Household Food Insecurity in the Sidama Zone of Southern Ethiopia

Factors, Coping and Adaptation Strategies

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This study deals with the factors of food insecurity and how these factors are linked to regional and global climate change in two farming systems in southern Ethiopia drawing on both qualitative and quantitative data collected in fieldworks. Doing fieldwork in rural areas especially in areas where previously unknown in my opinion is not simple even for experienced researchers. The fieldworks were demanding and compounded with challenges. However, I was open-minded and flexible to learn new about the study in question from the subjective reality of the participants. This method led to a wealth of information. My special thanks go to interviewed farmers for openly sharing both their local knowledge and food insecurity experiences, and for their respect in all my contacts and household visits. I extend my gratitude to key informants which include government and NGO officials, food security experts, Development Agents (DAs), Peasant Association officials, health extension workers, and teachers for their time and all-round guidance. I similarly appreciated the contribution of field assistants to the study.

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Dedication

I heartfully dedicate this thesis to my wife Lily Hadgu and to our beautiful and enjoyable kids Sumhal Gezahegn and Henrik Hadgu.

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1. Introduction

Most small-scale farmers (farmers hereafter) in Ethiopia derive their livelihoods from mixed rain-fed agriculture. Cultivation is small-scale using traditional methods. These farmers use limited farm inputs to improve productivity. Hence, production per household remains low. Population growth is faster than improvements in agricultural production. Poverty and food insecurity is a reality in rural Ethiopia (World Bank 2015). The total food production by the farmers today is not even sufficient to feed the agricultural population. Most farmers lack access to sufficient and nutritious food even in the absence of shocks. Although production and food availability at the national level have increased substantially during the last two decades (Gregory 2013), the country's contemporary food security condition is threatened because of global climatic events such as El Niño caused droughts and floods (ACAPS 2016; IFRC 2016; UNICEF 2017). The level of intensity and extensiveness of the current drought and rain failure affect a large number of farmers who previously were self-sufficient with respect to food production. In response, food aid (emergency and relief aid) and participation in the government's Productive Safety-Nets Program (PSNP) continue to be sources of food and income for farmers who are chronically food insecure. Yet, the problem of food security varies among farmers. Some of the farmers are facing chronic and acute food insecurity while others have shorter periods of hunger only.

Although a large body of studies on agriculture and food security were conducted in Ethiopia following the 1984 "Ethiopian famine" that affected almost all parts of the country, most of these studies give little emphasis to how what happened in a particular place can be linked to national and global climate change. Literature shows that climate change is one of many challenges that negatively affect climate-dependent livelihoods (Bals et al. 2008; IPCC 2012; O'Brien 2012; Olsson et al. 2014; Yaro et al. 2015; Anane & Cobbinah 2016; Jost et al. 2016). The effects of climate change events are multifaceted (from drought to flood) and multileveled (from local to global) and have short, medium and long-term outcomes (Wisner et al. 2006). A UNISDR (2013, 6) report indicates that drought, desertification, flooding and environmental degradation are all influenced by the effects of climate change. The increasing frequency of environmental risks affects poor farmers and affects disproportionately women. Although, in Ethiopia women play a seminal role in household food security, they experience hunger more than men. The study discusses the gender dimensions of agriculture and food insecurity and women perceptions on how they adjust the risks of food shortages.

Studies indicate climate change in the form of more unpredictable and erratic rainfall and more frequent extreme events is the major physical development challenge in Ethiopia (Bewket 2012; Bogale 2015; OCHA 2015; Kilawe et al. 2016; Abebe et al. 2017; Abebe 2017).

Although the type, frequency, intensity and duration of extreme climatic events widely differ geographically (IPCC 2012), the frequency and magnitude of such climatic events increase over time due to the global phenomenon El Niño (FAO 2016b; FEWS-NET 2016; UNICEF 2017). However, the factors that cause farmers food insecurity are complex, dynamic and vary widely among different agro-ecological settlements. The research focuses to the social dimensions of resilience, in that it considers the factors that decrease the farmers' ability to achieve food security originate from social and institutional, economic and political and physical issues and range from local to national and international levels. Although studies in Ethiopia show how social and institutional factors and ecological degradation contribute to a low level of agricultural production and to micro-climatic change and thus food insecurity (Deverux 2000; Tolossa 2003; 2005; Mulugeta 2012; Florax et al. 2014; Megersa et al. 2014; Taffesse et al. 2014; Endalew et al. 2015), there is less evidence of how these factors are linked to national and global climate change in the *Sidama* agro-forestry farming system of southern Ethiopia.

