While the risk from change in the mean value of climate parameters such as change in mean temperature and precipitation are key climate factors that expose households/communities to adverse events of climate change; the sensitivity or level of impact also depends on the adaptive capacity of the households/communities which are also influenced by non-climate change factors. As explained in the previous section, these non-climate change factors include existing livelihood profile, economic asset resources, human capital, institutional factors, access to infrastructure and information. This section presents the characteristics of the cotton and sugarcane growing regions in terms of non-climate change factors by gender category. The major non-climate determinants that dictate households' state of vulnerability include households' livelihood profile, their asset base and institutions and infrastructure. Each of the non-climate change determinants of vulnerability are descriptively discussed below.

4.1.1. Livelihoods Profile

The livelihood profile of a household is an important source of information to measure the extent of its vulnerability to climate change impacts. Furthermore, it reflects on the ability of the household to adapt to risks associated with climate change. The type of economic activity on which households depend crucially determines the vulnerability of

their livelihood. In this respect, our study characterises target population in terms of their main sources of livelihood. Besides, not only the type of main sources of income but also how sensitive it is to climate change related impacts is important. Thus, our study also characterized the level of diversifications in the study areas in which case we analysed the various ways of diversifying their livelihood in terms of the number of sources of income and allocating their labor to different activities. As our dataset comes from different sampling units, the discussion is made for cotton and sugarcane producing areas separately though we present the result in the same table. A comparative analysis is made by gender since the gender of the household head and the gender composition of the households also has implication on the size of the impact of climate change. For instance, Karfakis et al. (2012) and Barrientos and Khanji (2002) argue that female headed households are more vulnerable to the impacts of climate change in comparison to their male counterparts because of differences in access to basic resources, such as land and limited services such as financial services, which are important resources to mitigate the negative effects of climate change. As a result, female headed households are more likely to be affected by climate change than male headed households.

a) Primary Source of Income

The distribution of household members in different activities shows that the majority of the household members are engaged in farming both for sugarcane and cotton growing areas (Table 2). This was found to be true regardless of the gender of the household members. Farming accounts for 67% and 89% of the income for the households in sugarcane and cotton producing areas, respectively. The corresponding figure for income from farm labor accounts for 11% and 1%. On the other hand, income from non-farm businesses such as small-trading accounts for a very small proportion of the household income in both regions though it is relatively better in sugarcane producing regions. The fact that farming is the major source of income for households regardless of the type of commodity they produce shows that the households are vulnerable to climate change shocks. This activity is sensitive to the rise in temperature and change in rainfall provided that the change in both climate parameters are beyond the threshold

that is suitable for crop production or productivity (e.g. see Cabral et al., 2007; McGuigan et al., 2002; Skoufias, 2014). Previous empirical evidences indicated that in places where traditional agriculture dominates, the change in the length of the seasons makes it difficult to conduct the crop production process at the regular time unless some sort of adaptation mechanism is adopted (Cabral et al., 2007 and McGuigan et al., 2002).

In terms of gender, our study also reveals that the proportion of male household members that are engaged in farming is greater than that of the female household members. The difference between the proportion of female and male household members engaged in farming was much bigger for cotton producing areas than for sugarcane producing areas. Similar to the case for farming, the proportion of male household members that are engaged in farm labor is greater than the proportion of female members engaged in the same activity in sugarcane producing areas. However, the percentage of household members engaged in the same activity is very small in case of cotton producing areas. On the other hand, the proportion of female household members engaged in business/trading was greater than the proportion of male household members. The proportion of female household members in cotton producing areas engaged in business and trading is much higher than the same value for sugarcane producing areas (Table 2). This result has important implications for their vulnerability to climate change impacts. In addition to their exposure to any shocks to this form of livelihood, the likelihood of their vulnerability to impacts related to climate change will increase. If the level of change in temperature and precipitation become beyond the threshold level for crop production, not only that it has an impact in reducing household income but also that the gender difference in the type of activity has important implications particularly in female – headed households. For instance, in addition to their normal engagement in farming activity, women also have child care responsibilities. In this case, if the impact on farming is substantial, woman will be forced to leave the household to earn income, leaving children without care and this affects their wellbeing both in terms of nutrition and education. In addition, as the literature indicates, children may also be forced to work outside the household which comes at the expense of their education (e.g. see McGuigan et al., 2002).

Table 2: Primary Source of Income

Primary occupation	Growing areas						
	Sugarcane producing region			Cotton producing region			Total
	Female	Male	Total	Female	Male	Total	Total
Farming	60.51	69.89	67.44	56.76	91.17	89.05	78.26
	(95)	(311)	(406)	(21)	(516)	(537)	(943)
Farm labour	7.64	12.58	11.30	0.00	0.71	0.66	5.98
	(12)	(56)	(68)	(0)	(4)	(4)	(72)
Business/Trading	4.5	2.5	2.99	(18.9)	3.2	4.2	3.6
	(7)	(11)	(18)	(7)	(18)	(25)	(43)

b) Labor Time Allocation

The impact of climate change is not only manifested in the loss of farm income as a result of reduction in crop yield, but it also has important implications on allocation of family's labor. The reason is, the loss of income may force households to allocate their labor to non farm income sources and may even result in migration (Gemenne, 2010). In relation to labor time allocation, our survey indicated that an average household spend four days per week in farming activity in both crop growing areas. But households spend on average 1.5 and 1.2 days for non-farm business activities in sugarcane and cotton growing areas, respectively (Table 3). Gender wise comparison revealed that the average time household members in male headed households spend working on the farm was greater than the amount spent by female headed households in the same activity in both sugarcane and cotton producing farms. However, the difference in the average time spent working on the farm between male headed and female headed households is smaller for sugarcane producing areas. Moreover, the average time spent on farming activities is higher for households in the cotton producing areas.

The distribution of time allocated to different activities shows that the average time spent on non-farm activities is smaller, in general, when compared to the amount spent on farm activities except for female headed households in cotton producing areas. The average number of days spent on non-farm activities was again found to be higher

among male headed households in sugarcane producing areas. In contrast, the average time spent on non-farm activities in cotton producing areas was much higher for female headed households compared to their male counterparts. Overall, the average time spent in non-farm activities is higher for sugarcane producers while the opposite is true for the average time spent on farm activities for the same commodity.

Table 3: Labor time allocation (days/week)

Time allocation (days/week)	Sugarcane producing region			Cotton producing region			Total
	Female	Male	Total	Female	Male	Total	Total
Time spent Working on the farm	2.7	4.2	3.8	2.0	4.2	4.1	3.9
Time spent Working non- farm activities	1.0	1.7	1.5	2.1	.7	.8	1.2

c) Income

The reduction in agricultural productivity due to climate change has a strong implication for many of the countries with majority of their population relying on agriculture for livelihood. The loss of agricultural productivity affects the income and consumption of households. It could either push or keep households below the poverty line. The ability of net consumers to purchase consumer products could be constrained due to the reduction in their income. Net producers could also face a decline in their consumption due to smaller crop yield (Karfakis et al., 2012). The fact that households in cotton and sugarcane producing areas rely on these two crops as main sources of income implies that it is crucial to characterise them in terms of their income to address climate change impact on these two commodities.

