Agricultural Adaptation and Institutional Responses to Climate Change Vulnerability in Ethiopia

Working Paper No. 106

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

Woldeamlak Bewket
Maren Radeny
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RESEARCH PROGRAM ON
Climate Change, Agriculture and Food Security

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Correct citation:
Bewket W, Radeny M, and Mungai C. 2015. Agricultural Adaptation and Institutional Responses to Climate Change Vulnerability in Ethiopia. CCAFS Working Paper no. 106. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at: www.ccafs.cgiar.org

Titles in this Working Paper series aim to disseminate interim climate change, agriculture and food security research and practices and stimulate feedback from the scientific community.

This document is published by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), which is a strategic partnership of the CGIAR and the Earth System Science Partnership (ESSP). CCAFS is supported by the CGIAR Fund, the Danish International Development Agency (DANIDA), the Australian Government Overseas Aid Program (AusAid), Irish Aid, Environment Canada, Ministry of Foreign Affairs for the Netherlands, Swiss Agency for Development and Cooperation (SDC), Instituto de Investigação Científica Tropical (IICT), UK Aid, and the European Union (EU). The Program is carried out with technical support from the International Fund for Agricultural Development (IFAD).

Contact:
CCAFS Coordinating Unit - Faculty of Science, Department of Plant and Environmental Sciences, University of Copenhagen, Rolighedsvej 21, DK-1958 Frederiksberg C, Denmark. Tel: +45 35331046; Email: ccafs@cgiar.org

Abstract

Climate change is a major development challenge to Ethiopia. Climate change is expected to adversely affect all economic sectors, eco-regions, and social groups. Agriculture is one of the most vulnerable sectors as it is highly dependent on rainfall. This report synthesises four case studies focusing on the impacts, vulnerabilities and local adaptation practices in Ethiopia's agricultural sector, including policy and institutional responses. The case studies were carried out in nine districts, representing the major agro-ecological and farming systems. The case studies use qualitative data generated through rapid appraisal methods, complimented with a review of relevant literature. The results show that there are changes in local climatic conditions, manifested through several indicators. These include increased temperatures, changes in rainfall amounts and patterns, and increased incidence of drought and flood events. Drought was a major problem in almost all sites, while floods affected localized areas in some of the sites. Informants attributed climate change to poor management of natural resources (forests and grazing lands), with rapid population growth as a key driver.

Various adverse effects of climate change on crop and livestock production, natural resources and livelihoods were reported. Communities used a wide range of coping and adaptive strategies that included adjustments in crop and livestock production, natural resources management, and diversification into new food and income sources. In terms of policies and institutional response, Ethiopia is arguably in a good state of preparedness to address climate change. Despite the communities' coping and adaptation strategies, the policies and institutions in place, agriculture and food security are increasingly being negatively affected by climate change. This implies local coping and adaptive capacities are being overwhelmed by climate change effects. There is, therefore, need for effective implementation of planned adaptation interventions as outlined in the national policy and strategy documents and to build resilience in agriculture, natural resources and food security sectors. Also, further research is needed to fill in crucial knowledge gaps, some of which are identified and discussed in this report.

Keywords

Agriculture; natural resources; coping strategies; adaptation; institutions; policies; Ethiopia.

About the authors

Woldeamlak Bewket, Professor, Department of Geography and Environmental Studies, Addis Ababa University, woldeamlak.bewket@aau.edu.et, wbewket@yahoo.com

Maren Radeny, Science Officer, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) East Africa, m.radeny@cgiar.org

Catherine Mungai, Partnership and Policy Specialist, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) East Africa, c.mungai@cgiar.org

Acknowledgements

The authors would like to thank the contributors who collected data and prepared the initial reports for natural resources, livestock production, crop production and policy and institutional responses to climate change. The study was carried out in collaboration with the Ethiopian Ministry of Agriculture and Climate Change Forum – Ethiopia. We also acknowledge support from Vivian Atakos and Solomon Kilungu of CCAFS East Africa.

Contributors

Feyera Senbeta Wakjira, College of Development Studies, Addis Ababa University, P.O. Box 59774, Addis Ababa, Ethiopia

Adugna Tolera Yadeta, School of Animal and Range Sciences, Hawassa University, P.O. Box 05, Hawassa, Ethiopia

Demelash Kefale Hunegnaw, School of Plant and Horticultural Sciences, Hawassa University, P.O Box 05, Hawassa, Ethiopia

Mesfin Bayou, Institute of Biodiversity Conservation and Research (IBCR), P.O. Box 30726, Addis Ababa, Ethiopia

Contents

Acronyms

CRGE	Climate Resilient Green Economy
CRS	Climate Resilience Strategy
EPA	Environmental Protection Authority
EPACC	Ethiopia's Program of Adaptation to Climate Change
FGDs	Focus Group Discussions
GDP	Gross Domestic Product
GTP	Growth and Transformation Plan
IPCC	Intergovernmental Panel on Climate Change
LGP	Length of growing period
MoEF	Ministry of Environment and Forest
NMA	National Meteorological Agency
PIF	Policy and Investment Framework
RDPS	Rural Development Policy and Strategies
SNNPR	Southern Nations, Nationalities and Peoples Region

1. Introduction

Climate change is predicted to have major adverse consequences for the world's ecosystems and societies. Although a global phenomenon, the severity of the adverse effects of climate change will differ significantly across regions, countries and socioeconomic groups. Poor countries will suffer more, with the poorest in the poor countries likely to suffer most. Africa is highly vulnerable to the potential impacts of climate change and Ethiopia is often cited as one of the most vulnerable and with the least capacity to respond and adapt (Thornton et al. 2006).

Ethiopia already suffers from historical climate variability and extreme climatic events (Mesfin 1984, Pankhurst 1985, McCann 1987, IIRR 2007). In particular, frequent droughts coupled with environmental degradation and decline in food production are common and still remain major challenges to Ethiopia (NMA 2006, 2007, Senbeta et al. 2002, Senbeta 2006). Droughts and floods are common phenomena in Ethiopia, occurring every 3 to 5 years (World Bank 2006). The country has experienced at least five major national droughts since the 1980s (World Bank 2006), along with dozens of local droughts (World Bank 2009). In particular, there is increased incidence of meteorological drought episodes, famines and climate-sensitive human and crop diseases in the northern highland and southern lowland regions of Ethiopia (World Bank 2009, Aklilu and Alebachew 2009, Oxfam International 2010, UN-ISDR 2010). In many areas of Ethiopia, the frequency of droughts and floods has increased over the years, resulting in loss of lives and livelihoods (NMA 2007, Oxfam International 2010). Climate change is expected to exacerbate the problem of rainfall variability, and associated drought and flood disasters (NMA 2006).

Analysis of historical climate data show an increase in mean annual temperature by 1.3°C between 1960 and 2006, translating into an average rate of 0.28°C per decade. The annual minimum temperature increased by about 0.37°C every decade between 1951 and 2006 (McSweeney et al. 2008). In contrast, precipitation remained fairly stable when averaged over the country (Schneider et al. 2008). Similarly, no statistically significant trend in mean annual rainfall was observed in any season from 1960-2006 (NMA 2006, McSweeney et al. 2008).

However, the spatial and temporal variability of precipitation is high, thus large-scale trends do not necessarily reflect local conditions.

Projecting into the future, most global climate models indicate some increase in rainfall in both dry and wet seasons in Ethiopia (NMA 2006). Studies with more detailed regional climate models (RCM), however, indicate that the sign of expected rainfall change is uncertain over Ethiopia and East African highlands, and the general consensus is that rainfall variability is likely to increase. With regard to temperature, IPCC's mid-range emission scenario results show that compared to the 1961-1990 average mean annual temperature across Ethiopia will increase by between 0.9 and 1.1°C by the year 2030, and from 1.7 to 2.1°C by the year 2050. The temperature across the country could rise by between 0.5 and 3.6°C by 2080 (NMA 2006). The increasing temperature combined with rainfall variability will have serious consequences on ecosystems, economic sectors and communities of Ethiopia.

Ethiopia's National Meteorological Agency (NMA) identifies drought and flood as the major hazards in the future as well, with potential negative impacts on agriculture and food security (FDRE 2011). Agriculture is the backbone of Ethiopia's economy, contributing 42% of the GDP and supporting 85% of employment (FDRE 2011). Agricultural production in Ethiopia is dominated by small-scale subsistence farmers, and is mainly rain-fed, thus highly exposed to climate variability and extremes. According to the World Bank (2006), current rainfall variability already costs the Ethiopian economy 38% of its growth potential. Climate change is likely to worsen this already distressing situation. The major predicted impacts of climate change on Ethiopia's agriculture include frequent droughts and dry spells, shortened growing season, and increased incidence of pests and diseases (NMA 2007). Without effective adaptation, there is likely to be a decrease in the total area suitable for crop production in the country. A study based on the Ricardian method predicts that a unit increase in temperature could result in reduction of the net revenue per hectare by US$177.62 in summer and US$464.71 in winter seasons (Deressa 2007).

Understanding the nature of climate change impacts, key vulnerabilities and indigenous adaptive responses at local levels, and the national institutional responses are important for developing appropriate adaptation strategies at community and farm levels. Nevertheless, there is limited research evidence as to whether or not climate change is perceived as a major

problem or even a reality by the Ethiopian communities, particularly by the poor and most vulnerable farmers in the rural areas. Similarly, local adaptive responses to climate variability and change are not well documented.

This report synthesises four case studies focusing on impacts, vulnerabilities and local coping and adaptive strategies in the agriculture sector, including institutional responses. The evidence generated from the cases studies will contribute to the national vision of building a climate resilient green economy. The specific objectives of the case studies were to assess:

- Local peoples' perceptions and understanding of climate change;
- Experienced impacts of climate change on crop production, and local coping and adaptive responses;
- Experienced impacts of climate change on livestock production, and local coping and adaptive responses;
- Observed impacts of climate change on local ecosystems and natural resources; and
- Climate change and environment related policies and strategies, and national institutional responses or preparedness to address climate change.

Three of the case studies assess the perceptions of climate change by local communities, experienced impacts of climate change on local environmental resources, crop and livestock production, and local adaptive responses to climate variability and change. The fourth case study systematically reviews available policies and strategies related to climate change adaptation and building a climate resilient agriculture. These case studies provide useful information for designing local-level specific adaptation and mitigation interventions in the specific study sites and can also be applied in similar environments across the country. Nevertheless, it should be noted that the case studies covered only three major farming systems– mixed farming, agro-pastoral and pastoral systems, and the focus is on the agriculture sector, and thus not representative of the whole country. In addition, the studies are based on a rapid appraisal and qualitative methods and secondary sources of information.

2. Methodology

2.1 Description of study sites

The case studies covered nine districts (known as *Woredas* in Amharic) from five Regional States in Ethiopia — Tigray, Amhara, Oromiya, SNNPR and Somali. The districts were purposively selected to represent the major agro-ecological zones (highlands, midlands and lowlands) and farming/livelihood systems (pastoral, agro-pastoral and mixed farming) as described in Table 1. A brief description of the biophysical and socioeconomic characteristic of each district is given in the following paragraphs. Figure 1 shows the location of the districts.

Raya-Alamata: Located in Tigray, this district is characterized by diverse topography that includes valleys, valley bottoms, ridges, hills and mountains. Rainfall is bimodal, with a short rainy season from February-March (*Belg*) and the main rainy season from June-September (*Kiremt*). The district falls in the lowland and mid highland zones. Of the total area of the district, about 48.2% is under cultivation. The district has an estimated population of 95,203 people, with an average household size of 5 and average land holding of close to 0.5 ha per household. Mixed farming is the major livelihood source, where tef, sorghum and maize are among the major crops cultivated. Forest, soil and water degradation and expansion of invasive species are some of the major agricultural and livelihood challenges in the district, in addition to droughts and floods that occur in some parts.

Raya-Azebo: A large part of this district, which is also in Tigray, is in the mid highland zone (80% of area), with the lowland and highland areas covering 18.6% and 1.4% of the district, respectively. About 18% of the district area is under cultivation. Rainfall is bimodal, but potential evapotranspiration is high and exceeds rainfall amount most of the year. The district hosts about 32,360 households with an average of 4.2 persons per household. Mixed farming is the dominant livelihood system. Cereals, fruits and vegetables, pulses and oil crops are among the crops cultivated in the area. Beekeeping has become increasingly important to the livelihoods of households in the district. The major agriculture and food security challenges include degradation of natural resources, drought and population pressure on resources. Many poor households in the district sell cactus and firewood to earn income and purchase food, while better-off households own large herds of cattle and shoats.