1.1 Ethiopia: Climate change and food insecurity

One of the sustainable development goals contains the following: End hunger, achieve food security, improve nutrition and promote sustainable agriculture. However, it seems quite challenging in view of the impact of climate change on agriculture, to achieve the goal. Several studies show that global climate change risks exacerbates the level of food insecurity and malnutrition in complex ways (FAO 2008; Moorhead 2009; IFPRI 2010; WFP 2012; Zewdie 2014; Aggarwal et al. 2016; FAO 2016a). The impact of climate change events both on food and livestock production and consequently on people's lives is not a recent phenomenon in Ethiopia (Table 2). The country's agriculture is vulnerable to risks of climate change. For decades, more prolonged droughts and a declining and low level of mean annual rainfall over time and a high inter-annual fluctuation and increasing temperature are the country's major environmental stressors causing farmers' food insecurity. Since the early 1980s seven major and several localized droughts as well as failure of seasonal rains have negatively affected production (CARE-Ethiopia 2014). However, the earlier drought effects on agriculture were geographically concentrated in the northern, central, and eastern highlands where cereals are dominantly produced (Table 2). Moreover, the magnitude and severity of such climatic events are variable in the different agro-climatic zones of Ethiopia. Farmers in the lowland areas are exposed to frequent droughts and high temperatures, while farmers in the highland areas suffer from intense and erratic rainfall (Buit et al. 2015). Despite this fact the country's highland and midland areas are today facing similar climate changes as of the lowland agro-climatic areas.

Evidence suggest that drought and rain failure-driven food insecurity have expanded from the cereal-based farming system in the *Tigray* and *Wollo* areas of the north; in the regions of *Amhara* (Webb and Von Braun 1990; Africa Watch 1991; Rahmato 1991; Clay et al. 1999; Edkins 2000); in *Hararege* particularly in the East and West *Hararege* zones (United Nations 2003a; Kristen 2004; Bogale 2012); in *Oromia* including areas known to have a surplus wheat and barely production such as *Arsi* and *Bale* zones (Tolossa 2003; 2005); in the southern and southeastern pastoral areas of the *Borena* and *Guji* zones; and in *Somali* mainly following the 1999/00, 2002/03 and 2005/06 droughts (Salama et al. 2001; Maxwell and Hammond 2002; Wekessa and Pantuliano 2008); and in the agro-forestry farming system of the Southern Nations, Nationalities and Peoples' Region (SNNPR) (FEWS-NET 2005; 2015). The western rainfall-sufficient and resource rich regions of *Benishangul-Gumuz* and *Gambella* facing the problem of food security (Figure 2) where farmers previously were self-sufficient and food secure. As indicated in *Article 1* and *7*, Ethiopia faces both a declining and low level of mean annual rainfall over time and a high inter-annual fluctuation (Figure 1). Similarly, an increasing annual temperature has been observed in Ethiopia. Data indicate the average annual temperature has risen between 1955 and 2015 by 1.65 ^{0}C (Table 1).