As shown previously, the major sources of household income are crop production, farm labor and nonfarm businesses such as small trading. These income sources contribute differently to the households' total income. Crop production contributes the most to households' pool of income followed by income from business activities and labor income. Table 4 presents average annual income of households from each sources for both cotton and sugarcane growers. An average household in cotton growing areas

earn a total annual income of Birr 47,693.1 while in sugarcane growing areas, he/she earns Birr 107,044.4 in the year just before the survey year 2014. Large proportion of this income, which is Birr 41,452.9 and 88,996.03 respectively, comes from crop production,. While crop income for a household in sugarcane growing areas comes from the production of sugarcane, it comes from production of different crops mainly cereals and sesame for cotton growing areas. In comparison to the cotton producing areas, the average incomes from crop production, business activities and labor were found to be more than double in sugarcane producing areas. Moreover, there is a large difference between income earned from crop production and non-farm income which indicates that non-farm activities are fairly limited.

Gender wise, survey result shows that the average income from crop production is higher in male headed households in cotton producing areas. In contrast, female headed households earned more from business activities and labor. Similarly, male headed households earned almost double the income earned by female headed households from crop production in sugarcane producing areas. However, in contrast to cotton producing areas, female headed households earned less from business activities and labor compared to their male headed counterparts.

A detailed look into the share of income from the different sources, shows that crop income makes up the largest share in total income in both cotton and sugarcane producing areas. However, there is a significant difference in the share of crop income between the two areas. Crop income contributes more to the income of households in cotton producing areas when compared to sugarcane producing areas (Table 5). Business income accounts for much less of total income compared to income from crop production. While its contribution is higher among female headed households in cotton producing areas, the reverse is true in sugarcane producing areas. The share of labor income is the least to both cotton and sugarcane producing areas. However, its contribution is higher for sugarcane producing areas in comparison to cotton producing areas. Other sources of income do not make up for more than 2% of total income in cotton producing areas. In contrast, 20% of total income is obtained from other income

sources in sugarcane producing areas, which shows that there is more diversity in livelihoods in sugarcane producing areas than the cotton producing counterparts. However, there is a difference in the amount it contributes to the total income of male and female headed households between cotton and sugarcane producing areas. While crop production contributes more to male headed households in cotton producing areas, the share is higher for female headed households in sugarcane producing areas.

Table 4: Annual household income in Birr

Income source	Cotton			Sugarcane		
	Female	Male	Total	Female	Male	Total
Crop income	10614.8 (12768.3)	43468.9 (157114.5)	41452.9 (152446)	53967.7 (78559.7)	101354.3 (441709.4)	88996.03 (382327.9)
Business income	3681.7 (8004.8)	3218.4 (9516.1)	3246.9 (9425.1)	5499.5 (11438.0)	8770.5 (27529.3)	7917.4 (24411.3)
Income from labour	557.0 (2975.7)	300.1 (1526.4)	315.9 (1649.3)	1563.7 (2505.8)	2953.6 (5658.9)	2591.1 (5065.6)
Total household income	15066.0 (15070.8)	47693.1 (157542)	45691.1 (152869.3)	67492.5 (82827.0)	120998.6 (445788.2)	107044.4 (386195.5)

Table 5: Income Shares

Income type	Cotton producing region			Sugarcane producing region		
	Female	Male	Total	Female	Male	Total
Crop income	.71	.86	.85	.59	.57	.57
Business income	.25	.09	.09	.11	.16	.15
Labour income	.02	.03	.03	.06	.08	.08
Other non-farm income	.02	.02	.02	.23	.19	.20

A crucial point to note when looking into the impact of climate change on all economic units is that it is heterogeneous. For instance, the level of impact and resilience to it vary from one group of society to another depending on, for instance, its income status. In this regard, assessment of the vulnerability of households requires to first characterize

households based on their income status so that the level of exposure and their capacity to adapt to the impact can be determined. To look into the variation in income among households, the average income of households was calculated for each quartile group. Table 6 presents the percentage of households in each income quartile along with the corresponding mean income. In cotton producing areas, the majority of the households are in the first quartile. The number of households in each quartile declines with higher income quartile groups. The average income also increases exponentially with greater income groups. Unlike households in cotton producing areas, the largest proportion of households in sugarcane producing areas are in the highest income quartile. Similar to the case in cotton producing areas, the average income of the income quartiles in the sugar producing areas also rose exponentially with higher income groups. The result shows that higher proportions of households are more likely to be vulnerable to the anticipated climate change impact in cotton than sugarcane producing regions. On the other hand, while only 12% of households in cotton producing regions are in better position to cope up with the impact, it is 32% in sugarcane producing regions. In addition, even the better off in cotton producing regions have significantly less average income than their counterparts in sugarcane producing regions. This implies that adaptation strategies designed in sugarcane producing regions may not be as effective as in cotton producing regions.

Table 6: Income Quartile Group- Percentage and average income

Income quintile group	Cotton producing region		Sugarcane producing region	
	% (n)	mean income (Br.) (sd)	% (n)	Mean Income (Br.) (sd)
1	35.16 (212)	8746.4 (6206.2)	23.1 (139)	10345.5 (7440.6)
2	28.9 (174)	27903.1 (5269.9)	23.8 (143)	27925.1 (5960.2)
3	23.9 (144)	51692.6 (9781.2)	20.9 (126)	54581.7 (10143.8)
4	12.1 (73)	183542.6 (413399.1)	32.2 (194)	268722.2 (651816.8)
Total	100 (603)	45691.1 (152869.3)	100 (602)	107044.4 (386195.5)

4.1.2. Asset

While the level of income of a household crucially determines the vulnerability and adaptability of the household, the wealth status of the household measured in terms of asset holdings, expenditure, etc, affects the strength of the impact of climate change. Assets are an important source of mitigating risk and vulnerability. Households diversify risk by holding their assets in different forms which can also be used for productive activities. At times of shock, households may sell these assets to mitigate the impacts of the shock. With this in mind, this sub section will discuss households' ownership of different kinds of assets. Skoufias (2014) stated that if households have enough resources to rely on in times of adverse events related to climate change, these households can adapt to the impacts relatively easily. On the contrary, households at very low wealth status could easily be affected by the impact as their capacity to adapt is also very low. Our study also characterises households in terms of their wealth status using key indicators including access to land, ownership to modern farm tools and livestock. While the implication of access to land and livestock asset for vulnerability and adaptation to climate change impact is straight forward, it may need to briefly reason out the implication of ownership to modern agricultural input. Household's access to modern agricultural inputs also affects how well households can respond to climate change. The use of modern agricultural inputs helps households to circumvent the negative impacts of higher temperature and limited precipitation (IPCC, 2014). Karfakis et al., (2012) also suggested that use of such inputs is one of the ex-ante risk management mechanisms adopted by crop producers. It is also part of the recommended climate change adaptation mechanisms (IPCC, 2014). We also looked into the human capital aspects of our target households as it has important implications for adaptation to climate change. For instance, the fifth assessment report of the IPCC indicated that the education level of the household may affect the extent of the damage inflicted by climate change by increasing its ability to diversify and come up with adaptation mechanisms to mitigate the climate related risk (IPCC, 2014). Greater human capital endowment of the household could also help the household by making it less dependent on agriculture for income.