Table 1. Description of the study districts

Region	District (*Woreda*)	Approximate area (Km^2)	Altitude (m)	Annual rainfall (mm)	Annual temperature (^0C)	Agro-ecology	Livelihood system
Tigray	Raya-Alamata	753	1400-2300	400-600	16-26	Lowland/highland	Mixed farming
	Raya-Azebo	2,133	930-2793	400-700	15-30	Lowland/highland	Mixed farming
Amhara	Bati	1,247	1000-2700	500-1000	18-26	Lowland/highland	Mixed farming
	Kemissie	3,927	1000-2500	600-1000	18-25	Lowland/highland	Mixed farming
	North Shewa	15,936	1200-4012	800-1500	10-20	Lowland/highland	Mixed farming
Oromiya	Shala	745	1500-1900	800	15-27	Lowland/highland	Mixed farming
	Teltele	10,628	710-1560	500-700	25-35	Lowland	Pastoral/Agro-pastoral
SNNPR	Loka-Abaya	1,190	1500-1768	900-1400	17-20	Lowland/highland	Mixed farming
Somali	Filtu	17,000	350-1266	250-500	27-35	Lowland	Pastoral

Bati: Located in Amhara Region, Bati is characterized by diverse topographic conditions, with hilly areas and valleys accounting for about 42% and 28%, respectively. A large part of the district is in the lowland zone (approximately 81%). The estimated population is about 99,702, with average household size of 5 and average landholding of about 0.6 ha. Mixed farming is the main livelihood activity. The major agriculture and food security related challenges include natural resource degradation, rainfall variability, drought, water scarcity and population pressure.

Kemissie: This district is also in Amhara Region. About 78% of the district land falls within the lowland zone. Crop cultivation and livestock grazing are the major land use activities. Other land uses include forest and bush land. Mixed farming is the main livelihood activity, with sorghum as the dominant crop. Vegetables, fruits, maize, mung bean, groundnut, chat and sesame are emerging as important cash crops. Livestock production equally is important in the district, accounting for as much as 50% of household incomes. The major livestock owned include cattle, goats and sheep.

North Shewa: This district is located in the eastern part of the Amhara Region. About 59% of the zone is characterized by flat to gently sloping landscapes. The mid highland and highland areas account for 77.6% of the total area. Rainfall is bimodal and total annual rainfall varies between 160 mm in the lowland areas and to over 1500 mm in the highlands. Similarly, mean annual temperatures range from 0°C in parts of the highland areas to about 40°C in parts of the lowland areas. The major land use types include cultivation (29.5%), forest and bush (20.3%), and grazing (13.7%). Total population is estimated to be 2,012,323 people, with average household size of 5.0 and average landholding of 0.5 ha per household. Mixed farming is the dominant livelihood activity. Selling charcoal and other forest products also provide important sources of income during drought years in particular. The major agriculture and food security challenges are degradation of natural resources, drought and population pressure.

Shala: Located in Oromiya Region, Shala is entirely within the mid highland zone. Of the total area of the district, 61% is cultivated, while the rest of the land is under forest, grazing, settlements, and other land uses. The district has a wildlife sanctuary (Sinkle Wildlife Sanctuary) which is home to various wild animals such as Swayne's hartebeest, greater kudus, cheetahs, spotted hyenas, warthogs, jackals, monkeys, apes and several species of

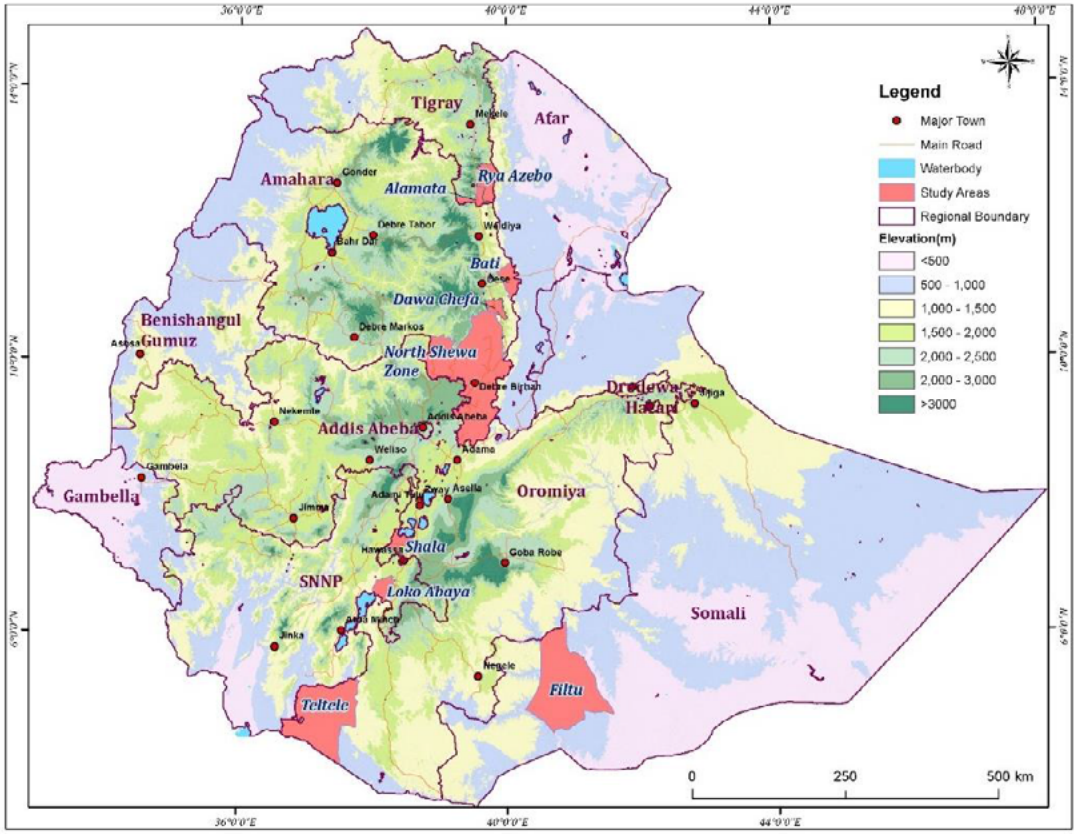
birds. Hence, it has a potential for development of ecotourism as a source of livelihood. Mixed farming is the main livelihood activity. Average landholding is about 3.9 ha per household. The major agriculture and food security challenges include soil erosion, deforestation, drought and inadequate rural infrastructure.

Teltele: This is part of the Borena area of Oromiya along the Ethiopia-Kenya border. The landscape consists mainly of lowlands and isolated hills. About 25% of the district is arable land, and 48% is pasture land. The district has an approximate population density of about 4.7 persons per km^2. Pastoralism is the major livelihood activity, with some agro-pastoralists in certain parts. Livestock holdings mostly determine the household wealth status. The main livestock types owned are cattle, sheep, goats and camels. Livestock exports from Teltele and Borena, contribute significantly to national foreign exchange earnings (Demeke 2006). This area is also a source of high quality animals that are used as the genetic base for breeding for the highland areas of Ethiopia (CORDAID and FSS 2009). The major agriculture and food security challenges include bush encroachment and expansion of invasive species, recurrent droughts, land degradation and climate change.

Loka-Abaya: This district is located in the Southern Nations, Nationalities, and Peoples Region (SNNPR). Of the total area, 20.2% is cultivated land, and 42.6% is under forest. The total population of the district is estimated to be 116,000 people. Agriculture is the main source of livelihood. Both perennial crops (mainly coffee and enset), cereals and root crops are important in the area. The major agriculture and food security related challenges include degradation of natural resources, frequent droughts and increasing population.

Filtu: Located in the Somali Region of eastern Ethiopia, Filtu is a vast lowland area with arid and semi-arid climatic conditions. There are two perennial rivers (Dawa and Ganale) that merge into one at Dolo-oda town along the Ethiopia-Somalia border. As of 2011, the estimated population of the district was 148,978 people. Pastoralism is the dominant livelihood activity, with agro-pastoralism in some parts. The major agriculture and food security related challenges include bush encroachment, degradation of natural resources, recurrent droughts and increasing population.

Figure 1. Location of study districts



2.2 Data and methods

Three of the case studies used multiple qualitative methods that included desk-based review of relevant literature, focus group discussion, key informant interviews, and field observation. The fourth case study systematically reviewed available national policies and strategies that are relevant to climate change adaptation and building of a climate resilient agriculture in the country.

The desk review used available and accessible documents, both published and unpublished from various sources. In the reviews, the three case studies together focussed on community perceptions of climate change, vulnerabilities, and local coping and adaptive strategies in the natural resources, crop and livestock sectors. Background biophysical and socioeconomic data were collected from relevant government offices in each of the study sites.

The focus group discussions (FGDs) included a mix of participants from the communities — elders, women, men, and youth in mixed group settings, and from dominant livelihood systems such as crop producers and livestock keepers. The FGDs were convenient platforms

to collect unbiased or non-exaggerated information from participants as group members would act as checks on one another. Checklists were developed and used to systematically guide the discussions.

Key informant interviews with community leaders, elderly community members, and officials of the district offices of administration and agriculture and rural development were also conducted at each study site. Different checklists were used for each category of key informants. These were complimented by field observation based on two weeks of field visits to the nine sites in the different agro-ecological zones. The field observation and photos taken provided an opportunity to collect first-hand information about local environmental and livelihood contexts.

Lastly, a critical review of existing policies and strategies on climate change, environment, biodiversity, agriculture and food security in terms of policy harmonization and implementation was undertaken. The review examined existing institutional responses to climate change and climate variability at the national and regional levels, to identify policy gaps such as availability, awareness, knowledge and implementation status, and suggest possible improvements in the policy and strategic frameworks.

3. Community perceptions about climate change

Community perceptions of climate change in the different study sites showed many common features. There was a general consensus from the FGDs and key informants including experts and officials across the sites that climate change has occurred and is occurring. The most commonly cited indicators of climate change were increasing temperatures and changes in the rainfall patterns. The perceived climatic changes were similar across the study sites despite variations in agro-ecological zones (highlands and lowlands) and livelihood systems (pastoral, agro-pastoral, mixed farming systems).

The reported changes included steady increase in temperature; reduction in seasonal and annual rainfall amounts, particularly that of the short rainy season between March-May (*Belg);* delayed onset and early cessation of rainfall resulting in shorter crop growing season; increased rainfall variability with frequent dry spells at crucial crop growth stages; increased rainfall intensity; and increased incidence of drought and flood events.

An elder from Raya Azebo district stated his observation of climate change as follows:

> "*Temperature is increasing from time to time and drought is recurring at short intervals. Some 40-50 years ago, we used to divert floods away from our crop lands. But nowadays when floods come from the highlands we divert it into our croplands as we do not get enough rain for our crops. The climate has changed. When drought strikes, farmers lose their assets and once they lose their assets they resort to cutting trees and selling wood and charcoal, and thus creating a vicious circle. The disappearance of forests is the main cause of climate change. It is a time of hardship. Planted seeds and seedlings are often lost due to lack of rain and very high temperatures*."

Droughts and floods are the two major climate related hazards across the study sites. Drought was identified as a key hazard across all the sites, while floods only affected particular (localized) areas in some of the districts (Shala, Loka Abaya and Filtu). Most communities and government officials interviewed reported an increase in drought frequency from every 6-10 years to every 1-2 years. The severe drought and flood events (where severity is often defined by significant losses in property and/or life) as reported by the FGD participants in each district are presented in Table 2.