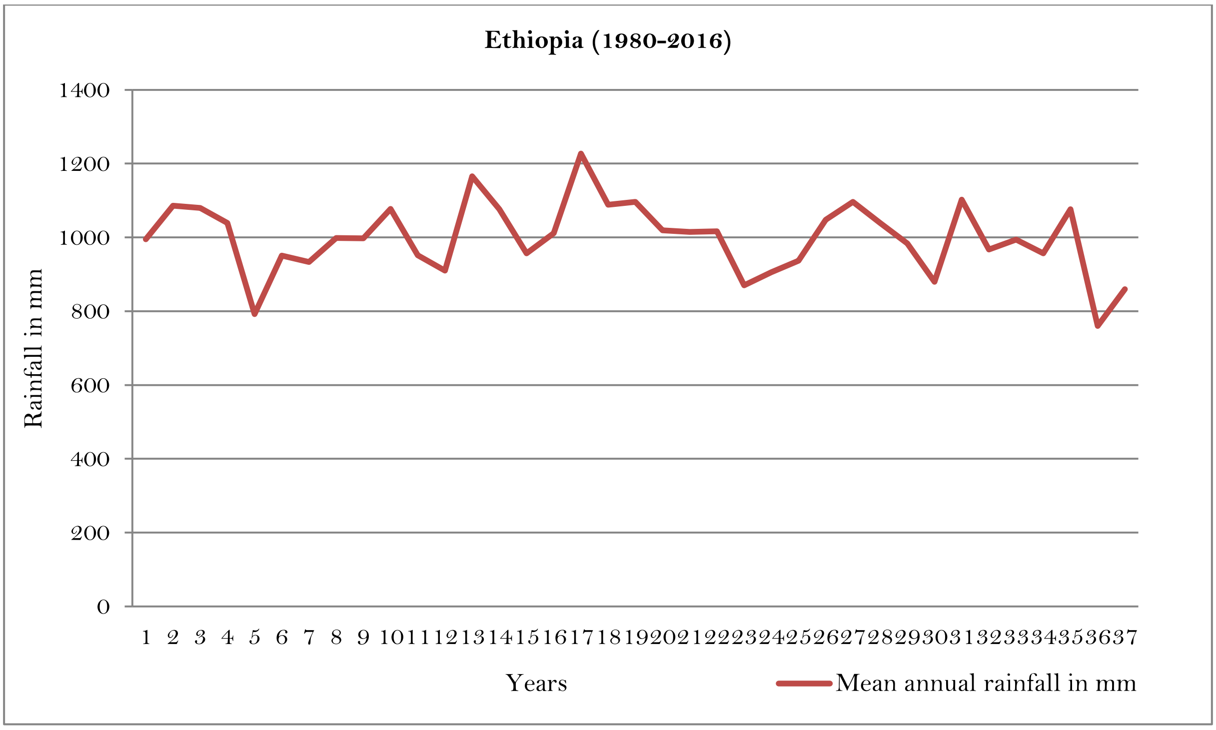

Figure 1: Mean annual rainfall in Ethiopia.
Source: Article 7. Computed based on raw data from the National Metrological Agency (NMA) of Ethiopia.

Table 1: Average annual temperature in Ethiopia: Representative weather stations.

Year	Addis Ababa	Arba Minch	Hawassa	Combolcha	Debre Markos	Beshoftu	Dire Dawa	Robe	Gode Metekel	Gondar	Gore	Jimma	Mekele	Metehara	Neghele	Nekemte	**Average annual Temp.**
1955	18.9	--	--	17.69	15.24	18.55	24.86	--	--	18.65	17.85	18.54	--	--	18.37	--	**18.70**
1960	18.85	--	--	19.7	15.2	18.87	24.97	12.72	--	18.37	18.17	19.3	17.62	--	19.66	--	**18.49**
1965	18.9	--	--	18.89	15.28	19.09	24.7	12.19	27.98	19.59	17.73	18.82	18.57	--	19.11	--	**19.23**
1970	19.65	--	--	19.2	16.45	19.07	24.93	12.93	28.82	19.9	18.24	18.73	18.63	--	19.38	17.25	**19.47**
1975	19.82	--	18.68	17.82	15.76	18.26	25.02	12.82	28.86	20.03	17.9	18.6	16.99	--	19.17	17.06	**19.05**
1980	19.92	--	19.9	19.07	16.22	18.93	25.4	14	28.92	19.97	18.6	19.19	17.66	--	20.05	18.06	**19.70**
1985	15.72	24.62	18.74	15.82	16.06	18.38	25.17	15.12	28.05	20.16	18.1	18.83	17.21	24.89	19.12	17.65	**19.60**
1990	16.1	24.08	19.76	19.73	16.04	19.13	25.37	15.02	29	19.54	19.95	19.01	11.2	25.37	21.23	18.51	**19.94**
1995	16.6	23.8	20.2	19.49	16.95	19.65	25.85	14.93	--	20.85	19.17	19.94	17.88	26.17	21.12	18.75	**20.30**
2000	16.62	23.66	19.88	19.3	16.35	19.41	25.68	14.08	28.91	19.44	18.82	19.79	18.15	25.42	20.75	18.6	**20.69**
2005	16.89	23.88	20.21	19.73	16.83	18.48	26.06	15.2	29.72	20.67	19.56	19.6	18.01	25.93	21.28	19.0	**20.56**
2010	16.95	23.94	20.62	20.4	17.09	18.78	25.9	15.43	30	20.73	19.42	20.14	18.23	26.07	21.76	18.99	**20.75**
2015	18.55	24.65	21.44	20.48	17.37	20.18	25.71	15.72	29.67	20.67	19.36	20.43	18.23	26.88	22.44	18.57	**20.35**

Source: Article 7. Computed based on raw data from the National Metrological Agency (NMA) of Ethiopia.

Table 2: Major environmental events and affected areas (1957 to 2017).