a) Land holding

Access to land is a key asset for households whose livelihood majorly depends on agricultural production. The impact of climate change on such households is severe compared to households whose livelihoods depend on non-farm activities. As the impact of climate change on farm households is manifested in change in crop productivity, which in turn affects their income, households with larger access to land and those that depend solely on this resource for their livelihood could lose due to the loss in agricultural productivity. However, wage earners could be insulated from this impact if they are not engaged in agricultural activities provided that there is no substantial reduction in food supply that can cause a rise in food price. Otherwise, the wage earners could lose due to the food price rise caused by the reduction in food supply. The overall effect, hence, depends on whether the loss of return from land and labor outweigh the loss of real income due to price rises for the poor (Skoufias et al., 2012).

In this regard, our survey contains information on land ownership and distribution in both regions. The average landholding of households in cotton producing region is 6 hectare while in sugarcane producing region is 2.5 hectare (Table 7). Given the income level and other factors, climate change may have more impact on cotton producing regions since an average household operates in larger farm land and lose more if climate related hazards that would have sever negative impacts occurred. Our result shows that income from crop takes the lion's share, indicating that severe damage on cropland due to the fact that climate related hazards will have big negative effects on households' income. The impact may be more severe due to low income level which may increase the risk of a household falling under poverty line though this depends on the degree of adverse effects. If the change in temperature and precipitation is to the extent that it becomes beyond the threshold level for crop growth, it is highly likely that a household currently above the poverty line may fall below the line as it may lose his/her production. The same is true for sugarcane producing regions though their income status is higher compared to cotton growing regions. Comparison by gender of household heads revealed that the distribution of land varies significantly between male

headed and female headed households in cotton producing regions. The average land size owned by female household heads was found to be significantly higher compared to male household heads in cotton producing areas. This implies that the impact may be more severe on female-headed households. On the other hand, in sugarcane producing areas, the average land size owned by male headed households is higher than the average land size owned by female headed households though the variation is not significant.

Fragmentation of landholding, measured by the number of plots per household, also has important implications for adaptation as it affects the labor time and thus productivity. However, the effect varies depending on the level of crop diversifications. The average number of plots is 2.7 and 3.3 in cotton and sugarcane producing region, respectively (Table 7). It is higher for male headed households in cotton producing areas. Nonetheless, the average number of plots was the same for both male and female headed households in sugarcane producing areas. Our result shows that land fragmentation is more in sugarcane areas where average landholding is smaller compared to cotton regions. The fact that farming in sugarcane producing areas is mono-cropping shows that the impact may be worse compared to cotton producing areas where there is high rate of crop diversification given the sensitivity of crops to the anticipated climate variability.

Table 7: Average land size and number of plots

Resources	Cotton producing region			Sugarcane producing region		
	Female	Male	Total	Female	Male	Total
Land size in hectare	10.9 (48.8)	5.9 (14.4)	6.0 (18.4)	2.2 (1.8)	2.6 (4.4)	2.5 (3.9)
Number of plots	1.9 (1.1)	2.7 (1.5)	2.7 (1.5)	3.3 (1.9)	3.3 (2.2)	3.3 (2.2)

b) Ownership of farm equipment

While it is an ex-ante adaptation mechanism to use improved inputs such as fertilizer, improved seed or improved farming practices, use of modern farm tools or implements

are essential for adaptation as they reduce labor time and improve traditional agricultural practices all along the value chain from preparation to harvesting. Our survey collected information on ownership and use of farm implements in the study areas. The result shows that more than 90% of the households own either light farm implements or heavy farm equipment (e.g. tractor, irrigation tools, etc) in both cotton and sugarcane growing regions (Table 8). The proportions of households that own heavy farm equipment are slightly greater in sugarcane growing areas, in contrast to cotton growing areas. Only 1.7% of the households jointly own such assets with other households in sugarcane growing areas. The number is even smaller for cotton growing areas with only a mere 0.41% of the households involved in joint ownership. Although the percentage of households that have hired such equipment is negligible in sugar producing areas, close to 6% of the households have hired such equipment in cotton growing areas. The unit value of ownership to farm equipment is greater in cotton growing areas compared to sugarcane producing regions. The current average value of farm equipment owned by households is ETB 1897 and ETB 1332 in cotton and sugarcane producing regions respectively.

Table 8: Light farm implements and heavy farm equipment asset ownership

Asset		Sugarcane Growing Areas	Cotton Growing Areas
Asset Ownership Type	Household has Ownership (%)	97.8	93.9
	Jointly Owned With Other Households (farm implements, etc) (%)	1.7	0.41
	Hired For Household/ Joint Use (%)	0.5	5.74
Average value of farm implement owned by households in ETB (Value per unit)		1332	1897

c) Ownership to Livestock

Livestock production is another source of livelihood in both sugarcane and cotton producing regions of Ethiopia. It is used as a source of income from the sale of live

animals and its products as well as used as input in crop production as means of ploughing and threshing. Like crop production, it is also vulnerable to climate change related adverse effects such as flood and drought. The fact that the sector is main source of income and used as input exposes farmers to the risk of climate change. Any shock on livestock harms farmers through reduction/loss of income as well as affecting their crop production. The impact can vary from household to household or from region to region depending on the level of importance of the livestock sector in the households' livelihood. Thus, it is imperative to explore ownership to livestock in our study areas. Accordingly, Table 9 shows ownership to livestock both in terms of number and current value in Ethiopian currency (Birr). The ownership of livestock was found to be higher in cotton growing areas compared to sugar growing areas except for chicken and other livestock which were the same for both areas (Table 9). However, the value of the different livestock is not proportional to the number of livestock which may be related to the quality of the breed and price variation in the two regions. As one may surmise, cattle and oxen have the highest value followed by sheep and goat. . The result indicates that the livestock sector is an important source of livelihood in both regions.

Table 9: Livestock Ownership (Number and Value)

Livestock Asset Type		Cotton Growing Areas	Sugar Growing Areas
Breeding Bulls	Number owned per household on average	3	1
	Average Value per unit (ETB)	3770	-
Cattle For Meat	Number owned per household on average	4	2
	Average Value per unit (ETB)	5080	5396
Cattle For Milk	Number owned per household on average	4	2
	Average Value per unit (ETB)	5143	4521
Chicken	Number owned per household on average	7	7
	Average Value per unit (ETB)	86	70
Goat	Number owned per household on average	9	8
	Average Value per unit (ETB)	1148	571
Oxen	Number owned per household on	3	2

	average		
	Average Value per unit (ETB)	6845	6579
Sheep	Number owned per household on average	8	6
	Average Value per unit (ETB)	1213	701

Comparing ownership of livestock between female-headed and male-headed households, the result shows that there is no significant variation in ownership of livestock between the two groups of household heads in sugarcane growing regions. The same does not hold true in cotton growing regions where male headed households owned more livestock (Table 10). The average number of livestock owned by male headed households was found to be double compared to female headed households in cotton growing areas.