Table 2. Severe drought and flood events across the study sites

District	Severe drought years	Severe flood years
Raya-Alamata	1974; 1983/84; 2000	2008
Raya-Azebo	1974; 1983/84; 2000	2008
Bati	1974/75; 1983/84; 2000/01	2008/09
Shala	1983/84; 2000/01; 2008/09	2010
Teltele	1983/84; 1995/96; 2000/01	2008/09; 2011
Filtu	2000/01; 2008/09; 2011	
Loka-Abaya	1999; 2000/01; 2008/09	1996; 2006; 2008; 2009; 2010; 2012

Local people attributed climate change to poor management of local natural resources, particularly forests and grazing lands, with population growth cited as a key driving factor. Forest cover loss was frequently mentioned as the cause of increasing temperatures and increasingly erratic rainfall patterns. For some of the local people who draw upon their religious beliefs (e.g. Ethiopia Orthodox), they feel that they have all sinned against their God, especially in relation to the poor management of natural resources that God bestowed

upon them. Hence the changing climate is God's retribution to mankind, and God can reverse climate change if they accept responsibility for their actions. Only expert key informants related the experienced climatic changes to the global climate change phenomenon. The major causes of climate change as perceived by communities are summarized below:

- Population growth, increased settlements and expansion of cropping land, thus changing the environment into hot and dry conditions;
- Deforestation resulting from charcoal burning and other uses;
- Cultivation of steep slopes and hilltops without appropriate soil and water conservation measures;
- Increasing livestock pressure on grazing lands and the traditional grazing land management system (free grazing);
- Destruction of natural vegetation through seasonal mobility of large cattle population from pastoral areas into highland mixed farming areas, specifically referring to the seasonal mobility of livestock from Afar to Cheffa wetland crossing the highlands of Bati in the Amhara Region.

The local people's perceptions across the study areas were consistent with historical temperature data, which shows an increasing trend in many parts of Ethiopia (NMA 2006). However, there is some differences between the local people's perceived changes in rainfall patterns and the historical rainfall data, at least in terms of seasonal and annual amounts of rainfall. Regarding the impacts of the experienced or perceived changes in climate on local resources and livelihoods, the FGDs and key informant interviews reported many effects, direct or indirect impacts. These are presented in the next section (chapter 4), including the community adaptive responses.

4. Impacts, vulnerabilities and adaptive responses in natural resources and agriculture

4.1 Natural Resources

Ecosystems and biodiversity

Ethiopia has a wide variety of ecosystems. These include tropical savannahs, tropical forests, fresh water habitats, wetlands and mountain ecosystems. The ecosystems have a wide variety of plants, mammals and birds, amphibians and reptiles. Ethiopia has more than 6,600 known plant species, 262 species of birds and 277 species of mammals, and is one of the world's biodiversity centers. These resources are sources of food, fiber, fuel, shelter and medicine, and also contribute to stabilizing the global climate and other ecosystem services.

Climate change is likely to have significant negative impacts on the ecosystems and biodiversity of Ethiopia. Increasing dry season temperatures coupled with decreasing precipitation, for example, can create widespread droughts, which in turn could lead to insect epidemics and major wildfires that can significantly affect biodiversity. The ecosystems of dry and sub-humid lands are particularly at risk because small changes in temperature and rainfall patterns can have deleterious impacts on the viability of plants and animals. Most dry lands are already under stress from cultivation, livestock grazing and other human activities. With climate change, dry land areas are likely to expand. Increase in temperature could also impact the montane biodiversity of Ethiopia, the upper line of shrubs and semi-shrub vegetation will shift up, whereas the vegetation on the foot hills will be degraded. Similarly, the wetlands ecosystems could be impacted by a decrease in runoff. Therefore each ecosystem will respond differently to climate change and climate variability, and increasing temperatures will lead to alteration of the flora and fauna, and biological linkages within ecosystems.

Findings from the key informant interviews and FGDs indicated that increased climatic variability was partly responsible for reduction in vegetation cover, species composition and plant diversity in their localities. Rainfall variability and frequent droughts reduced biomass production of plants, leading to reduced ground cover and exposure of soils to water and wind erosion. As soils and native vegetation become degraded, invasive plants tend to dominate the landscape. In Raya-Alamata, Raya-Azebo and Bati districts, for instance, the dry montane

forest was getting degraded and gradually replaced by bush and shrubs. Similarly, in Filtu, Teltele and Yabelo districts, woodland cover was being replaced by bush encroachers. In this ecological change process, there was loss of important plant species. Previously edible wild plants and other economically important tree species that were widely available, for example, were reportedly either pushed to local extinction or were found in very few numbers in their localities. These species include *Ficus spp., Carissa spinarum, Olea europaea, Syzygium guineense, Balanites aegptica, Podocarpus falcatus, Juniperus procera* among others. Photo 1 shows an example of drought stress on plants in Filtu district.

Photo 1. Drought stress on plants in Filtu district

The decline in natural vegetation cover and species composition constitutes habitat loss to wildlife resources. Key informants in many of the sites indicated that a few decades ago there were many types of wild animals in their localities such as bushbucks, lions, elephants, leopards, antelopes, birds, reptiles and amphibians, but most disappeared due to anthropogenic and climatic factors, which led to loss of habitats, water and other resources. In Teltele district, for example, key informants reported that most wild animals had migrated to Kenya due to severe competition for grazing, water and space with humans and livestock as well as increased climatic variability.

In conclusion, available evidence and community observations suggest that climate change coupled with other stresses, is significantly affecting ecosystems and biodiversity resources of Ethiopia.

Water resources

Climate change is adversely affecting water resources in Ethiopia. The impacts of climate change on water resources are mainly through rising temperatures, changing rainfall patterns and increasing atmospheric water demand. These are manifested through changes in amount and seasonal patterns of stream flows, lake levels, and soil moisture contents. Community members and expert key informants observed that frequent droughts has led to acute seasonal water shortages across most of the study areas. The problem is even more severe in the pastoral and agro-pastoral areas where water scarcity is already a challenge. In Teltele and Filtu districts, for example, the amount of rainfall has not been sufficient to fill up the existing water harvesting structures. Rainfall variability is projected to increase with climate change, with potential serious consequences on availability, quantity and quality of water resources in the study areas, including many drylands of Ethiopia.

Apart from climate change, changes in land use such as deforestation and clearing of woodlands for agriculture are also contributing to reduced water retention capacity of watersheds, and thus aggravating the effects of climate change. Photo 2 shows a water stressed area in Filtu district, and a flooded area in Meki district.

Photo 2. Drought incidence in Filtu district and flood incidence in Meki district

Soils

Soils are a critical natural resource for food security and sustainable development. Climate is one of the major factors affecting soil formation and soil degradation. Climate change affects the physical and biochemical properties of the soil through changes in soil moisture and soil temperature, including soil erosion and salinity. Many of the soil properties are quite stable

with respect to short-term variations in climate, making it difficult to detect the effects due to the greater impact of land use and land use change (Baldock et al., 2012). However, there are examples in which the relationships between climate and soils are evident. For instance, the relationship between soil types and temperature, rainfall and evapotranspiration is well known. Soils affected by salinisation may change their distribution with the change in the climatic factors. Across the study sites, respondents observed that soil erosion, degradation, and soil cracking were major problems which could be partly attributed to climate change.

4.2 Crop production

Pathways of impacts

Climate change affects crop production in several ways. These include effects of increased temperatures, changes in soil water balance, changes in length of growing period (LGP), increased soil erosion and land degradation due to increased rainfall intensities, increased incidence of floods in flood-prone areas, and increased incidence and expansion of crop pests, diseases and weeds mainly associated with increasing temperatures. Climate change can also lead to a shift in agro-ecological zones as a result of altered water balances and local climatic conditions, rendering existing technologies less relevant. Across the study sites, crop production is highly vulnerable to climate change through all of above ways, creating high annual variability in crop production. Under changing climatic conditions, more prolonged high temperatures and periods of drought will force large regions of marginal agriculture out of production. On the other extreme, frequent floods could cause substantial damage in flood-prone areas and affect crops and agricultural lands. The reported climate change impacts on crop production and associated major social consequences in each study site are presented in Table A1 in the Appendix.

The major effects of climate change on crop production across the study sites from the FGDs and key informant interviews included:

- Change of bimodal rainfall into mono-modal pattern;
- Reduction in crop yields and in some years complete crop failure due to increasingly erratic rainfall patterns and drought incidence;
- Year-to-year fluctuation and decline in LGP, making it difficult to fix reliable cropping calendars;

- Increased crop pest and weed prevalence associated with increasing temperatures;
- Increased rainfall intensity resulting in serious soil erosion;
- Frequent loss of fertilizers and seeds due to dry spells, droughts and floods; and
- Extensive flooding especially in the high potential foothills, often leading to crop destruction, livestock deaths, landslides and road blockage (e.g. Photo 3).

Photo 3. Plains and foothills regularly affected by flood, Raya-Alamata (a), and Bait (b) districts

Coping and adaptive strategies in crop production

Local communities across the study sites use a range of strategies to cope with climate variability and adapt to climate change. These strategies can be broadly grouped into three categories: adjustments in crop and livestock production; responses through natural resources management; and adjustments to new household food and income sources. Adaptation strategies in crop production include:

- Changes in types of crops produced such as cassava and jatropha production as alternative income sources;
- Diversification of crops produced (e.g. use of micro-irrigation for production of fruits and vegetables);
- Adjusting the agricultural calendar or planting and harvesting dates;
- Use of early maturing crop varieties for the traditional crops e.g. maize;
- Use of pest tolerant varieties; and
- A shift to production of high market value crops, mainly fruits and vegetables.

Improved management of natural resources was also a key strategy used by the communities' and households to cope with climate variability and climate change, including other non-

climatic livelihood stressors. Improved natural resources management strategies at the community level included area enclosure, forestation and reforestation of hillsides, watershed management and water harvesting through construction of community ponds and digging of water wells. At the household level, soil and water conservation and improved feed resources management were among the important natural resources management strategies for coping with and adapting to the changing climatic conditions. Majority of the households also participated in the community level interventions. All of the community level interventions were supported and administered by the District Agricultural Offices. Improved natural resource management is perhaps the most commonly used method for adapting to climate change elsewhere in Africa.

Diversification into new household food and income sources included use of *Moringa spp.* (in many places called *Shiferaw*) and cactus (*Ficus carica*) as food by some households, in areas where this was previously uncommon (e.g. Photo 4). Other coping and adaptive responses included working as casual laborers, micro businesses and migration of family members to towns and cities including to neighboring countries and the Middle East in search of employment opportunities. The detailed reported coping and adaptation strategies in crop production for each of the study sites are presented in the Appendix (Table A2).

Vegetable production at Raya-Alamata *Collection of cactus fruits at Raya- Azebo*

Photo 4. Livelihood diversification as an adaptation strategy

Strategies for enhancing adaptation in crop production

The key informants, the FGD groups and the technical experts across the study sites, were asked to suggest additional measures and practices (to those that were already being used) that are likely enhance adaptive capacity of communities to climate variability and climate change. A wide range of potential adaptation measures were reported, and in many cases most of the measures were already in use in one or more of the other study sites highlighting the usefulness of exchange of knowledge through farmer exchange visits. Some of the innovative strategies for enhancing adaptation in crop production and household food security reported are summarized below (with detailed strategies by study site presented in Table A3 in the Appendix):

- Introduction of teff in frost sensitive highlands, as teff is tolerant to frost;
- Promotion of production and utilization of crops such as mung bean, cactus (*Ficus carica)* and moringa (*Moringa oliefera*) in the drought-prone lowland areas;
- Crop diversification as current cultivated crops are limited, while there are opportunities for introducing and cultivating other crops (e.g. pigeon pea, groundnut, jatropha, pearl millet, mung bean, cassava and other crops) that are adapted to drought prone environments (e.g. see Photo 5);
- Introduction and cultivation of high value fruits crops such as apples in the highlands;
- Promotion of perennial crop-based inter-cropping and agro-forestry systems;
- Cultivation and use of less popular but ecologically viable crops such as cassava (*Manihot esculenta*), pigeon pea (*Cajanus cajan*), and date palm (*Phoenix dactylifera*);
- Promote production and processing of jatropha (*Jatropha curcas*), which has already demonstrated great potential to grow on degraded soils and under erratic rainfall in Bati district;
- Control and use of prosopis (*Prosopis juliflora*) as animal feed and other uses;
- Improving use of cactus as human food, camel feed and ingredient for cattle feed;
- Establishing large-scale gum tree plantations, which have great potential to grow in dry land areas;
- Developing and adopting improved technologies that are less labor intensive for removal of sediment from community ponds; and
- Re-introduction of the traditional fire burning practice for controlling bush encroachment.

Date Palm *Jatropha*

Photo 5. Potential crops for enhancing adaptation to climate change in Bati district

4.3 Livestock production

Pathways of impacts

Livestock are key assets in rural Ethiopia providing multiple economic, social, and risk management functions. Currently, livestock production accounts for about 12-16% of the GDP and about 16% of foreign earnings of Ethiopia. Livestock is the primary source of livelihood to pastoralists living in the vast dry sub-humid, semi-arid and arid areas (approximately 65% of total area) of the country. In these areas, there are an estimated 12 million pastoralists and agro-pastoralists that constitute one of the poorest and most vulnerable populations to climate change impacts.