Year	Environmental events	Areas affected
1957-1958	Droughts and rain failure in 1957 coupled with locust and epidemic in 1958.	The effect on people and livestock mortality was high in *Tigray* and *Wollo* areas of the north.
1964-1966	Rain failure and famine. Poorly documented.	Affected the *Tigray* and *Wollo* areas.
1972-1974	Droughts and successive failure of *Meher* rains-induced food shortages. Killed 50% of livestock.	Ethiopia, particularly the *Tigray*, *Wollo* as well as *Ogaden* areas.
1978-1979	The *Belg* rains failure.	Affected southern Ethiopia.
1982	Drought and late come seasonal rains.	Affected in particular northern Ethiopia.
1983-1985	Droughts and famine causing hundred of thousands death and migration in search of employments in the state farms in eastern and coffee producing areas of the southern region.	Ethiopia, most farmers were in need of emergency food assistance. A large humanitarian response flowed following the BBC report on the 1984 famine including the Band Aid.
1987-1988	Droughts and food shortages. Undocumented severity.	Ethiopia, particularly in *Eritrea*, *Tigray* and Northern *Wollo*, north *Shoa*, northeastern *Gondar*, and *Hararege* highlands.
1990-1992	A continues rain failures and military conflicts.	Northern, eastern, and southern Ethiopia.
1993-1994	Droughts strike causing an estimated 4 million people required food assistance.	Higher magnitude was recorded in the *Tigray* and *Wollo* areas of the north.
1997-2000	Prolonged drought and successive rains failure, conflict and declining livestock prices. The affected population rose from 2.7 million in 1996 to 7.7 million in 2000 drought years. Others estimated the figure over 10 million people in 2000.	Particularly affected the eastern highlands and pastoral lowlands including *Gode*, *Shinile*, *Jigjiga*, *Kebre-dahan* of *Somali* region; *Konso*, north and south *Omo* zone of southern region; *Borena* zone of *Oromia* region; *lay-Gayint*, *Humera* and *Wollo* areas of *Amhara* region. Moreover, conflict leads localized food shortages in *Eritrea* and *Tigray*.
2002-2003	Severe droughts-driven food shortages affected an estimated 12.6 million people.	Affected most part of Ethiopia, even known cereals producing areas including *Arsi* and *Bale* highlands of *Oromia* region.
2005-2006	Drought severely affected pastoral and agro-pastoral communities. Over 1.2 million people were affected.	Southeastern Ethiopia including *Afder* and *Liben* and part of *Gode* zones of *Somali* region and *Borena* zone of southeastern *Oromia* region.
2008-2009	Localized drought coupled with world food price rise affected 6.4 million people.	Southern region particularly the lowland moisture deficit districts.
2011-2012	Eastern Africa drought.	Affected the Horn of African countries. The *Afar*, *Somali* and Southern regions including *Borena* and *Bale* zones of *Oromia* region were affected.
2015-2017	Worst droughts in 30 years affected more than 10.2 million people who required food assistance in 2016. The continued effects of drought left a large number of people, in different parts of the country, seeking food assistance in 2017. In addition to the effects of frost, heavy rainfall and floods were also affected people and public services. The newly emerged crop diseases (locally named *Temche*) spread out rapidly and affected young maize plants by feeding the leaves. Traditional controlling mechanisms were often adopted by the farmers for managing the disease.	Northern, eastern *Hararege* and central Ethiopia particularly in *Afar*, in *Shinile* zone of *Somali* region, and parts of *Amhara*, *Oromia*, and southern regions. Floods recorded in *Mustahil*, *Kelafo*, and East *Imy* in the *Shabelle* zone of *Somali* region and in western *Arsi* zone of *Oromia* region and in *Kindodidaye* area of *Wolayita* zone of SNNPR. Frost affected the *Meher* harvest in some cereals producing areas of *Oromia* region. Moreover, in 2017 crop disease affected maize plants which have been covered on 146,000 hectares of land in some districts of the *Tigray*, *Oromia* and *Benishangul-Gumuz* and SNNPR regions.

Sources: Complied from literatures mentioned above including: Deverux 2000; Edkins 2000; Graham et al. 2012; WFP 2015; Disaster Risk Management, Food Security Sector and Ministry of Foreign Affairs, Ethiopia and Ethiopian Broadcasting Corporation: EBC News.

1.2 Objective of the study and research questions

The objective of this study is to explore the determining factors of food insecurity and how these factors are linked to global climate change among farmers in maize-based and in coffee-based farming systems in the Sidama administrative zone of southern Ethiopia. The *Sidama* zone is vulnerable to the effects of climate change. This includes high temperature and a prolonged dry season, recurrent localized droughts and changes in frequency and intensity of rainfall. The farmers' vulnerability to the changing environment, however, is not uniform throughout the zone. More unpredictable and erratic rainfall and more frequent droughts are typical features in the lowland *Sidama*. Farmers in the highland and midland *Sidama* suffer sometimes from intense and erratic rainfall. The highland and midland *Sidama* today face prolonged dry seasons, late *Belg* (spring) and *Meher* (summer) rains and high temperature-driven pests and diseases. Yet, the effects of climate change risks on farmers' food security are determined by their level of exposure, sensitivity and adaptive capacity (OECD 2014). Studies in Ethiopia contain little evidence of the varied climate change impacts *between* communities and socio-economic groups *within* a community.