Table 10: Livestock asset ownership by gender of household head

	Cotton Growing Areas		Sugar Growing Areas	
	Female-Headed household	Male-Headed household	Female-Headed household	Male-Headed household
Livestock Asset Ownership Per Household (Average, Number)	2.5	5	4	4

In sum, this sub section attempts to discuss entitlement of households to economic resources including sources of livelihood, income and asset such as land and livestock in climate change perspective in cotton and sugarcane growing regions. These economic resources determine the vulnerability of the households and influence the adaptive capacity to climate change impacts. The study generally indicates that households in the study regions depend on climate sensitive sectors such as crop and livestock productions as major means of livelihood, which are more sensitive to climate change by their nature. Though households in both regions depend on the same livelihoods, they have different levels of vulnerability due to their variations in income

level, asset holdings such as land, livestock and ownership of farm equipment. This difference reflects difference in the adaptive capacity.

4.1.3. Institutions and Infrastructure

The previous sub section presents a description of the economic resource, which has key implication for adaptation capacity to climate change impacts. This sub section deals with institutional constraints which is another key constraint that also determines such capacity in the study areas. Berkhout (2012), cited in IPCC AR5, provides extensive evidence that institutional capacity is a key factor that can potentially constrain the adaptation process. This is mainly due to the fact that as it determines the public service provided adaptation efforts are associated with the extent to which institutions prioritize environmental management more broadly (Keskitalo 2010 and Lesnikowski *et al.* 2013). It is, therefore, crucial to assess the institutional services as well as access to infrastructure in our study areas so as to see its implication to build the adaptive capacity of households in the study areas. Institutional services and access to infrastructure affect the adaptation responses of households through incentive structures. Moreover, they are an intermediary through which external interventions such as finances, information and skills are channelled to the local economy. Hence, institutions and infrastructures determine whether household vulnerability increases or declines. Taking these factors into consideration, this section will discuss households' access to infrastructure and institutions.

a) Extension Services

The United Nation Framework Convention on Climate Change (UNFCCC) shows that individual, institutional and societal knowledge influences the capacity to develop and use technologies to achieve adaptation objectives (UNFCCC, 2006). In line with this, the AR4 noted the role of technology in contributing to spatial and temporal heterogeneity in adaptive capacity and the potential for technology to constrain adaptation or create opportunities (Adger *et al.*, 2007). Key consideration with respect to technology is access to extension services on improved input and best practices to households' livelihood including crop and livestock production. Extension service is one

of the strategies to transfer knowledge and skill to users to take actions to build their adaptation capacity. Our survey shows that households have access to extension services for crop and livestock production, which are major livelihoods in the study regions. However, only about half of the households have access to these services (Table 11).

Access to extension service also varies by gender of household head. The percentage of female headed households that have received crop extension service was higher than male headed households in sugarcane growing areas. Similarly, the proportion of female headed households that have received livestock extension service was higher compared to male headed households in sugarcane producing areas. The opposite holds true in cotton producing areas. The proportions of male headed households that have received crop extension were higher than such female headed households. The same was found to be true for male headed households that have received livestock extension service.

Table 11: Percentage of households that have received extension service by gender of household head in percent

Extension service	Sugarcane producing region		Cotton producing region	
	Female	**Male**	**Female**	**Male**
Crop Extension Service (%)	49	47	38	58
Livestock Extension Service (%)	46	39	35	49

b) Irrigation

While access to physical resources such as land and water is essential for adaptation, the use of technology is one of the most important components for building the adaptation capacity of community. Technology ranges from the use of efficient irrigation methods to plant breeding for drought tolerance. In this respect, the survey collected information on the availability and use of irrigation in crop production in both regions (Table 12). The use of irrigation is limited in cotton growing regions whereas it is widely practiced in sugarcane producing regions. Though this is partly due to availability of

water resources, it is mainly due to the presence of sugar factory in the sugarcane producing regions. The coverage of irrigated land amounts to 59% of the farm lands in sugarcane producing regions in contrast to only 1% of the land in cotton producing areas. In terms of the type of irrigation technology, the result shows that 16% of the land that is irrigated with furrow irrigation system while 70% is irrigated using sprinkler in sugar producing areas. In cotton producing areas, surface irrigation takes up 65% of the irrigated land while other irrigation techniques are used in the remaining 35%.

Table 12: Land covered with irrigation in sugarcane and cotton producing region in percent

Proportion of land irrigated	Sugar	Cotton
Irrigated Area (%)	59	1
Type of irrigation technology		
Surface	16	65
Sprinkler	70	-
Other	14	35

Gender wise, in sugar producing areas, 70% of the female headed households irrigate their land which is higher than such male headed households which make up only 56%. In cotton producing areas, the percentage of households that engage in irrigation are negligible amounting to only 1% of the male headed households and no female headed households (Table 13).

Table 13: Access to Irrigation by gender of household head in percent

Sugarcane producing region		Cotton producing region	
Female	**Male**	**Female**	**Male**
70	56	0	1

Access to information about improved irrigation practice is another important input to alleviate constraints to adaptation. In this regard, our survey asked respondents whether or not farmers practice the required amount of water for crop growth. The result shows that frequency of irrigation varies with crop types as expected. At least 57% and 19% of households irrigate their plots two to three times a week and once per day in

cotton growing regions, respectively. On the other hand, 29% and 26% of the households in sugarcane producing region irrigate two to three times a week and twice a day, respectively (Table 14). On the other hand, 26% of the households irrigate their plots twice a day, whereas only 9% of households used the same irrigation frequency. A quarter of households do not have regular irrigation frequency in sugarcane producing areas.

Table 14: Frequency of irrigation in sugarcane and cotton producing region (percent)

	Sugarcane producing region	Cotton producing region
Twice a day	26	9
Once a day	6	19
Two – three times a week	29	57
Once a week	14	0
Other (have no regular irrigation interval)	25	16

Our survey also collected information about the key constraints in using irrigation in crop production in both regions. The survey result revealed that water shortage, poor water distribution systems and shortage of irrigated farm land are key constraints in sugarcane producing regions (Table 15). While these problems are also mentioned by farmers in cotton producing regions, the most serious problem stated by these households is the lack of improved seeds followed by shortage of farmland. Lack of awareness on the health effects of irrigation is also a serious problem in cotton growing regions (55%) though it is also in sugarcane producing regions (19%). Low farm gate price is also another constraint in the study areas.