Climate change has direct and indirect effects on livestock production. The direct impacts mainly result from weather and extreme climate events on animal health, growth and reproduction. Climate change increases the heat stress on livestock, with detrimental effects on livestock productivity and reproduction. Under current climate conditions, animals suffer heat stress during at least part of the year in many parts of Ethiopia. Extreme events, such as heat waves, droughts and floods often have considerable negative impacts on livestock production systems.

Indirectly, climate change affects livestock through changes in availability and quality of feed and water, and changes in the distribution of disease vectors and parasites. Changes in temperature and precipitation patterns may result in the spread of diseases and parasites into new areas. Ethiopia's livestock production system has already been severely affected by vector-borne diseases such as *nagana* (Trypanosomiasis), commonly known as sleeping sickness. Many of these diseases are known to be climate sensitive and climate change is

likely to expand the ecology of the vectors of these diseases. With climate change, the number, distribution and productivity of permanent pastures and water points, which are critical for livestock survival during the dry season, are bound to decline. Other indirect effects are linked to the expected potential shortage of feed due to a rapid increase in competition for food, feed, fuel and land use systems.

Across the study sites, livestock production is adversely affected by climate change effects such as increased temperatures, prolonged dry periods, droughts, and floods in some years in some localities. A summary of the reported climate change impacts on livestock production in each site is presented in Table A4 in the Appendix. The reported major effects of climate change on livestock production from the FGDs and key informants interviews are presented below:

- *Heat stress*: Increased temperature in the dry lowlands is causing considerable heat stress on livestock. The reported potential effects of heat stress on livestock include less feed leading to less milk production, less body weight and increased susceptibility to diseases, and hence contributing to decreased livestock productivity.
- *Declining water availability:* Decreasing water levels in rivers and low levels of water accumulation in community ponds have been observed in recent years. Critical water shortage was observed particularly in the lowland districts such as Loka Abaya. Ponds are drying up quickly after the end of the rains during the dry season due to increased evaporation resulting from increased temperature.
- *Declining feed availability:* Prolonged dry seasons and increased temperatures, particularly in the lowland districts have resulted in reduced pasture quantity and quality of available pasture. Because of frequent crop failures, there is also shortage of crop residues for use as livestock feed.
- *Bush encroachment and invasive species:* Apart from increased temperatures, prolonged dry seasons and frequent droughts, bush encroachers and alien invasive species[1] are causing significant reduction in availability of livestock feed. Invasive

[1] Bush encroachment is a natural phenomenon that results in the transformation of a grass-dominated ecosystem in to a shrub/tree dominated ecosystem through plant succession process. Unmanaged grasslands become colonized by hardy, pioneer tree or shrub species. Whereas an invasive species occurs as a result of human activities, beyond its normal ecological distribution and which threatens valued environmental, agricultural or other social resources by the damage it causes.

species such as *Prosopis juliflora, Parthenium hysterophorus, Lantana camara* and *Opuntia ficus-indica* have expanded in rangelands of the pastoral districts of Teltele and Filtu. The bush encroachers are threatening the livelihoods of Borana and Somali pastoralists and the ecosystems. *Acacia drepanolobium, A. mellifera, A. bussi, A. bresvispica, and A. senegal* were among the major encroaching species in both sites. Photo 6 shows an example of loss of grazing lands to invasive plants in Filtu district.

- *Decreased livestock productivity:* Shortage of feed and water contribute to reduced productivity and reproductive performance of livestock. This includes slow growth rate of animals, loss of body condition, reduced milk production and poor reproductive performance in mature animals. Draught oxen that are emaciated and in poor body condition cannot provide adequate draught power for plowing, and thus affects crop cultivation.
- *Increased incidence of diseases:* Increased incidence of diseases were reported during the long dry season, when animals are in poor condition due to inadequate feed supply and increased heat stress as a result of the increased temperature.
- *Climate change induced conflicts:* Climate change induced droughts and degradation of rangelands force pastoralists to migrate to other places in search of feed and water resources, which might be a cause for conflict over use of the scarce pasture and water resources.

Parthenium hysterophorus (invasive) *Acacia mellifera* (encroachers)

Photo 6. Loss of grazing lands to invasive plants in Filtu district

Coping and adaptation strategies in livestock production

Climate change has induced considerable changes in livestock production by smallholder farmers across the study sites. Farmers have made adjustments in livestock production in response to climate variability and climate change that include:

- Increased use of crop residues as animal feed;
- Diversification of animal feeds by including Kinchib *(Euphorbia tirucalli*) for goats and camels, cactus *(Ficus carica*) for camels, elephant grass and even using *prosopis* and *parthenium* weeds as ingredients for livestock feed;
- Changing herd composition by reducing cattle herd size while increasing the number of camels and goats in their herds. Camels and goats have better feeding habits, and the shorter life cycle of goats is good for marketing mainly in the lowland pastoral areas;
- Asset rebuilding after droughts through the traditional mutual support system—locally referred to as *Busa Gonofa* particularly in Borana area;
- Migration of people to other areas in search of alternative sources of livelihood.

In addition to the above strategies, other coping strategies used by the pastoral communities include delineation of dry and wet season grazing areas, tracking of resources and opportunistic seasonal mobility. In Borana, for example, a combination of resource tracking and mobility to areas of better forage and water availability are used during drought years, and complimented by a traditional mutual support system that helps them to recover after loss of herds and flocks in times of disasters. However, these traditional coping strategies are becoming ineffective because of increasing human population, expansion of crop cultivation, environmental degradation and other development interventions in the pastoral areas. Increasing human population and changes in land use are pushing pastoralists into land areas that are too small to support sustainable pastoral livestock production.

Other measures and practices with potential for enhancing adaptive capacity of communities in pastoral areas from the FGDs, key informants interviews and technical experts in the study sites are summarized below, with most of the measures already in use in one or more of the other sites:

- Reducing livestock numbers to match carrying capacity of grazing lands through increased commercial off-take rates;

- Forage development such as elephant grass and fodder trees (e.g. Leucaena and Sesbania);
- Building on existing traditional mutual support systems and organizing communities into savings and credit associations;
- Supporting inter-regional state collaboration in development and management of natural resources;
- Strengthening traditional conflict resolution mechanisms;
- Supporting cultivation of cactus in Afar to be used as feed; and
- Developing alternative livelihood sources, especially for the younger generation.

Table A5 in the Appendix provides a detailed summary of current coping and adaptation strategies, including potential strategies for each of the study sites.

4.4 Other socio-economic impacts of climate change

Climate change has social and economic impacts through its adverse effects on livelihood assets, strategies and outcomes. In addition, climate change has more direct negative effects on health and wellbeing of individuals and communities. Significant impacts can be expected on human health and nutrition, social structures and interactions, as well as markets and prices. For example, increased human health problems are already being experienced due to high temperatures and scarcity of clean drinking water in many parts of Ethiopia. Of particular concern is the spread of diseases such as malaria which occur within particular climates into new areas. The major socio-economic impacts of climate change are briefly discussed below:

Health and social structure

Across many of the study sites, and particularly in the pastoral and agro-pastoral areas, increasing temperatures and increased rainfall variability coupled with increasing land degradation and bush encroachment resulted in increased food and nutritional insecurity for many households. As droughts become more frequent, the youth are increasingly migrating to nearby towns and even to neighboring countries in search of employment opportunities. Migration as a drought coping mechanism and other related problems were commonly reported in Filtu and Teltele districts, where pastoralism is the main source of livelihood.

Rural-urban migration is likely to increase with changes in climatic conditions, with potentially serious implications for food security, poverty and social structures.

Gender effects

Women carry a disproportionately heavy workload compared to men in most parts of rural Ethiopia. In pastoral areas, for example, women are responsible for constructing houses, collecting water and fuel wood, caring for children, elderly and the sick, milking animals, processing the milk, and attending to small livestock including calves as well as sick animals, and other household chores. As pastoralist families move from place to place in search of pastures and water for their livestock, women dismantle and construct new houses, while the men look after the livestock. The situation is not very different in the agro-pastoral and other farming communities except for some differences in the types of activities women are involved in. As indicated by the key informants, with the changing climatic conditions, collection of water and fuel wood is taking a longer time than before, and the shortage of fuel wood implies that food preparation has become more tedious. In times of drought, men migrate to distant places with their livestock leaving women and children behind, and hence increasing the burden on women of looking after the family and weak livestock that may be left behind.

Environmental conflicts

There is growing evidence that climate change induces scarcity of natural resources such as water and pasture, and this in turn triggers intra-community and inter-community conflicts. Across the study sites, there is an increase in the incidence of conflicts over water and grazing resources, mainly in Teltele and Filtu districts (see Photo 7). Conflicts between different clans of Somali, Borana and Konso, and others have increased in recent years. In some of the sites, climate change has also exacerbated human-wildlife conflicts. While most of the wildlife has disappeared due to poaching and habitat loss, baboons and warthogs have slightly increased in number due to local environmental conservation initiatives such as area enclosure. Scarcity of pasture and other types of food is driving the wildlife to adopt more aggressive grazing and food collection habits, and thus bringing them into conflict with humans. In Raya-Azebo, Raya-Alamata and Bati districts, respondents highlighted that there was already a rush for land grabbing, establishment of enclosures and breakdown of communal use practices. Proliferation of enclosures has become a very serious challenge in recent years across the

study sites. Enclosures obstruct free access to permanent water sources and to the main grazing plains and valleys, and this often creates local conflicts, especially in periods of drought cycles where pastoralists often trespass the enclosed areas.

Photo 7. Displacement and temporary settlement due to conflict in Filtu district

4.5 Vulnerable social groups

Climate change is affecting all environments, societies and social groups. However, vulnerability to the adverse effects of climate change varies across environments, and communities depending on their exposure, sensitivity and adaptive capacity to climate-related hazards. Developing countries such as Ethiopia are highly vulnerable to climate change impacts due to underdevelopment and widespread poverty, thus limiting their capacity to adapt. Within countries, communities in arid and semi-arid areas with limited water resources, and those in flood-prone lowland areas are particularly vulnerable to climate change. Often the poorer households are likely to suffer the most from climate change impacts. Similarly, women, children, the elderly, and the disabled are highly vulnerable to the adverse impacts of climate variability and climate change.

Findings from the study show differential vulnerability to climatic shocks such as droughts across the different age and social groups. Children, pregnant and lactating women, and elderly people were the most affected by food shortages in times of drought. In addition, climate change had already caused increased workload on women as they are responsible for fetching water and fuel wood for their households and collect grass for calves from increasingly long distances. Moreover, children, women, the elderly and the disabled were the

social groups that have limited capacities to escape from such disasters as floods and landslides, and hence are the most vulnerable groups.

5. Institutional responses to climate change in the agricultural sector

The Government of Ethiopia has mainstreamed climate change issues in various national policies, strategies and programs. This section reviews policies and strategies related to agriculture and food security. These include the Environment Policy, the Climate Resilient Green Economy (CRGE) initiative, and the Growth and Transformation Plan GTP and others.

The Environmental Policy

The Environmental Policy of Ethiopia (1997) provides an umbrella policy framework for a range of environmental issues including climate change. The overall objective of the policy is to promote social and economic development through sustainable management and utilization of the natural, man-made and cultural resources, and the environment. The specific objectives of the policy include:

- Ensuring that essential ecological processes and life support systems, biological diversity and renewable natural resources are conserved, developed and sustainably used so that the needs of future generations are not compromised;
- Identifying and developing natural resources that are currently underutilized and/or intensifying existing uses; and
- Ensuring the empowerment and participation of the people and their organizations at all levels in environmental management activities.

The environment policy outlines the guiding principles underlying the overall policy objectives and which shall shape all subsequent policy, strategy and program formulation and implementation. Sectoral and cross-sectoral policies and environmental elements of other macro policies will be checked to ensure consistency. Specifically, the environment policy outlines policy elements which shall be pursued in various sectoral and cross-sectoral environmental matters. Climate change is one of the cross-cutting issues addressed by the environment policy. With regard to climate change, the policy stipulates that the country needs to:

- Demonstrate a firm and visible commitment to addressing climate change;
- Emphasize on harnessing the country's potential for hydro-, geothermal and solar energy as a way of reducing greenhouse gas (GHG) emissions, and to develop its energy sector accordingly; and
- Maximize the standing biomass in the country through a combination of reforestation, agro-forestry, rehabilitation of degraded areas and a general re-vegetation of the land and the control of free range grazing in the highlands and to seek financial support for this from industrialized countries for offsetting their carbon dioxide emissions.