Food insecure farmers are not passive to the effects of climate change risk and other socio-economic changes. The study discusses the multiple strategies used by food insecure farmers to manage events and changes that affect their present sustenance negatively and jeopardize their future income generating capacity. The adopted strategies differ depending not only on the severity and duration of food insufficiency incidence but also on household characteristics, socio-economic and environmental conditions, gender as well as season. This study discusses *why* the farmers' food security deteriorates over time, and *how* they adapt to the adverse events.

The study have the following specific research questions:

A) Identify food insecure small–scale farming households in the study areas.
   - What are the typical characteristics of food insecure small–scale farmers?
   - What is the intensity of food insecurity among these farming households?
   - Do the different intensities of food insecurity correlate with household characteristics?

B) Explain the existence of food insecurity among the studied farming households.
   - What are the structural factors of household food insecurity at higher geographical levels?
   - What are the local processes affecting the food security of the studied households?
   - What is the studied households' perception of the more or less important causes of their food insecurity?

C) Discuss the coping strategies of the studied households regarding selected adverse events.
   - What do the households do to adapt the impacts of adverse events to their food security?
   - What is the perception of the studied households when it comes to improving their food security?

1.3 Ethiopia's contemporary food security condition

The literature shows that climate change impacts on food security are complex (FAO 2008, WFP 2012; FAO 2016a). Table 8 briefly presents the effects of climate change risk on food security. "Ensuring food security in the face of climate change is among the most daunting challenge" (FAO 2016a, 1). Although global climate change has the greatest impact at the local level (UNISDR 2012), local contexts are highly variable (IPCC 2012) meaning that all places are unequally vulnerable to the effects of climate change events. The WFP (2012, 8) defines climate change as the long-term trend in climate such as average temperature and precipitation which includes trends in climate extremes and shifts in the pattern of weather events "… whether due to natural variability or as a result of human activity" (Ehrhat et al. 2009, 5). Conversely, weather variability refers to seasonal changes in climatic elements. The effect of climate change risks is short-term, resulting from frequent and intense extreme events which include drought, floods, heavy precipitation and snow events and long-term changes in temperatures and precipitation patterns (Bals et al. 2008; FAO 2008, 2016a). Yet, farmers' vulnerability to changes is a function of the magnitude, duration, and frequency of shocks as well as their ability to respond to them (Frankenberger et al. 2013).

Although agricultural production has increased for decades (Abebe 2017), the effects of El-Niño have caused droughts and heavy rainfall events resulting in loss of harvest in districts of *Afar*, *Amhara*, *SNNPR*, *Oromia*, *Somali*, and *Tigray* Regions since 2015 (FEWS-NET 2015; OCHA 2015; ACAPS 2016; FAO 2016b; IFRC 2016). As a result, an estimated 10.2 million people required food assistance in 2016 (WFP 2016) with a fall back to 5.6 million in 2017 (UNICEF 2017). This source paradoxically indicates the increasing number of hotspot districts that require food assistance from 158 in July 2016 to 192 in January 2017. The BBC (12.6.2017) reported that currently over 7.8 million people are requiring food assistance and the number of people are expected to rise by 2 million because of the successive seasonal rain-failure and back-to-back droughts. Geographically, the districts are concentrated in five regions: *Somali*, *Oromia*, *Afar*, *Amhara* and SNNPR.