Table 15: Problems related with irrigation in sugarcane and cotton producing regions (percent)

	Sugarcane producing region	Cotton producing region
Water shortage	50	45
Poor distribution	45	30
Water logging	13	30
Lack of awareness to health effects	19	55
Lack of access to credit	19	52
Shortage of farm land	40	58
Shortage of improved seed	15	61
Low farm gate price	20	42

c) Access to Finance

Lack of access to finance can constrain or affect adaptive capacity of producers or actors along the value chain. The AR5 stated with very high confidence that the implementation of specific adaptation strategies and options can be constrained by access to financial capital which can be manifested in the form of access to credit (WGII AR5 Chapter 16, IPCC, 2013,). In this regard, households in the cotton and sugarcane producing regions of Ethiopia have limited access to credit both in terms of source and amount. As can be seen from Table 16, the majority of the households' source credit is relatives or friends in both sugarcane and cotton producing areas. Among the households in sugar producing areas 13% of the households took credit from relatives or friends. Similarly, 30% of the households in cotton producing areas got credit from the same source. More households in cotton producing areas used formal organizations such as farmers' associations/ cooperatives and microfinance institutions as sources of credit. 15% of the households in cotton producing areas took credit from farmers' associations. Moreover, 21% of the households in the same area took credit from microfinance institutions. In sugar producing areas, 7% of the households have taken credit from farmers' associations or cooperatives and another 7% have received credit from microfinance institutions.

With regards to the size of the loans received, on average, the largest amount was taken from microfinance institutions in both cotton and sugarcane producing areas. The

second largest amount was taken from relatives/friends in cotton producing areas while other sources contributed the second largest amount in sugarcane producing areas. The third largest amount was received from farmers' associations in both cotton and sugarcane producing areas. The result indicates that access to credit both in terms of access to formal credit institutions and amount is very limited which can be one of the key determinants of vulnerability to communities in both cotton and sugarcane producing regions of Ethiopia. About 19% and 52% of households in sugarcane and cotton producing regions stated that access to credit is one of the key constraints for improving their livelihood (see table 15).

Table 16: Access to credit (percent of households and amount in ETB) in sugarcane and cotton producing region

Source of credit	Percent of Household		Amount in ETB	
	Sugar producing region	Cotton producing region	Sugar producing region	Cotton producing region
Relatives/ Friends	13	30	1783.256	5573.871
Farmer associations/co-operative	7	15	1837.857	4382.772
Microfinance institutions	7	21	3842.857	8448.231
Others (specify)	3	0	2427.406	300.000

d) Access to Infrastructure

Access to infrastructure has important implications for adaptation capacity of households or communities in the study areas. A variety of infrastructures can constrain the adaptive efforts of a particular community. With regards to households' access to infrastructure, a set of facilities was taken under consideration. Access to road transport, market, education and other public services including health, administrative and agricultural office are among the key infrastructures with important implications for adaptation capacity in the study areas. Access to road transport enables households to take part in trading and get fair price for their outputs. In this regard, our survey shows that on average it takes 26 minutes for a household to walk to the nearest all weather

road in sugarcane producing region whereas it takes 221 minutes for an average household in cotton producing region in 2014. It would have taken more time if such measurements were taken in 2005 (Table 17). The survey result shows that the average walking distance in minutes to different infrastructures was found to decline over the period 1997 - 2006 for both sugar and cotton production. A similar result is observed for the other types of infrastructure though the size of the decline varied based on the type of infrastructure. Moreover, the average distance to the nearest facility was found to be much bigger for cotton producing areas than sugar producing areas. Among the different facilities, distance to the nearest hospital was found to be the largest both in sugar producing and cotton producing areas. The facility that can be found in the shortest distance is seasonal road for sugarcane growing areas. On the other hand, the facility that can be found in the shortest distance is grain mill and primary school in cotton producing areas.

e) Access to basic social services

Access to basic social services such as potable water, sanitation and energy are integral parts of the adaptive capacity of households or a particular community to climate change impacts. In this regard, our survey result shows that 14% of the households in sugarcane producing areas were found to have access to piped water (Table 18). The percentage was found to be much smaller in cotton producing areas with only 4% of the households having access to piped water. The percentage of households that have access to public piped water or tube well was found to be much larger in both sugarcane and cotton producing areas.

Table 17: Access to Infrastructure in minutes in sugarcane and cotton producing regions

	Infrastructure name	Sugarcane producing region		Cotton producing region	
		2005	**2014**	**2005**	**2014**
1	**Access to road transport**				
	All weather road(asphalted)	39.72	25.88	366.77	220.63
	Seasonal road	27.26	16.48	85.04	42.50
	Bus/transport station	54.74	39.66	311.19	220.06
2	**Access to district market center**	**74.66**	**61.61**	**381.93**	**373.83**
3	**Access to education**				
	Primary school	31.62	20.51	39.22	19.85
	Junior secondary school	46.88	31.42	133.68	66.88
	Senior secondary school	115.12	74.57	464.03	377.80
4	**Access to other public service**				
	Health center / clinic	64.26	52.55	88.12	61.27
	Hospital	237.21	216.82	971.60	939.96
	Veterinary clinic	69.69	56.13	113.61	86.08
	Grain mill	47.47	28.47	30.30	15.23
	Kebele office	44.27	40.26	38.00	27.68
	DA office	44.67	39.90	43.72	29.10

Among the households in sugarcane producing areas, 71% had access to public piped water while 53% of the same households have access to the same facility in cotton producing areas. A reasonable proportion of households (26%) use protected well/ spring/ pond or river as their source of water in cotton producing areas while only 1% of the households in sugar producing areas used these sources of water. With regards to households' access to toilet, 61% of the households in sugarcane producing areas and 65% of the households in cotton producing areas have pit (private) latrine. In contrast, 33% of the households in sugarcane producing areas use open air. In cotton producing areas only 27% use open air. The majority of the households use wood for cooking purposes in both sugarcane and cotton producing areas. 83% of the households in sugarcane producing areas and 98% of the households in cotton producing areas use the same. There is large difference in terms of access to electricity between cotton and sugarcane producing areas. 63% of the people in sugarcane producing areas use

electricity for lighting. In contrast, only 18% of the households in cotton producing areas use electricity for lighting.

Table 18: Access to Basic public services in sugarcane and cotton producing region of Ethiopia in percent

	Sugarcane producing region	Cotton producing region
Potable Water		
Piped into dwelling/yard/plot	14	4
Public standpipe/tube well	71	53
protected well/spring	1	26
Sanitation		
Pit latrine (private)	61	65
Open air	33	27
Energy		
Wood for cooking	83	98
Gas/electricity for cooking	10	0
Electricity for light	63	18

In sum, this subsection discussed the non – climate drivers of vulnerability. It has been shown that there are a multitude factors that make communities in the sugarcane and cotton producing regions vulnerable to anticipated climate change risks. They depend on livelihoods that are climate sensitive such as crop and livestock production, which are very sensitive to climate change risks. Non-farm income accounts for a small portion of their income. Even though they have some assets which can be used as coping mechanisms at times of adverse events related to climate change, they can easily fall below poverty as their asset holdings and income cannot take long as means of shifting or looking for other livelihoods that are not sensitive to climate change. In addition, they have very limited access to finance such as credit which can be used as a coping mechanism that can help them survive after the occurrence of adverse events. Access to public services such as roads is also limited and can limit their efforts to look for other livelihood strategies. As a result, these factors can limit or constrain their adaptive capacity. The next subsection discusses climate related factors such as change in temperature and rainfall in the last three decades and access to climate related information that determines the vulnerability of households and their adaptation.