With respect to climate change adaptation, the environment policy only provides for a climate monitoring program, perhaps due to the knowledge gap that existed at that time regarding the need for adaptation. The Environment Policy therefore does not provide strategy, options or measures that are required to address observed and likely changes in the climate and the negative impacts thereof in various sectors.

However, the Environment Policy deals with a range of sectoral and cross-sectoral issues which are relevant for adaptation to climate change such as land use planning—where the policy provides for the sustainable utilization of the land resource through appropriate land use planning. Land use planning provides the basis and opportunity for promoting ecosystems management and thereby leading to ecosystem based adaptation to climate change.

The Rural Development Policy and Strategies

The Rural Development Policy and Strategies (RDPS) of 2002 guides the rural and agricultural development activities in Ethiopia. RDPS promote rural and agriculture centered development as a means to promote rapid economic growth, enhance benefits to people, and eliminate dependency on food aid. With respect to agricultural development, RDPS aim to transform subsistence farming into market-oriented agricultural production. Specific aims of the RDPS include:

- Maximizing labor productivity through continuous skill improvement and motivation of the people;
- Facilitating access to land for agriculture and efficient utilization of land to enhance agricultural productivity and sustainable agriculture;

- Undertaking agricultural development activities that are compatible to and give the best out of the various agro-ecological zones;
- Maximizing utilization of existing production capacity while at the same time working on creating production capacity and technology;
- Integrating agricultural activities with infrastructure and social services, trade and finance, industry and other similar sectors.

The major strategy of the government currently is to transform agricultural production and productivity—focusing on promoting adoption of yield enhancing technologies such as improved crop varieties, chemical fertilizers, pesticides and small scale irrigation. For livestock production, the technologies for enhancing productivity include improved breeds, animal feeds and nutrition, animal health care, improved aquaculture and honey production techniques.

RDPS identifies sustainable use and management of natural resources as one of the strategies for agricultural development. In this regard, it underscores the need to ensure land tenure security and stability in order to encourage land owners to conserve and sustainably use land. In addition, RDPS seeks to ensure the effective and sustainable utilization of land through the development and implementation of a comprehensive land-use plan, and providing a package of technologies that enable use of land for the purpose most beneficial for development. Although RDPS does not explicitly or directly address climate change, the principles such as promoting agricultural development through expanding input supplies, irrigation and water management techniques, skills development, rural financing, dissemination of technologies and natural resources management and ascertaining the participation of land users including women in the management of land resources are all relevant for climate change adaptation.

The Sustainable Land Management Program (SLMP), which has been designed in the context of RDPS, is also an important program that aims at reducing rural vulnerabilities and building ecosystem resilience to the changing climatic conditions. Currently, the SLMP covers 90 watersheds in the so-called food secure areas out of the 177 that have been prioritized. Rehabilitation of additional watersheds is ongoing through the Productive Safety Nets Program (PSNP) in food insecure districts and through community mobilization in almost all parts of the country. The challenge is to ensure sustainability of outcomes from all these

interventions using appropriate approaches that are tailored to each of Ethiopia's agro-ecological zones and farming systems.

The Growth and Transformation Plan

The current five-year national development plan—known as the Growth and Transformation Plan (GTP) aims to accelerate agricultural growth and builds on the solid performance of the previous five-year plan—the Plan to Accelerate Sustained Development to End Poverty (PASDEP). Given that smallholder agriculture is the major source of agricultural growth, increasing the productivity and production of smallholder agriculture is the main thrust of GTP through:

- Scaling-up best practices of leading and innovative farmers;
- Improving natural resources management focusing on improving water utilization and expansion of irrigation; and
- Encouraging farmers to shift from low to high value agricultural products, with complementary investments in market and infrastructure development.

GTP identifies three main agro-ecological zones, namely, adequate moisture areas, moisture deficit areas, and pastoral areas. Strategic areas of intervention have been identified for each of these zones. In areas with adequate moisture, GTP focuses on scaling-up best production and marketing practices to increase productivity by supplying agricultural inputs. Priority areas of focus include soil fertility management using organic and inorganic fertilizers, improved rainfed agronomic methods, irrigation and improved water use efficiency, production and distribution of seeds, natural resource conservation, livestock and forage development, and strengthening the research-extension-farmer linkages.

In moisture deficit areas, the focus will be on soil and water conservation, and watershed management. Particular areas of intervention include underground and surface water utilization, development of small ruminants, poultry and apiculture, and productive safety net initiatives to support food security of vulnerable households. Lastly, in pastoral areas, the focus will be on livestock development, specifically water for people and livestock, forage development, irrigation, and improving livestock marketing systems.

The GTP recognizes that climate change presents a threat as well as an opportunity for Ethiopia. Under the 'Environment and Climate change' sub-section, the GTP recognizes the

role that environmental management plays in sustainable development and clearly declares the government's commitment to building a 'green economy' and ongoing implementation of environmental policies and laws of the country. In order to build a climate-resilient economy and facilitate the move towards a carbon-neutral economy, the GTP declares that Ethiopia will pursue both appropriate climate change adaptation and mitigation measures. Although Ethiopia's contribution to GHG emissions is minimal, the GTP recognizes that, Ethiopia is among the most vulnerable countries which will be hardest hit by the impacts of climate change. Annually, Ethiopia loses 2 to 6% of its annual production due to climate change (MoFED 2010). Unless appropriate adaptation measures are put in place, the impacts of climate change will be manifested more in the loss of agricultural production, inundation and drying up of water resources and loss of biodiversity. Apart from the adaptation measures, the plan recommends embarking on aggressive economic expansion and development in the areas of renewable energy resources, building climate change mitigation capacity and implementation of environmental management practices. In order to effectively implement these plans, it is envisaged that:

- A plan of action, strategies, laws, standards and guidelines will be prepared;
- Programs to develop the capacities of stakeholders will be developed and implemented;
- Local and foreign technologies for climate change mitigation will be collected, analysed and adapted;
- Capacities of the private sector and community organizations for fund raising globally will be enhanced;
- Environmental activities, public awareness and experience and knowledge sharing on environmental management practices will be developed and community participation in environmental activities increased;
- Good practices of environmental protection will be identified and widely disseminated;
- Certification, standardization and accreditation of experts and organizations working on environmental issues and climate change mitigation will be put in place;
- International environmental laws and protocols will be ratified and implemented; and
- Appropriate action will be taken when offences against environmental laws are committed.

In general, it can be argued that the GTP considers issues of climate change adaptation and nationally appropriate mitigation actions. However, effective integration of climate change issues in any future sectoral development policy instruments as suggested in the GTP is yet to be realized.

The Agriculture Policy and Investment Framework

Ethiopia has prepared a national Agriculture Sector Policy and Investment Framework (PIF) within the framework of the Comprehensive African Agriculture Development Program (CAADP). The PIF is a 10-year (2010-2020) road map for agricultural development which identifies priority areas for investment. Priority areas identified for investment include increasing agricultural productivity and production, rural commercialization, improving natural resources management, and disaster risk management and food security, including setting out the corresponding strategic objectives and outcomes. An important aspect of the PIF is that it presents a more elaborate analysis of climate change and adaptation. In its gap analysis, the PIF recognizes climate change as one key cross-cutting issue (under the NRM strategic objective) that could adversely affect agriculture and rural development, and points out potential options for climate change adaptation and mitigation. In setting the specific strategic objectives and outcomes, however, the PIF focuses on improving agricultural production, with little mention of specific climate change adaptation options for the agricultural sector.

Ethiopia's Program of Adaptation to Climate Change (EPACC)

More recently, a separate work program of action on adaptation to climate change has been developed by the Environmental Protection Authority (EPA). The work program strongly links climate change adaptation with economic and physical survival of the country and identifies key climate change adaptation measures, and strategic priorities and intervention areas to address the adverse effects of climate change. According to the program, climate change is likely to interact with local environmental and socioeconomic factors in different ways across regions to reduce the ability of some environmental systems to provide, on a sustained basis, key goods and services needed for successful economic and social development including adequate food and feed, water and energy supplies, employment opportunities, gender equality, good health and social advancement in general.

The main objective of EPACC is to create the foundation for a carbon-neutral and climate-resilient path towards sustainable development, with four key components:

- Expected new problems from climate change and exacerbation of existing problems, along with the responsible national agencies that need to come up with the solutions. Most of these solutions will be implemented by the inhabitants and the farmers at the local and district levels and thus the role of the federal institutions will be to initiate, facilitate and monitor activities.
- Solutions to climate change as well as the federal and regional executing bodies. Six solutions are mentioned, with provisions for gender, persons with disabilities and the elderly. The solutions include developing a disaster map, improving information sharing and delivery to build climate change adaptation and disaster management capacity, strengthening early warning system, institutional capacity building and raising awareness at local level, integrating climate change adaptation in education curricula, and strengthening research on adaptation to climate change.
- Activities that need to be carried out to ensure successful implementation of the work program. These activities include mainstreaming of climate change adaptation at all levels and phases of development.
- Finance and technology provision and the need to seek and access promised financial and technological support from the developed countries as per the Copenhagen Accord.

EPACC identifies close to 20 climate-related risks which can broadly be grouped into human, animal and crop diseases, land degradation, loss of biodiversity, decline in agricultural production, dwindling water supply, social inequality, urban waste accumulation, and displacement due to environmental stress and insecurity. In addition, it identifies adaptation strategies and options in the various socio-economic sectors including cloud seeding, crop and livestock insurance mechanisms, grain storage, societal re-organization, renewable energy, gender equality, factoring disability, climate change adaptation awareness and education, capacity building, research and development, and enhancing institutional capacity and the political momentum.

The work program adequately captures the growing threat of climate change in Ethiopia and clearly spells out the need to mainstream climate change in all spheres of development policy

making and planning, including the implementation process. The program clearly states the urgency of taking practical adaptation and mitigation actions in the various social and economic sectors. Given that the program is compiled from contributions of different ministries, there is need for strong coordination and consolidation in order to avoid fragmented approaches. Also, the role of non-state actors in the planning, design and implementation of activities outlined in the work program is not clearly articulated.

The Climate Resilient Green Economy Initiative

Ethiopia launched a vision to achieve a carbon-neutral middle income status in November 2011, by building a Climate Resilient Green Economy (CRGE) by 2025. This vision is supported by two pillars or strategies—the Green Economy Strategy (GES) and the Climate Resilience Strategy (CRS). The CRS has been completed for the agriculture sector, but yet to be prepared for the other sectors of the economy. The GES, which was completed and launched in November 2011, identifies seven sectors (power, buildings, forestry, soil, livestock, transport and industry) with collectively high emission reduction potential. The strategy has defined four pillars for delivering a green economy (FDRE, 2011):

- Improving crop and livestock production practices for higher food security and increased farmer incomes while reducing emissions;
- Protecting and re-establishing forests as carbon stocks;
- Expanding renewable power generation for domestic and regional markets; and
- A shift to modern and energy-efficient technologies in transport, industrial sectors and buildings.

The translation of the green economy plan into practical investments is likely to contain Ethiopia's emissions by 2030 to current levels[2].

The Climate Resilience Strategy for Agriculture

Priority was given to the agriculture sector to have a National Climate Resilience Strategy given its importance to the national economy and livelihoods. This strategy is expected to serve as an entry point for the preparation of climate resilience strategies across the remaining

[2] Ethiopia's current total emission of GHGs is estimated at 150 Mt CO_2e, and is projected to reach 390 Mt CO_2e in 2030 (FDRE, 2011b).

sectors of the economy. The agriculture sector's CRS is centered on current and future impacts of climate change on agriculture, options to cope with the challenges and financing issues for implementation of the options identified. The three building blocks of the strategy include:

- Analysis of impacts of current climate variability and projected future climate change on Ethiopia's agriculture;
- Identification of options to build climate resilience and reduce the impact of current climate variability and climate change, and costing of the same; and
- Mapping of the steps necessary to finance and implement efforts to build resilience.

Hence, the CRS of agriculture has outlined how the agricultural sector can ensure resilience to climate change and the realization of the strategy is expected to bring sustainable development in the agriculture sector.