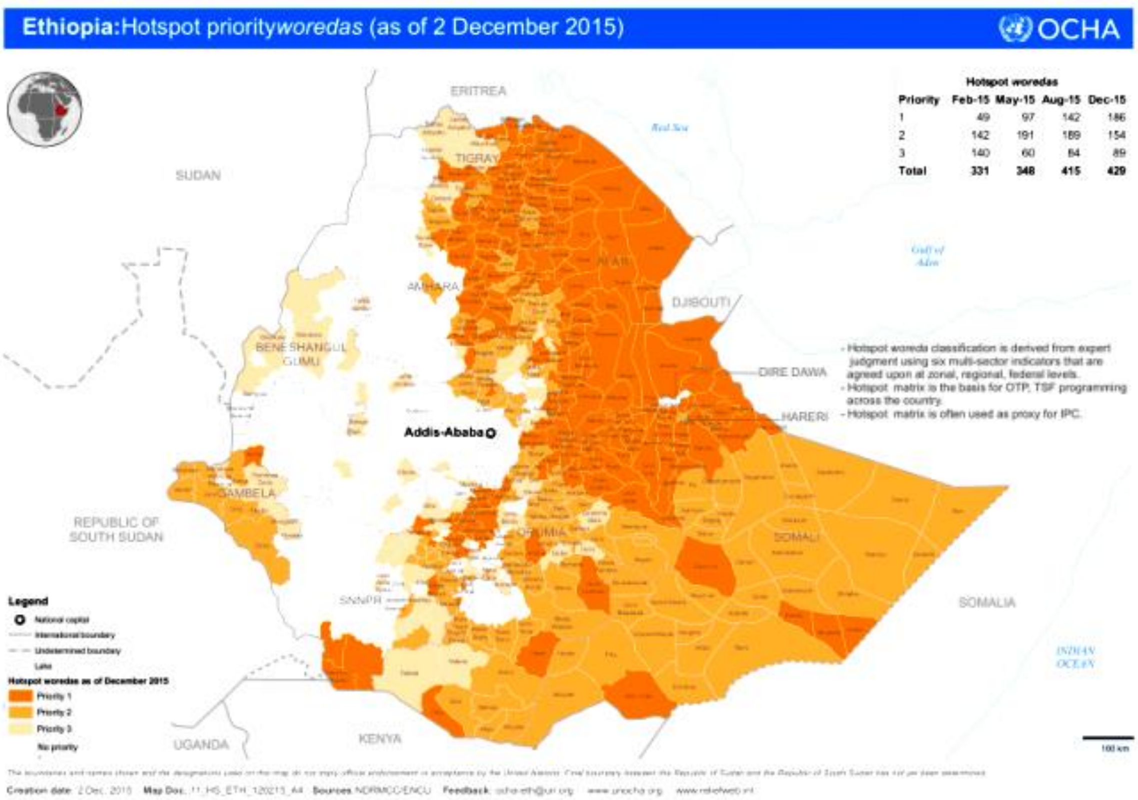

Figure 2: Hotspot priority districts.
Source: OCHA (United Nations Office for the Coordination of Humanitarian Affairs).

Rain failure and insufficient rainfall was recorded particularly in drought-prone and short-term *Belg* rains dependent areas (Figure 3). The National Metrological Agency (NMA) of Ethiopia warns most of the *Belg* rains dependent areas will receive rainfall below the normal amount in 2017.[1] Such an environmental change increases food insecurity and malnutrition

[1]Ethiopian Broadcasting Corporation: EBC News: 11.02.2017.

level across the country (WFP 2015). In this regard, a FAO (2016b, 3) report on the El Niño response in Ethiopia indicates the devastating drought effects on farmers:

> The current El Niño is one of the strongest on record. … Significant rainfall deficit have recorded in pastoral areas. The most extreme drought conditions in the northern, [Eastern and Southeastern] regional states experienced two consecutive rainy seasons – *Belg* and *Kiremt* [summer]. The delayed and erratic *Kiremt* rains led to crop failures and food insecurity. … Several hundreds of thousands of livestock have died in *Afar* and many more in *Somali* regions. … Malnutrition rates have spiked … [and] reached the highest amount ever reported.

An Ethiopian Ministry of Communication and Information Technology (EMCIT) newspaper release[2] indicates the continued existence of rain failure-induced food shortages in different parts of the country including in some *Kolla* (lowland) districts of the southern and southeastern regions. The OCHA (Figure 2 and 3) graphic analysis shows that drought severely affects the pastoral and agro-pastoral communities in *Bale*, *Borena*, *Guji*, and East and West *Hararege* zones of the *Oromia* region, and *Afar*, Northeast and East *Amhara*, 9 out of 11 zones of *Somali*, *Gambella* and *Benishangul-Gumuz* regions and *Gamo-Gofa*, *South-Omo*, and *Sidama* zones of the SNNPR. Similarly, a joint Government and Humanitarian Partners' Requirement Document (HRD 2016) indicates that due to the continued drought additional food insecure people are expected to be recorded in most lowlands and dry midland Rift Valley areas. The FAO (2017) report notes that the humanitarian needs remain high in 2017 because of the *new* drought in the *Belg* rains dependent areas of southern and southeastern regions. UNFPA et al. (2011, 5) explains climate change impacts on sectors and particularly affect on the poorest given their reliance on the natural environment and limited access to productive assets.