4.2. Climate Change Drivers of Vulnerability

Climate change is a global concern mainly due to its effect on two parameters – change in temperature and the rainfall in quantity or pattern. The combination of increasing temperature and shifting rainfall amounts and patterns negatively impact agriculture (IPCC, 2000; Muller, 2009). As per the report, the potential direct effects on agricultural systems are seasonal changes in rainfall and temperature, which could impact agro-climatic conditions, altering growing seasons, planting and harvesting calendars, water availability, pest, weed and disease populations, etc.; it has also an effect in altering the evapo-transpiration, photosynthesis and biomass production, and thereby affects yield. In addition, land suitability can also be changed as a result of the change in temperature and precipitation. Increase in CO2 levels also can lead to a positive growth response for a number of staples under controlled conditions, which is also known as the "carbon fertilization effect". However, there is uncertainty over the magnitude of the change in these climate variables. Given these uncertainties, there are increasing concerns that the change in climatic variability patterns will make households dependent on agriculture even more vulnerable than they already are. In view of this threat, it is essential to understand the trends in temperature and rainfall patterns in our study areas as such information can have important implications for building the adaptation capacity. In line with this argument, our study collected information on the trends in temperature and rainfall for the last three decades as perceived by old people in the two commodities' growing regions. The study also collected information on the occurrence of climate related adverse events and the associated actual impacts. The responses are presented as follows.

4.2.1. Climate Variability

Long term variability in mean temperature and precipitation are the two key climate parameters associated with climate change. To gain an insight into the extent to which climate has changed in their areas, elderly people were interviewed to provide their assessment of the change in rainfall and temperature over the past 20 years. For temperature, elderly people were asked to state the change in terms of either 'more hot days', 'more cold days' or 'no change' compared to the years before. For the change in

precipitation, they were asked to state their responses in terms of 'Rainfall increase', 'Rainfall decrease', 'Rains are more erratic', 'Rains come earlier' or 'Rains come later'.

Regarding weather changes, half of the elderly believe that there are more hot days now in cotton producing areas. The percentage is even larger in sugarcane producing areas. Close to 86% of the elderly in these areas believe that there are more hot days now than before. The difference between the percentage of the elderly that believe rainfall is increasing and those that believe it is decreasing is not more than 3 percent in cotton producing areas. However, in sugarcane producing areas, a significant number believe that there is a decline in rainfall. In contrast, only 4.2% believe that there is an increase in rainfall. Regarding the timing of rainfall, 11% of the elderly believe that rain is coming at a later point than needed in cotton producing areas. In sugarcane producing areas, the problem seems to be more serious. About 39% of the elderly in these areas believe that rain is less timely now than 20 years ago. Table 19 shows the response of the elderly regarding weather changes in both cotton and sugarcane producing areas.

Table 19: Perception of the elderly regarding climate change in sugarcane and cotton producing regions

Climate variable	Cotton producing region			Sugarcane producing region		
	Female	Male	Total	Female	Male	Total
More hot days	35.1	51.3	50.3	85.4	85.8	85.7
More cold days	0	43.7	48	0	0	0
Rainfall increasing	13.5	18.2	17.9	3.2	4.5	4.2
Rainfall decreasing	10.8	21.2	20.6	55.1	37.8	42.3
Rains come later	2.7	11.5	10.9	30.4	42.0	38.9

4.2.2. Climate related adverse events

Elderly people were also asked to state the climate related adverse events that occurred during the last two decades in their areas. Drought and flood were the two events that occurred in the two regions though the extent varies from region to region.

We also asked the number of times these events occurred within the preceding five years of the survey year. The percentage of male headed households that have experienced drought in cotton producing areas amounted to 11%. Less female headed households experienced drought in the same area. In sugarcane producing areas, flood is a more common problem although drought is also contributing its fair share to the problem. The climate events were felt more by female headed households in sugarcane producing areas in contrast to the cotton producing areas in which male households were the ones that experienced drought and flood more. Table 20 shows the percentage of households that have experienced drought and flood. The average occurrence of drought and flood was found to be the same (Table 21). Each household experienced drought and flood twice.

Table 20: Experience of climate change event, (%)

Climate event	Cotton			Sugarcane		
	Female	**Male**	**Total**	**Female**	**Male**	**Total**
	Yes	Yes	Yes	Yes	Yes	Yes
Drought	5.56	11.13	10.52	7.79	6.55	12.4
Flood	0.00	4.35	0.58	8.33	7.00	0.72

Table 21: Mean occurrence of climate change events within the last five years

Events	Mean occurrence		
	Cotton region	**Sugarcane region**	**Both regions**
Drought	2.16	2	2
Flood	0.5	.5	2

4.2.3. Climate related information

Households are reported to have gained information about the climate from different sources. The first one is radio which is the primary source of information in both cotton producing and sugarcane producing areas. The second main sources of information are family and friends in cotton producing areas while it is TV for sugarcane producing areas. The third important source of information is DA office in cotton producing areas in

contrast to family and friends in sugarcane producing areas. Table 22 shows the sources of climate related information for households.

Table 22: Sources of climate related information

Sources of climate related information	Cotton	Sugarcane	Total
Radio	26.20	32.28	29.3
Family and Friends	20.57	17.09	18.8
TV	12.64	21.40	17.1
DA office	16.79	15.20	15.9
Village leaders	15.50	4.86	10.1

Overall, this section discussed the climate change and non-climate drivers of vulnerability in two subsections. The first subsection discussed the non-climate drivers of vulnerability, and it has been shown that a multitude of factors make households or communities in both cotton and sugarcane producing regions vulnerable to climate change risks. The second subsection also discussed the change in climate variables including long term mean change in temperature and rainfall as perceived by the local elderlies within the last three decades. The result shows that there has been an increase in mean temperature measured in more number of hot days, and rainfall has also changed both in its pattern and amount. Accordingly, the result revealed that the households and communities are vulnerable to impacts related to climate change observed in their regions within the last three decades. However, their vulnerability varies not only between the two commodities' growing region but also within a region due to differences in access to economic resources, institutional services, access to infrastructure and basic social services as well as climate change related adverse event occurrences, which together determine the adaptive capacity of households or communities. Though the result shows that households are vulnerable to climate change impacts that have already occurred in their region, the real impact is not well addressed in this section. Thus, the next section discusses the impacts already faced as a result of the occurrence of the climate related adverse events and the climate and non – climate factors that determine their level of vulnerability.