Institutional Framework

The Ministry of Environment and Forest (MoEF), formerly the Environmental Protection Authority (EPA) is the lead government agency for climate change in Ethiopia. MoEF is responsible for the coordination of national adaptation and mitigation activities and represents the country at the UNFCCC. However, until COP15, these functions were under the NMA (National Meteorological Agency), within the Ministry of Water, Irrigation and Energy (MoWIE). NMA now plays a purely technical and analytical role in climate data collection, monitoring and prediction. The changes in leadership were likely because NMA was seen as a technically-focused agency whilst MoEF is believed to have greater institutional and technical capacity to address the wider political, socio-economic and environmental issues related to climate change. The original National Adaptation Programme of Action (NAPA) process was coordinated by NMA and it is still viewed by many as belonging to NMA rather than to the EPA/MoEF (Oates et al. 2010). Such examples raise issues of 'ownership' of the climate change agenda, which is likely to affect effective coordination and multi-sectoral approaches for effective integration and mainstreaming of climate change issues into development planning.

6. Knowledge gaps and research needs

Previous studies on the impact of climate change show that Ethiopia is among the poor countries in Africa that is most vulnerable and likely to experience the worst of climate change impacts. This has also been confirmed by the rapid and qualitative assessments in previous chapters (case studies) presented here. Despite the seriousness of the problem, there are still a number of knowledge gaps that need to be addressed through research on climate change and its associated impacts on the various economic sectors, livelihood systems, communities and ecosystems of Ethiopia. Climate change projection is complex and involves a large amount of uncertainty in both the spatial and temporal dimensions. Future outcomes from both adaptation and mitigation actions are unknown, as is their interaction over time and space. Similarly, little experience and knowledge exists on the type of institutional and policy frameworks that will be needed to enhance implementation of adaptation and mitigation actions at national and local levels. The rapid appraisal studies that constitute this volume identified the following important knowledge gaps that require further empirical research.

- *Differential impacts of climate change*: Climate change is likely to have differential impacts on different ecosystems and associated natural resources, crop types, livestock types, livelihood systems, and socio-economic and demographic groups. These differential impacts are largely unknown in the Ethiopian context and it is necessary to better understand the differential impacts. Also, there is need to understand impact-response relationships for ecosystems as well as communities in the different farming systems of Ethiopia.

- *Effects on local vulnerability of expansion of crop cultivation into pastoral areas:* Despite frequent crop failures due to inadequate moisture availability, crop cultivation is still expanding into pastoral areas. In general, there is increased conversion of grazing and forest land into crop land. There is a need for closer scrutiny and investigation of the impact of such expansion on the environment, particularly on soil and land degradation, crop and livestock productivity and livelihood of communities.

- *Potential of range vegetation as carbon sinks:* Earlier studies show that the southern rangelands of Ethiopia have a great diversity of natural resources and potential for

carbon sinks. However, this needs to be investigated in terms of ecosystem benefits that could be used to reduce poverty through diversification of local livelihoods.

- *Recognition and strengthening of traditional institutions:* Pastoralists are key partners in managing natural resources and enhancing resilience of the rangeland ecosystems through regeneration of indigenous vegetation and proper utilization of natural resources. Pastoralists have accumulated knowledge through their interaction with their environment overtime. Consequently, the role of traditional institutions in natural resources management including contribution to regeneration of indigenous vegetation species and adaptation to climate change as well as temporal dynamics of carbon stocks in rangelands needs to be understood.

- *Fodder development:* Despite many years of research and development efforts in improved forage production, the adoption rate has been very low. There is a need to identify the bottlenecks and factors hindering adoption, including potential options for accelerating adoption. This includes identification of niche areas where production of forage crops is technically possible and socially and economically acceptable. The impact of free grazing of livestock on improved forage production also needs to be considered in future research and development initiatives.

- *Selection and genetic improvement of local livestock resources:* Local livestock breeds are better adapted to the prevailing production environment and changing climatic conditions. They have a better chance of surviving and producing under the harsh environmental conditions than exotic or crossbreed animals in situations where the production environment and availability of feed and water is variable. Although the local livestock have a low level of productivity even when given better feeding management and production environment, there is a scope for selection to improve their performance as there is wide variability among individuals and groups of livestock. The climate change adaptation benefits of selection and genetic improvement of local livestock resources in the Ethiopian context should be studied.

- *Potential benefits of climate services*: There is need to understand the extent to which improving climate services such as seasonal forecasts of rainfall or vegetation monitoring can in practice improve farm-level decision-making for adaptation to climate change and coping with climate variability.

- *Role of non-climatic factors*: An analysis of the influence of other non-climatic factors such as population growth, technological changes and development policies on local vulnerability to climate change is also useful.

7. Conclusions

Ethiopia already suffers from climate variability and extreme events, and future climate change poses a major development challenge. In order to identify and implement appropriate adaptation strategies at local level, it is important to understand the nature of climate change impacts, key vulnerabilities and indigenous adaptation practices. This report synthesizes four case studies on impacts, vulnerabilities and local adaptation strategies; as well as institutional and policy responses in Ethiopia for the agricultural sector. Three of the case studies assess local communities' perceptions of climate change; experienced impacts of climate change on local environmental resources, crop and livestock production systems; and local adaptive responses to climate variability and change. The fourth case study systematically reviews available policies and strategies relevant to climate change adaptation and building of a climate resilient agriculture in the country. The case studies were carried out in nine districts, representing the major agro-ecological and farming systems of Ethiopia. The case studies used qualitative data and a review of relevant literature.

Changes in the local climatic conditions were reported and included steady increase in temperature; reduction in seasonal and annual rainfall amounts, particularly changes in the short rainy season (*Belg*); delayed onset and early cessation of rainfall resulting in shortened crop growing season; increased rainfall variability with frequent dry spells at crucial crop growth stages; increased rainfall intensity; and increased incidence of drought and flood events. The perceived or observed changes were similar across the study sites despite variations in agro-ecological zones and livelihood systems.

Droughts and floods were the two major climate related hazards across the study sites. Drought was identified as a priority problem in almost all of the sites, while flood affected localized areas in some of the sites—Raya-Azebo, Shala, Loka Abaya and Filtu. While droughts used to occur every 6-10 years in the past, the frequency has increased to every 1-2 years. The local communities attributed climate change to poor management of local natural

resources, particularly forests and grazing lands, with population growth as a key driver. Forest cover loss was frequently mentioned as the cause to the increasing temperatures and increasingly erratic rainfall patterns across the sites. Expert key informants related the experienced climatic changes to the global climate change phenomenon.

With regard to the impacts of the observed climatic changes, the FGDs and key informant interviews reported a number of direct and indirect adverse effects on agriculture, natural resources and livelihoods. Climate change contributed to decline in water availability, soil erosion, soil cracking, soil degradation, and thereby exerting significant influence on ecosystems and biodiversity resources of Ethiopia. For crop production, climate change was reported to have caused negative effects due to increased temperatures, negative changes in soil water balances, reduction in length of growing seasons, increased soil erosion and land degradation, increased incidence of floods in flood-prone areas, and increased incidence and expansion of crop pests, diseases and weeds. Similarly, climate change negatively affected livestock production in various ways: increased heat stress on livestock with detrimental effects on livestock productivity and reproduction; decrease in availability and quality of feed and water resources; and increased incidence of livestock diseases and parasites.

Local communities across the study sites used a range of strategies to cope with climate variability and adapt to climate change. These coping and adaptation strategies broadly included adjustments in crop and livestock production, responses through natural resources management, and adjustments to new household food and income sources. Specific important strategies in crop production included changes in the types and varieties of crops produced, increased diversification of crop production, and adjusting the agricultural calendar, and soil and water conservation. Important strategies for livestock production included increased use of crop residues as animal feed; diversifying animal feed by including Kinchib *(Euphorbia tirucalli*) for goats and camels, cactus (*Ficus carica*) for camels, elephant grass and even using *prosopis* as feed ingredients; changes in herd composition through reducing number of cattle while increasing camels and goats associated with better feeding habits; migration over long distances in search of feed and water resources; and development of fodder banks (e.g. haystacks) for the dry season or drought period. Other adaptation responses included investments in natural resources management. These include soil and water conservation with physical and biological measures, water harvesting, afforestation and reforestation, and area

enclosure and rehabilitation of degraded lands. In addition to these, informants suggested a number of other innovative potential interventions for enhancing adaptation to climate change.

On policies and institutional support, Ethiopia has prepared a number of policies and strategies. These include the Climate Resilience Strategy for Agriculture and the Climate Resilient Green Economy initiative more broadly, and institutional arrangements have been improved to facilitate implementation of these policies and strategies. Some of the key policy and strategy documents are, however, relatively new and yet to be fully implemented.

Despite the range of local adaptive responses used by the farmers and the policies and institutions in place, improving agricultural production and achieving food security have increasingly been constrained by climate change. This indicates local coping and adaptive capacities are being overwhelmed by the extent of climate change effects. There is therefore the need for effective implementation of planned adaptation interventions as outlined in the policy and strategy documents and for building climate resilience in the agriculture, natural resources and food security sectors. Further research is also needed to address the crucial knowledge gaps that still exist to support the government's efforts at building a climate resilient green economy. Some of the major knowledge gaps identified relate to:

- The differential impacts of climate change on the different ecosystems and associated natural resources, crop types, livestock types, livelihood systems, and socio-economic and demographic groups in the Ethiopian context;
- Effects on local vulnerability to climate change of conversion of grazing and forest lands into crop lands and expansion of crop cultivation into pastoral areas;
- Potential of rangelands as carbon stocks and sinks, and ecosystem benefits that could be used to reduce poverty through diversification of local livelihoods;
- The role of traditional institutions in natural resources management including contribution to regeneration of indigenous vegetation species and adaptation to climate change as well as temporal dynamics of carbon stocks in rangelands;
- Identifying bottlenecks and barriers to adoption of improved technologies including improved fodder varieties that have potential benefits for climate change adaptation;
- The climate change adaptation benefits of selection and genetic improvement of local livestock resources;

- Potential adaptation benefits of improving climate services; and
- The role of non-climatic factors such as population growth, technological changes and development policies on local vulnerability to climate change.

Appendix

Table A1. Climate change impacts on crop production and social consequences by district

District	Climate change impacts on crop production and related activities	Social consequences
Raya-Alamata	▪ Crop yield reduction and complete failure in some years ▪ Destruction of crops by flood especially in the high potential foothills ▪ Increased crop pest prevalence associated with rising temperatures	▪ Food insecurity ▪ Migration of youth to other regions and neighboring countries
Raya-Azebo	▪ Change of rainfall patterns from bimodal to mono-modal ▪ Decline in natural vegetation cover leading to soil erosion ▪ Increased surface runoff and reduced infiltration of rainwater ▪ Increase in prevalence of crop pests due to increasing temperatures ▪ Cultivation of marginal and sloppy lands – increases soil erosion and land degradation	▪ Food insecurity and food aid dependency or dependency on the safety net program ▪ Migration of the working force to big towns, other regions and foreign countries
Bati	▪ Crop yield reduction and sometimes total crop failure caused by drought ▪ Year-to-year fluctuation and decline in LGP, making it difficult to fix reliable cropping calendars ▪ Increase in groundwater depth - could be used for irrigation and other purposes	▪ About 40% of the population dependent on food aid or safety net program ▪ Migration of girls to towns and other countries in search of employment opportunities
Kemissie	▪ Crop yield loss and complete crop failure in some years ▪ Increase in depth of groundwater and decline in discharge of water from wells ▪ Decrease in water quantity of large rivers like Borkena and intermittence of small streams during dry months as well as complete drying of springs ▪ Extensive soil erosion resulting in formation of gulleys in uplands and sedimentation in community ponds downstream ▪ Extensive flooding causing crop destruction, livestock deaths and landslides ▪ Emergence of new weeds due to climate change and dung of seasonally moving livestock	▪ Dependency of considerable proportion of the local population on food aid or safety net program ▪ Increase in number of school dropouts as children move with their parents to graze their livestock ▪ Migration of the youth to towns and other countries in search of jobs ▪ Decline of fishing business in Cheffa valley for income ▪ Decline in honey production caused by loss of honey bees due to extensive use of pesticides
North Shewa Zone	▪ Increased rainfall intensity causing serious soil erosion ▪ Decline in soil depth and fertility ▪ Rise in soil acidity in highlands due to the intense rainfall and severe soil erosion ▪ Decline in crop productivity as a result of intensive soil erosion and land degradation ▪ Occurrence of frequent destructive floods and landslides, often blocking the main road to the northern part of the country	▪ Increased migration to towns in search of alternative sources of income and livelihood ▪ Food insecurity and dependency on emergency food aid and the safety net program