> The impacts of climate change will increasingly affect the daily lives of people everywhere in terms of employment and livelihoods, health, housing, water, food security and nutrition, and the realization of gender equality and other human rights. Impacts are expected to hit those living in poverty the hardest, partly due to their more prevalent dependency on the very natural resources affected by climate change

[2]EMCIT notes in addition to international donors, the Federal and regional governments have allocated budget for helping the affected communities. EBC News: 05.02.2017.

and also because they have less capacity to protect themselves adapt or recuperate losses.

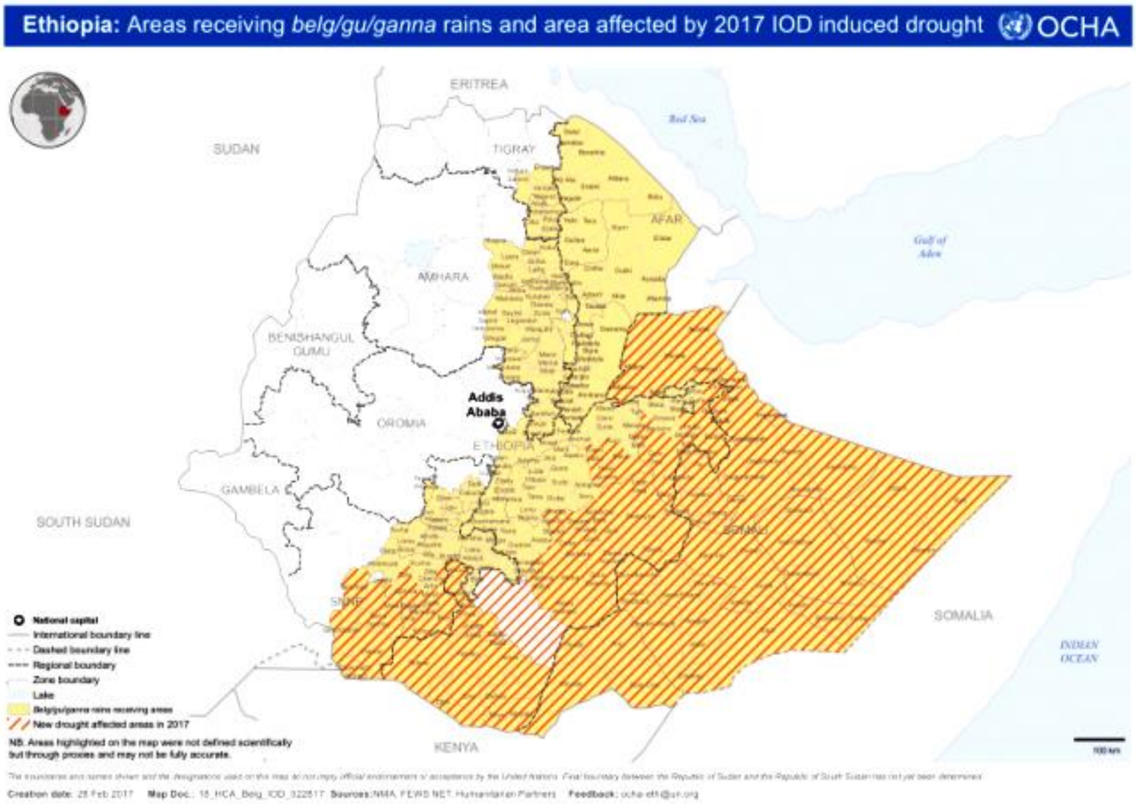

Figure 3: The *Belg* rains dependent areas affected by 2017 drought.
Source: OCHA (United Nations Office for the Coordination of Humanitarian Affairs). IOD refers to Indian Ocean Dipole.

Drought and unusual high temperature over time lead to water shortages, lack of pasture and the outbreak of diseases disproportionately affect the food and nutritional security status of children and women (FAO 2016b). Data show that in 2017 an estimated 303,000 children require treatment for severe acute malnutrition (SAM) and over 2.7 million children (6 to 59 months) and pregnant and lactating women require supplementary feeding (HRD 2016). Moreover, a large number of people are in need of multi-sectoral response such as health, nutrition, education, water and sanitation (UNICEF 2017). The UNICEF report indicates that 9.2 million people were targeted for a WASH project, 4.37 million people for access to health services and 2 million children for school feeding programs. The figures suggest not only the pervasive effects of drought but also the problematic future of these communities. Climate change in the form of prolonged droughts and failure of rains not only affect food production negatively but also have an impact on the available *non-farm* wage employment opportunities (FAO 2016a). Figure 4 shows the regional variation in the number of people who required relief food assistance between 2015 and 2016.