5. Impacts of climate change on households' welfare

The above climate related adverse events affect local people's lives directly through their impacts on livelihoods, reduction in crop yields or income, loss of assets such as destruction of homes, livestock, etc and indirectly through, for example, increased food prices and food insecurity. The level of impact shows not only the severity of the events but also the extent of vulnerability. It also affects the adaptive capacity of the community since it has implications on the ability to revive from the impact and to cope up with future events. In this regard, our study collected the impact of the bad events in terms of their impact on household income, food production as well as loss of assets.

5.1. Impact on household income

Both drought and flood events had serious negative impact on household income in both areas though the extent varies by gender (Table 23). Decrease in income of households due to flood is observed more in female headed households than male headed households in cotton growing areas but less in sugarcane areas. The households that have experienced drought include 100% of the male households in cotton producing areas and both female and male producers in sugarcane producers. Moreover, 98.41% of the female headed households hit by drought had their income reduced.

Table 23: Income reduction due to climate change events in sugarcane and cotton producing region (% of households)

Climate event	Cotton producing region		Sugarcane producing region	
	Female	Male	Female	Male
Drought	98.41	100.00	100.00	100.00
Flood	75.00	0	80.65	92.31

5.2. Impact on household asset

A reduction in household assets was also experienced in both cotton and sugarcane producing regions though the impact also varies by gender of the household heads. The impact is observed more in male-headed households in cotton producing areas. About

83% of the male headed households had their assets decline due to drought and 49.59% in female headed households Table 24). Households hit by drought in sugarcane producing areas experienced a reduction in assets as well. 66.67% of drought hit female headed households and 48.28% of the drought hit male headed households experienced a reduction in assets. Flood caused the reduction in assets among many of the households in sugarcane producing areas. Among the households hit by flood, 69.23% of the female headed households and 64.52 of such male headed households have experienced a decrease in household assets.

Table 24: Decrease in household Asset as result of climate change adverse events (% of households)

Climate event	Cotton producing region		Sugarcane producing region	
	Female	Male	Female	Male
Drought	0.00	82.54	66.67	48.28
Flood	0.00	49.59	69.23	64.52

5.3. Impact on food production

Some of the households that have experienced drought and flood have also experienced a reduction in food production. In cotton producing areas, all of the female headed households that have experienced drought have had a decline in food production (Table 25). About 91% of the male headed households in the same area have experienced a reduction in food production due to drought as well. Similarly, 65% of such male households have lost all or part of their food production due to flood. In sugarcane producing areas 83.3% of female headed households that experienced drought had their food production decline. Moreover, 93.1% of the male headed households and 83.3 % of the female headed households that have experienced drought have experienced a decline in food production. Among the households hit by flood in sugarcane producing areas, 92.3% of the female headed households and 70.9 % of the male headed households experienced a reduction in food production due to flood.

Table 25: Decrease in Food Production due to climate change related adverse events in cotton and sugarcane producing region (% of households)

Climate event	Cotton		Sugarcane	
	Female	Male	Female	Male
Drought	100.0	90.5	83.3	93.1
Flood	0.0	65.0	92.3	70.9

This section discussed the impact observed on households' income, food and asset loss due to the occurrences of climate change related adverse events including drought and flood. It has shown that the impact has been substantial. The observed impact can also show the degree or severity of these climate hazards as well as the extent of the vulnerability of the households to the hazards. Whether these impacts can be minimized or not is a question of what adaptation mechanisms have been adopted to cope up with bad events by the households, local community or government. The next section presents the result on the adaptation mechanism adopted by households to cope up with bad events.

6. Autonomous Adaptation Strategy

The effect of climate change on poverty also depends on the extent of households' adaptation to emerging circumstances. Adaptation to cc can be autonomous or planned, depending on how the strategy is initiated.[4] Actors at different levels including international, national, subnational and community levels have different roles in building adaptive capacity or formulating and implementing adaptation strategies to build the resilience of a particular sector or community to anticipated climate change. The combined effort of these actors is crucial for effective adaptation strategies. While the international actors have crucial roles in supporting the creation of adaptation strategy and its implementation at the national level, national governments have big roles in formulating and coordinating adaptation strategies including the provision of information

[4] Autonomous adaptation can be defined as market based response to climate change by individuals, households, or firms, typically by adjustments over time in their production and consumption patterns. Autonomous adaptation is typically distinguished from planned adaptation, which refers to policy-based actions that are needed when market failures or other coordination problems hinder relevant collective responses to climate change.

and policy frameworks to subnational governments as well as creating legal frameworks to protect vulnerable groups. National governments also facilitate the coordination of budgets and financing mechanisms (Alam *et al*. 2011; Kalame *et al.* 2011). Subnational level governments have active roles in adopting the national level policy and strategy to their own context as well as in the implementation of adaptation strategies. Local communities also play important roles not only in the implementation of adaptation strategies but also in contributing to the formulation of the strategies so that they can own them for their effective implementation to address problems related to climate change. The crucial role of local communities in designing appropriate adaptation strategies and effectively implementing them mainly comes from the context specific nature of adaptation, which is influenced by differences in resources, values, needs and perceptions among and within society. The fact that climate adaptation is context dependent and it is uniquely linked to location makes it predominantly a local government and community level of action (Corfee- Morlot *et al*., 2009; Glaas *et al*., 2010; Mukheibir *et al*., 2013). In addition to its context specific nature, the heterogeneity of adaptation strategies also results from differences in knowledge, information and awareness of adaptation alternatives across societies. Therefore, it is important to understand and characterize the local knowledge and practices in adaptation to the adverse effects of climate change that have occurred in the study areas. Accordingly, our survey contains information about the autonomous adaptation mechanisms which are used by the local community in order to cope up with the different impacts that happened as a result of the adverse effects that occurred in the last two decades. Our result indicated that there are several adaptation mechanisms adopted by households in response to the impacts from climate change related adverse events (Table 26). The most frequently used adaptation mechanism is own-saving with 24.5% of the households having had relied on it at times of need. The households also sold crop and livestock as an adaptation mechanism. However, 43% of the households did not take any measure to deal with the disaster. This shows that the adaptive capacity of households have been very low. This low adaptive capacity of households is not unexpected since the different sections discussed previously clearly revealed that they are vulnerable to climate change hazards that already occurred due to the fact that both

the climate and non – climate drivers of vulnerability have put the households in such a position that they are constrained to the required adaptive capacity.

Table 26: Adaptation Mechanisms adopted by households in cotton and sugarcane producing regions (% of households used the adaptation)

Adaptation mechanism	Percent
Relied on Own-Savings	24.5
Sold Crop Stock	5.5
Sold Livestock	4.7
Did Not Do Anything	42.8

7. Summary and conclusion

Climate change is a global concern mainly due to its effect on two parameters that affect the ecological setup and particularly agriculture – increase in the average temperature and rainfall variability. Even though the agriculture sector as a whole is vulnerable to climate hazards including flood and drought, climate change poses a particular threat to certain agricultural commodities and social groups due to difference in agro-ecology and heterogeneity in non – climate change drivers of vulnerability. This context specific nature of the impact of climate change calls for the need to identify adaptation options to build a climate resilient production of particular agricultural commodities and vulnerable groups.