District	Climate change impacts on crop production and related activities	Social consequences
Shala	▪ Increased rainfall variability and making it difficult to set reliable cropping calendars ▪ Reduction in crop yield and crop failure due to erratic rainfall and intermittent droughts ▪ Livestock feed shortage for draught power ▪ Increased rainfall intensities and flood incidences ▪ Increased frequency of droughts ▪ Early drying up of community ponds and springs before dry season	▪ Food and water shortages during drought years ▪ Early livestock migration to water sources before dry season ▪ Increase in school dropouts as children take on additional responsibilities of moving with the livestock in search of water ▪ Loss of fertilizers and seeds due to droughts and floods
Loka-Abaya	▪ Reduction in crop yields and crop failure due to dry spells at critical stages of crop growth ▪ Increased soil acidity in highlands and salinity in lowlands ▪ Increased rainfall intensity and runoff ▪ Increased incidence of floods and landslides causing livestock deaths and property damage ▪ Increased sedimentation in lake Hawassa caused by heavy rain and floods ▪ Remarkable reduction in volume of river flows ▪ Increased depth of groundwater and drying of community ponds ▪ Frequent fire incidence caused by extended dry season and increasing temperatures ▪ Reduction in coffee productivity related to flower abortion caused by high temperatures ▪ Shift of the short rainy season (*Belg*) towards the main rainy season (*Meher*)	▪ Resistance of farmers to use agricultural inputs due to increasingly unreliable rainfall ▪ Decline of agricultural productivity due to seasonal mobility of adults searching for water for their livestock ▪ Increase in school dropouts to help in housekeeping responsibility while adults move with their livestock
Teltele	▪ Reduction in maize yield and complete failure in some cases due to erratic rainfall ▪ Loss of indigenous plant species and their replacement by unknown bushy species without economic importance or feed value ▪ Expansion of invasive plants such as *prosopis* and *parthenium* ▪ Increased water shortage for draught animals during the dry season ▪ Frequent floods and landslides ▪ Migration of wild animals to neighboring Kenya	▪ Inter-communal conflict associated with water shortage ▪ Increasing shift from livestock production to crop cultivation
Filtu	▪ Reduction in crop productivity e.g. of short maturing maize varieties ▪ Decrease in volume of the two major rivers - Genale and Dawa ▪ Decreased livestock grazing lands resulting from severe bush encroachment ▪ Changes in livestock herd composition - decline in number of cattle and sheep and and increase in number of goats and camels	▪ Shift from livestock production to crop cultivation. E.g maize can be used as animal feed in drought situations ▪ Human and livestock migration in less than 2 months after end of rainy season due to early drying of water ponds often expected to be functional for at least 4 months ▪ Change in communal migration patterns e.g. from Filtu to adjacent *Woredas* of Oromiya region unlike in the past

Table A2. Coping and adaptation strategies in crop production by district

District	Coping and adaptation strategy
Raya-Alamata	▪ Integrated watershed management with emphasis on soil and water conservation ▪ Strengthened in-situ rainwater harvesting practices ▪ Intensive use of micro-irrigation for fruit and vegetable production ▪ Integrating unpopular food crops such as *Moringa spp*. (shiferaw) into regular diets ▪ Diversification of household income sources e.g. through casual labor or micro-businesses ▪ Reducing household expenses on traditional ceremonies
Raya-Azebo	▪ Use of rainwater harvesting techniques ▪ Establishment of area enclosures ▪ Shift from late maturing to improved early maturing crop varieties ▪ Increased cultivation and use of cactus (*Ficus carica*) as food and income source ▪ Limiting family size ▪ Migration to bigger towns, other regions and other countries in search of employment opportunities
Bati	▪ Increased use of improved and early maturing crop varieties ▪ Use of new crop types e.g. cassava and jatropha as food and income source ▪ Use of alternative crops e.g. groundnut and pearl millet, especially in times of late rainfall onset ▪ Use of in-situ geo-membrane assisted farm water harvesting practices ▪ Enhanced use of the traditional feed preservation techniques for oxen, so as to boost their energy for plowing just before the onset of rain to plant on time ▪ Community based watershed development, mainly rehabilitation of degraded communal lands ▪ Soil and water conservation and improved farm management strategies ▪ Voluntary resettlement
Kemisie	▪ Inter-cropping maize and chickpea during the short rainy (*Belg*) season. If the rains are sufficient, the grains are harvested from both crops. However, if the rain stops in the middle of the season, the maize is thinned and used as animal feed while the chickpea uses the residual soil moisture to grow and mature ▪ Use of new crop types e.g. cassava, jatropha and mung bean (Masho) ▪ Community based watershed development ▪ Two-way seasonal livestock migration between the eastern dry lowlands and the western Cheffa wetland during the dry and rainy seasons ▪ On-farm soil and water conservation ▪ Diversification of household income sources, mainly casual labor in towns and other regions ▪ Dependency on remittances from family members working in other countries e.g. Middle East ▪ Relying on income from sale of livestock especially goats ▪ Sale of firewood and charcoal ▪ Participating in development activities of NGOs e.g. in watershed development, land rehabilitation, jatropha cultivation and processing ▪ Digging deep wells for domestic use and for irrigation
North Shewa Zone	▪ A shift towards increased use of early maturing improved crop varieties ▪ Watershed management practices ▪ Use of different water harvesting techniques, especially geo-membrane assisted rainwater conservation ▪ Seasonal mobility of the youth to regions with better agricultural potential and to towns as casual laborers ▪ Use of lime to reduce soil acidity in highland areas

District	Coping and adaptation strategy
Shala	▪ Integrated watershed management ▪ Establishment of area enclosures ▪ Renovation of abandoned community ponds ▪ Shift from livestock to crop production mainly due to shortage of livestock feed and grazing resources
Loka-Abaya	▪ Increased use of improved and early maturing crop varieties ▪ A shift from wheat to barley production mainly due to increased incidence of rust diseases ▪ A shift towards teff production during the short rains (*Belg*), since production of maize and haricot bean has become uncertain ▪ Integrated watershed development activities, focusing on afforestation or reforestation of degraded areas and establishment of area enclosures ▪ Use of lime to reduce soil acidity in highland areas ▪ Construction of deep water wells
Teltele	▪ Use of early maturing crop species and varieties ▪ Increased cultivation of teff as a food security crop as it can withstand moderate droughts ▪ Integrated watershed development activities ▪ Rainwater harvesting using micro-dams and ponds ▪ Participating in development activities of NGOs such as construction of ponds ▪ Involvement in safety net program activities to access food and or cash
Filtu	▪ Involvement in safety nets program activities to access food and or cash ▪ Use of meteorological forecasts from NMA –under the FAO collaboration project ▪ Integrated watershed development ▪ Migration of head of households with their livestock while women and children are left behind to use available resources ▪ A shift from pastoral to agro-pastoral livelihood ▪ Fattening and marketing of livestock ▪ Accessing livestock feed from fodder bank established in collaboration with the NGOs and the government ▪ Accessing livestock feed from irrigated forage and maize production scheme along the Genale and Dawa river basins

Table A3. Suggested strategies for enhancing adaptation to climate change in crop production and household food security by district

District	Adaptation options
Raya-Alamata	▪ Promote conservation agriculture ▪ Promote water harvesting and water conservation technologies ▪ Constructing new deep wells and renovating existing ones ▪ Rehabilitation of degraded lands and improving vegetation cover ▪ Establishment, maintenance and use of area enclosures effectively ▪ Construct micro-dams along small streams for irrigation ▪ Exploit the full potential of cactus (*Ficus carica*) which is drought tolerant as human food, ingredient for animal feed and processed and packaged into jam and juice for income ▪ Promote planting and use of *Moringa oliefera*, a perennial plant with good potential to be cultivated in the area and consumed as vegetable for household food security ▪ Support agricultural diversification. Additional crops that can be cultivated include pearl millet, pigeon pea, jatropha, cassava, date palm ▪ Promote drip irrigation, particularly using deep wells in the foothill semiarid plains
Raya-Azebo	▪ Promote opportunistic use of occasional rains and shifting seasons ▪ Promote conservation agriculture and agro-forestry ▪ Promote crop diversification and improved agronomic practices ▪ Establishment and sustainable use of area enclosures as an alternative income source through appropriate community bylaws ▪ Develop alternative and renewable household energy sources ▪ Effective use of ground water for irrigation ▪ Promote use of cactus as human food, camel feed and as an ingredient of cattle feed ▪ Control and use of prosopis (*Prosopis juliflora*) as animal feed and other uses ▪ Support integrated development projects with adjacent districts in Amhara and Afar Regions for common and complex problems
Bati	▪ Promote cultivation and utilization of new crops such as cassava, pigeon pea and jatropha ▪ Promote use of weather information for agricultural decision-making ▪ Promote perennial crop based intercropping and agro-forestry systems ▪ Develop alternative sources of household energy such as bio-fuel, solar and electrical energy to substitute the use of firewood and charcoal ▪ Set clear community bylaws for protecting and sustainable use of sloppy areas and area enclosures for income generation such as forage production and beekeeping ▪ Support inter-regional development projects that address problems associated with livestock mobility from Afar region across Bati, to-and from Cheffa wetland for grazing land and water during the dry season ▪ Promote cultivation and sustainable use of unpopular but potentially useful crops such as cassava (*Manihot esculenta*), pigeon pea (*Cajanus cajan*), and date palm (*Phoenix dactylifera*) ▪ Promote cultivation and processing of jatropha (*Jatropha curcas*), which has great potential to grow on degraded soils and under erratic rainfall
Kemissie	▪ Introduce and promote use of new crops such as cassava, pigeon pea, soybean, pearl millet and groundnut ▪ Promote conservation agriculture and agro-forestry ▪ Support micro-irrigation along existing water sources ▪ Promote effective use of ground water and other water harvesting techniques ▪ Develop erosion control and flood protection technologies ▪ Promote jatropha cultivation on degraded soils

District	Adaptation options
	▪ Promote beekeeping in area enclosures ▪ Protect Cheffa wetland and conserve certain plant species that can be used a source of income such as the fresh grass (*chefe*) and the grass for making mattress ▪ Consider Borkena watershed development as a national agenda ▪ Develop alternative household energy sources e.g. wind and solar, reduce the rate of deforestation. The plateaus of Bati and Kemissie stand between two plains on opposite sides with high potential for wind energy ▪ Promote large scale cultivation and processing technologies for jatropha ▪ Promote perennial crop based on multiple cropping and agro-forestry
North Shewa Zone	▪ Establishment of area enclosures in degraded sloppy areas, and develop strategies for sustainable use, particularly by the landless youth ▪ Promote supplementary irrigation ▪ Introduction and promotion of cultivation of underutilized but promising crops e.g. triticale and malt barley in the highland area. ▪ Promote perennial crop based cropping system and agro-forestry ▪ Promote large scale cultivation of fruits and processing ▪ Promote production of poultry and small ruminants, especially sheep
Shala	▪ Promote water harvesting for supplemental irrigation and in-situ soil moisture retention ▪ Develop improved technologies and less labor intensive methods for sediment dredging from community ponds ▪ Promoting cultivation and utilization of unpopular but potentially useful crops e.g. cassava, pigeon pea, cowpea and soybean ▪ Support rehabilitation of degraded lands and gully treatment ▪ Establishment and sustainable use of area enclosure for income generation
Loka-Abaya	▪ Promote agro-forestry and conservation agriculture ▪ Increase access and effective use of meteorological information services at community level ▪ Diversification of household income sources e.g. through fattening and beekeeping in area enclosures ▪ Promote cultivation and use of sweet potatoes, currently not a popular crop in the area, but with good potential to perform well ▪ Promote surface water harvesting practices and use of ground water ▪ Promote cultivation of drought tolerant e.g. pigeon pea, soybean, finger millet, pearl millet, cowpea and cassava which are underutilized in the area ▪ Establishment of jatropha plantations, including processing
Teltele	▪ Introduction of appropriate bush clearing techniques, including re-introduction of the traditional burning practice ▪ Support reforestation through planting of indigenous plant species ▪ Use of irrigation by using the Woito river for forage and crop production ▪ Establish large scale gum production schemes, as the area has high potential for the gum tree species ▪ Improve provision and access to meteorological information services at community level. ▪ Promote conservation tillage, along with water harvesting and drip irrigation ▪ Introduction of alternative drought tolerant crop types for semi-arid areas
Filtu	▪ Support integrated and irrigated forage development projects ▪ Support the study, conservation and use of herb and tree species for income generation and medicinal purposes ▪ Promote crop diversification e.g. pigeon pea, groundnut, jatropha, pearl millet, mung bean, cassava and other crops adapted to drought-prone areas ▪ Establish large scale gum tree plantations with good potential to grow in the area