In addition to coffee, the Agricultural Development Led Industrialization (ADLI) strategy and the Growth and Transformation Plan (GTP) clearly stipulate that sugar and textile are strategic export commodities in the industrial development strategy of Ethiopia. They are labour intensive, have broad linkages with the rest of the economy, use agricultural products as inputs, are export-oriented and import substituting, and contribute to rapid technological transfer. They are strategic commodities because they are crucial in transforming the country's economy from the agriculture – led into industry - led economy within the GTP period of 2011 - 2015.

Accordingly, the study focuses on two commodities including sugarcane and cotton. While sugarcane is key input in the production of sugar, cotton is key input in the production of textiles. In addition to their economic importance, empirical evidences from other developing countries on the impact of CC on sugarcane and cotton commodities show that CC poses risk on the two commodities. However, evidence on the impact of CC on these two commodities is absent in Ethiopia. As a result, not only that the export earning of the country is affected due to the impact of climate change on these two commodities, it is also that the different actors along the value chains of the two commodities are vulnerable to the anticipated climate change impacts. Therefore, it is imperative that urgent action is required to build a climate resilient agricultural production for these two agricultural commodities so as to reduce the negative impacts

of climate change on the country's export earning or economic growth and reduce the impacts on vulnerable social groups.

Therefore, a research project is initiated by the Ethiopian Development Research Institute to identify adaptation options to build a climate resilient production of the two commodities. The research has different activity components including climate modelling, agronomy study, value chain analyses, welfare impact and economy wide impact of climate change. Across all these research activities, data generated using a household survey on 1200 randomly selected households in the cotton and sugarcane producing regions is key input. This report, therefore, contains the descriptive analyses of the characteristics of climate risk, vulnerability and adaptation mechanisms adopted by households in these regions of Ethiopia.

In characterizing the nature of climate risk, vulnerability and adaptation, the study adopted the notion that identifying adaptation needs requires an assessment of the factors that determine the nature of, and vulnerability to, climate risks and an assessment of adaptation options to reduce risks. This is mainly due to the fact that the ability to adapt and cope with climate related hazards depends on the economic resources, institutions, knowledge, social status, infrastructure, technology, and social safety nets. Accordingly, to characterize the nature of climate risk, vulnerability and adaptation in the sugarcane and cotton producing regions of Ethiopia, the study explores the climate and non-climate drivers that influence the vulnerability of households and communities. It also explores the adverse events that occurred due to climate change, associated impacts and adaptation mechanisms adopted by households to cope up with the adverse events that occurred. The key results of the study are summarized as follows.

The non-climate drivers of vulnerability including livelihood, asset holdings, institutional and access to infrastructure have been explored. The result indicated that households in the cotton and sugarcane producing regions mainly depend on crop production and livestock production as their means of livelihood. Crop production accounts for the lion

share (93%) of annual household income whereas non – farm income takes very small proportion of their annual income. These livelihoods are very sensitive to climate change adverse events. The asset holding status of the households also indicated that land is the key asset. In addition, crop harvest and livestock are also assets that can easily be used at times of bad events. There are also durable assets owned by households that can be lost or easily converted to liquid income if bad events occurred. However, households vary in their level of income from all sources as well as in their level of asset holdings. So, the result shows the variation not only observed between sugarcane and cotton growing regions but also within a particular region, indicating that their vulnerability level also varies. Access to institutional services such as extension services and access to finance or credit have also been explored in the study areas since they are key determinants of vulnerability and adaptive capacity of local communities. In this respect, the survey result shows that there is low level of such services though some households responded that they have access to extension services in relation to crop and livestock productions. Similarly, households have very limited access to credit. Even those who had access to credit stated that they got very small amount of loans. As a result, households usually get credit either from relatives or money lenders. This is especially true in cotton producing regions where households do not get access to credit for purchasing farm inputs such as fertilizer and harvesting machines. Access to infrastructure is also another key determinant of vulnerability and adaptive capacity. Our survey explored access to road transport, market, school, health and local government administrative services. The result also indicated that households especially in cotton growing regions had to travel long distance which takes hours to reach the nearest all weather road. The same is true for access to vehicle transport. Overall, access to infrastructure and basic social services such as energy, potable water and sanitation is relatively better in sugarcane producing regions. Communities in cotton growing regions have limited access to these services, which are integral components of adaptive capacity.

Climate change parameters including long term changes in mean temperature and rainfall have also been explored in the study areas from local communities' point of

view, which is aimed at understanding the local knowledge regarding climate change. Elderly people were asked to state their perception regarding change in temperature and rainfall in their locality within the last three decades. The result shows that the number of hot days has increased within the specified period. They also revealed that there have been changes in rainfall amount and pattern. For the majority, rainfall has decreased compared to the year before. In addition, its pattern has changed, which for the majority decreased and comes late/delayed. There is some awareness about climate change among the growers whose main sources of information are their own experiences and mass media such as radio.

Regarding the occurrences of climate related hazards, drought and floods have been the two adverse events related to climate change observed in study areas. As a result, households in cotton and sugarcane growing areas are vulnerable to climate change, and the impact has been observed in terms of decrease in income, food production and asset holdings. In many cases, growers could not do anything to adapt to shocks. Those who are better off, use mainly their own savings to cope with shocks related to climate change such as drought and flood. However, these traditional adaptation mechanisms were not as effective as they should be as the adverse effects already resulted in the reduction of food production, income and loss of assets. This means that the increasingly erratic patterns of climate change will certainly further reduce their effectiveness, and thus, the vulnerability of households, unless effective adaptation strategies are planned and implemented.

In conclusion, our result shows that households' characteristics not only vary between the cotton and sugarcane producing regions but also that there is high degree of heterogeneity within specific regions. Accordingly, the nature of climate risk, vulnerability and adaptation also varies between the two regions but also households' ability to adapt to the adverse effects of climate change that occurred in their specific region. Given these characteristics of the non-climate and climate drivers of vulnerability to climate change impacts and adaptation mechanisms, it is critical to have a deeper understanding and to identify the most important and significant determinants of non-

climate drivers of the vulnerability of households to climate change impacts. In addition, the observed impact on income, food production and asset was not caused only as result of drought and flood; it is important to single out the impact of climate change that induces the occurrences of these bad events. Moreover, the extent of its impact on the welfare and export earning of the country is not well addressed in this report. This requires estimating the magnitude of the impact and the fundamental drivers that crucially determine the reduction of the impact on household welfare and economy as a whole. Such analyses will help to identify adaptation options, from which effective adaptation strategies can be selected and implemented, to build a climate resilient community and production of the two commodities that minimize the negative impacts on the export earning of the country.

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