Table A4. Climate change impacts on livestock production by district

District	Climate change impact on livestock production
Raya-Alamata	▪ Shortage of livestock feed due to desiccation of grass and crop failure caused by moisture deficiency as well as conversion of grazing lands into crop lands ▪ Shortage of water for livestock and domestic use as surface waters (ponds and springs) dry up during drought or prolonged dry seasons ▪ Reduced livestock productivity and reproductive performance ▪ Increased incidence of animal diseases. Increased temperatures create favorable environment for multiplication of disease causing organisms e.g. foot and mouth disease (FMD)
Raya-Azebo	▪ Emergence and gradual expansion of invasive species e.g. *Prosopis juliflora* with adverse effects on the grazing areas ▪ Shortage of animal feed and grazing resources and conversion of grazing lands to croplands ▪ Decreased production and reproductive performance of livestock due to feed shortage — delayed age at first mating, first calving, low conception rates, long inter-calving intervals and low milk yields ▪ A shift in livestock herd composition, with an increase in camels and goats due to changes in vegetation composition (more bushes and shrubs than grasses). Camels and goats have a better ability to withstand drought, feed and water shortages than cattle and sheep ▪ Recurrent droughts, increased temperatures and variable rainfall, negatively affecting feed and water availability for livestock ▪ Increased price of livestock and hence inability of households to re-stock after shocks
Bati	▪ Shortage of pasture and water for livestock ▪ Increased incidence of livestock diseases ▪ Poor condition and productivity of animals — decreased growth rate, low milk production and reproductive performance and in extreme cases death of animals. E.g. in 2007/2008 there was significant loss in livestock productivity due to severe drought causing shortage of feed
Kemissie	▪ Loss of grazing lands due to drying of wetlands, which are important grazing areas due to increased temperature and evapotranspiration. The Cheffa valley in particular had shrank considerably and the water table was decreasing ▪ Loss of grazing lands due to increased soil erosion and gully formation causing siltation in the valley bottom ▪ Shortage of water for livestock — decline in water discharge or drying up of springs and rivers ▪ Expansion of invasive species such as *Lantana camara* and disappearance of some valuable plant species ▪ Increased incidence of flooding and hailstorms, e.g. in 1998 there was high incidence of flooding which caused damage to livestock and other properties ▪ Outbreak of livestock diseases such as black leg, anthrax and FMD due to increased temperature during the long dry season and congregation of a large number of animals in one place at the Cheffa valley, coming from different drought affected areas as far as from the Afar Region. In 2009/10 about 180,000 heads of cattle congregated at the Cheffa valley, and in 2011/2012 some 250,000 heads of cattle congregated in the area ▪ Migration over a long distance in search of feed and water predisposes animals to increased stress and in some cases death
North Shewa Zone	▪ Decreased availability of livestock feed due to decreasing rainfall amount and increased variability. Major feed resources include crop residues, natural pastures/meadows, and hay ▪ Reduced production and reproductive performance of animals, and weight loss ▪ Calves born during the long dry season usually have poor body condition and low survival rates because of low milk production of lactating cows to properly nurse the off-spring ▪ Reduced potential to use artificial insemination (AI) service because of feed shortage ▪ Increased incidence of disease outbreak and mortality rates. Some diseases that were traditionally confined to the lowland areas are now expanding to the highlands e.g. lumpy skin disease and trypanosomiasis. Incidences of other diseases e.g. pasteurolosis, African

District	Climate change impact on livestock production
	horse sickness, sheep pox and fasciolosis are increasing as livestock becomes more susceptible due to feed shortage and other environmental stresses
Shala	▪ Water shortage due to inadequate, erratic and unpredictable rainfall. Often there is a late onset and early cessation of the rains thus shortening the effective rainy season and sometimes complete failure of either the long or short rains ▪ Damage from increased flood incidence due to high intensity rainstorms and degraded watersheds. E.g. in 2009/2010 heavy flooding led to loss of livestock and other properties ▪ Shortage of livestock feed as grazing areas are shrinking due to expansion of crop cultivation and decreased availability and quality of pasture during the prolonged dry seasons ▪ Increased incidence of disease outbreaks, particularly during the long dry season when animals are in poor condition due to inadequate feed supply and increased heat stress resulting from increased temperatures ▪ Increased incidence of livestock diseases related to the seasonal migration of livestock in search of feed and water, and may sometimes leading to conflicts with other communities ▪ Decreased production and reproductive performance of animals—slow growth rate, loss of body weight, reduced milk production and poor reproductive performance in mature animals ▪ Draught oxen that are emaciated and in poor body condition cannot provide adequate draught power for plowing leading to reduced crop productivity
Loka-Abaya	▪ Shortage of livestock feed due to erratic and unpredictable rainfall patterns. Usually early cessation of the rains and sometimes rains occur when they are not expected ▪ Drying up of surface water sources (e.g. ponds) as temperature increases ▪ Increased incidence of heavy rainfall leading to flooding e.g. in Abaya Zuria Kebele ▪ Increased incidence of livestock diseases and parasites ▪ Reduced pasture production and quality of available pasture because of shortage of rain and increased temperature ▪ Water shortage due to decreasing volume of streams and low level of water accumulation in community ponds. Declining water volume is also associated with increased salinity of the water, particularly in the case of Bilate river, reducing its suitability for irrigation purposes
Teltele	▪ Shortage of feed and water due to recurrent droughts and increasing temperature. Major droughts occurred in 1984, 1994/95, 2000, 2004, 2008 and 2010/11 ▪ Shorter rainy season affecting water and feed availability ▪ Changes in composition of vegetation and loss of feed resources. Areas that used to have savannah grass have been invaded by undesirable bushes and shrubs ▪ Increased incidence of flood and landslide due to changes in watershed vegetation cover ▪ Long distance migration of livestock in search of feed and water resources, sometimes causing conflicts over use of these scarce resources ▪ Decreased livestock production and productivity—slow growth rate or stunted growth in growing animals, drop in milk production, poor reproductive performance and increased mortality—due to prolonged dry seasons and recurrent droughts ▪ Animals are predisposed to different health problems due to shortage of feed and the climatic stress during droughts, leading to loss of large numbers of cattle and sheep
Filtu	▪ Decreased water and feed availability due to significantly decreased rainfall, increased temperatures, and frequent droughts ▪ Flood damages along Dawa and Genale rivers; 4 of the 10 Kebeles located along the Dawa river are vulnerable to seasonal flooding ▪ Bush encroachment (i.e. invasion by undesirable bushes such as Acacia drepanolobium and Acacia mellifera in the rangelands) ▪ Reduced availability of water, limiting use of available grazing resources that are far away from the two rivers (Dawa and Genale) ▪ Quick drying of ponds in the dry season due to increased temperatures and evaporation ▪ Reduced livestock productivity due to stress from high temperatures, water and feed shortage—manifested in reduced growth rate, low milk production and weight loss

Table A5. Current and potential coping and adaptation strategies to climate change in livestock production by district

District	Current coping and adaptation strategy	Potential strategies
Raya-Alamata	▪ Livestock migration in search of feed and water ▪ Collecting hay and crop residues or purchase from those who have it; one sack of straw is sold for as much as 30 Birr (USD 1.0 ≈ 19.50 Birr) ▪ Use of cactus and Parthenium weed as livestock feed ▪ Change in livestock composition (more camel and goats replacing cattle) ▪ Establishment of flood risk management committee at different levels ▪ Establishment of physical structures e.g. use of gabions for flood and soil erosion control	▪ Area enclosure and rehabilitation of degraded lands, bylaws are needed to ensure effective implementation of the practice ▪ Planting of multipurpose fodder trees and protection of natural resources ▪ Water development (irrigation, digging wells, harnessing underground water, harvesting rainwater), and rivers need to be diverted and used for irrigation purposes ▪ Forage development such as elephant grass and fodder trees (e.g. L*eucaena and Sesbania*)
Raya-Azebo	▪ Use of cactus as animal feed. The cladodes (leaf like structures) are used as animal feed while the fruits and cladode juice are used as human food ▪ Use of hay and crop residues for dry season feeding ▪ Livestock migration to distant places in search of feed and water. However, this option is currently limited to shortage of land ▪ Water harvesting. There is increasing interest in water harvesting because of the prevailing moisture stress resulting from shortage of rain and prolonged dry seasons	▪ Implementation of area enclosure to allow for natural regeneration of degraded areas ▪ Closer collaboration between neighboring regions or districts on natural resources management
Kemissie	▪ Livestock migration in search of feed and water ▪ Migration of people to other areas for alternative sources of livelihood, with most of the young people migrating to Arab countries	▪ Rehabilitation of degraded areas through participatory area enclosure ▪ Support household asset building ▪ Support watershed management and environmental protection initiatives
Bati	▪ Livestock migration to the Cheffa valley in search of pasture and water during the long dry season ▪ Changing the livestock herd composition to adapt to the changing environment and vegetation of the area (i.e. increasing goats and camels populations and reducing cattle population)	▪ Rehabilitation of degraded areas through area enclosure ▪ Strengthen traditional conflict resolution mechanisms in order to minimize or avoid conflicts between neighboring communities on use of scarce resources such as grazing land and water resources ▪ Reduce herd size and keep fewer and more productive animals ▪ Develop alternative energy sources to reduce the destruction of natural vegetation for firewood and charcoal production ▪ Develop alternative means of livelihood, especially for the younger generation

District	Current coping and adaptation strategy	Potential strategies
North shewa zone		▪ Provision of early warning information to increase community preparedness to climate variability and shocks ▪ Create and strengthen awareness of farmers in improving livestock feed supply and livestock productivity
Teltele	▪ Seasonal migration of livestock in search of feed and water ▪ Fodder conservation for the dry season or drought period e.g. the traditional practice of setting aside part of the grazing land as grazing reserve (*kaloo*) for use during the dry season by pastoralists ▪ Making hay towards the end of the rainy season for use in the dry season ▪ Collection of crop residues after crop harvest for use as livestock feed during periods of feed shortage ▪ Asset rebuilding after droughts through traditional mutual support system known as *Busa Gonofa*	▪ Support integrated watershed management. This may include bush clearing in bush invaded grazing areas, rehabilitation of degraded areas through area enclosure, terracing, planting trees and construction of micro-dams, check dams and ponds ▪ Reducing livestock numbers to match the carrying capacity of the grazing land. This can be done by increasing commercial off-take and reducing herd size to the carrying capacity of available forage resources ▪ Build on existing traditional mutual support systems and organizing the communities into savings and credit associations to build a more organized mutual support system ▪ Strengthen current government efforts to provide early warming information
Shala		▪ Support integrated watershed development and management ▪ Introduce plant species with multiple uses e.g. providing fodder for animals, and for soil and water conservation ▪ Encourage planting of forage crops on soil conservation structures so that they can serve the dual purposes of conserving soil and water and providing fodder for animals ▪ Promote water harvesting ▪ Support livelihood diversification in the community through introduction of alternative income generating activities such as animal fattening and bee keeping
Filtu	▪ Seasonal migration of livestock in search of feed and water ▪ Development of fodder banks based on Sudan grass and elephant grass ▪ Irrigated forage development along Dawa and Genale river banks	▪ Support livelihood diversification through engagement in gum and incense production
Loka-Abaya	▪ Use of hay and crop residues for feed ▪ Water harvesting by using ponds, cisterns among others	▪ Integrated watershed management and rehabilitation of degraded areas through area enclosure ▪ Cultivation of Jatropha on degraded areas for ecological and economic benefits ▪ Integrate forage production with soil and water conservation e.g. grasses such as elephant grass and 'desho' can be grown on soil bunds ▪ Reduce livestock numbers, including reducing the number of unproductive animals (i.e. keep only few and more productive animals)

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