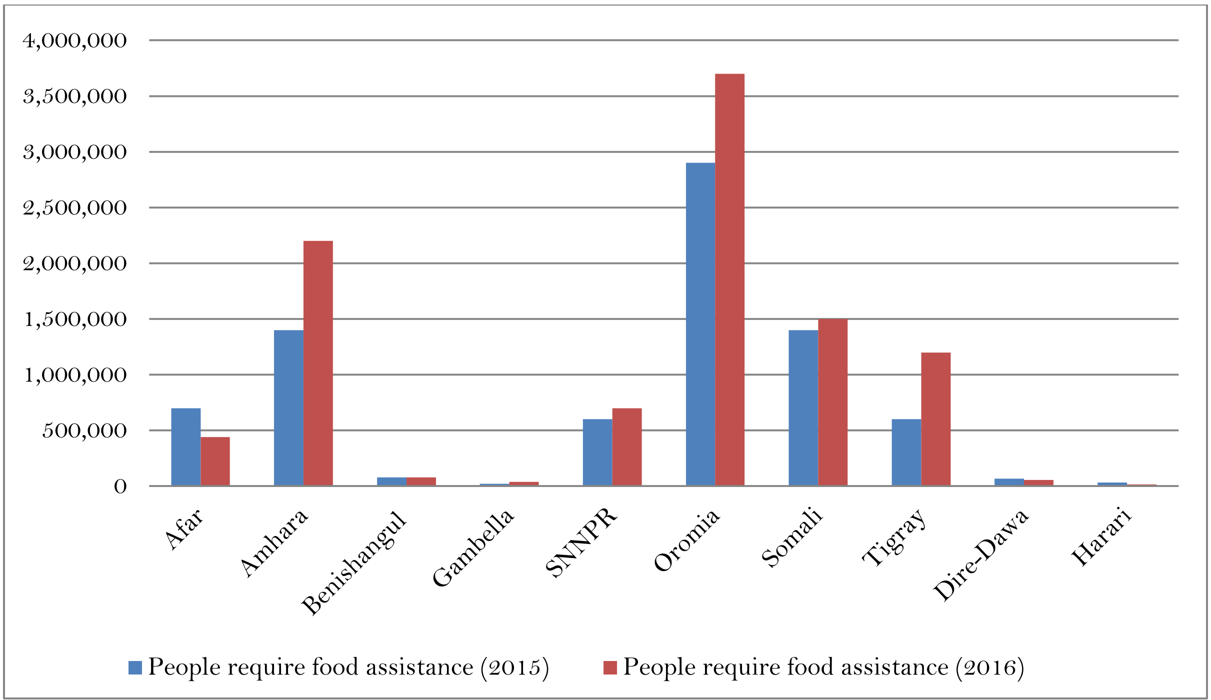

Figure 4: People requiring food assistance by region (2015 versus 2016).
Source: Numbers complied from the Humanitarian Requirement Document (HRD, 2016).

For a long time, the southern and western regions of Ethiopia were largely perceived by the government to be food self-sufficient. Part of the explanation is that the successive drought and rain failure-driven food shortages before and after the 1984 famine and food shortages because of military conflicts affected these farmers less compared to the farmers living in the northern highlands of the country. Regardless of the 1978/79 *Belg* rains failure-induced food shortages (Table 2), the SNNPR was not as food insecure as regions to the north and east (HRD 2016).

Furthermore, *Article 1* indicates farmers' food insecurity condition can be negatively affected because of the increasing trends of commercialization of small-scale agriculture. It presents the debates on the effects of commercialization on small-scale agriculture and food insecurity with a focus on rural development in Ethiopia. Agricultural development policies in Ethiopia promote marketable production as a pathway to achieve sustainable development and food security. A transformation of small-scale farmers' food production from subsistence with limited income from market sales to cash-crop production for export has opportunities in terms of employment generation, income and national-level growth. However, despite the potential prospects, the increasing trend of cash-crop production poses risks to small-scale farmers' food security. It argues that industrial agriculture reduce both food supply and the income of the farmers. Loss of access to agricultural land and exposure to market risks also endanger their livelihood and change the local production patterns and the farmers' multiple livelihood strategies. The paper contends that this contributes to local climate change and environmental degradation. It is concluded that, based on the local context and livelihoods strategies, improving productivity to strengthening the food production for consumption and investment in manufacturing is an important intervention that also will contribute to poverty reduction in rural Ethiopia.

1.4 Theoretical framework

1.4.1 Changing approaches to food security

This section deals the changing food security analysis from a modernist perspective which often privileges the "macro, uniform and growth-oriented" approach to the post-modernist understanding of the "complex, diverse realities and development at the micro level" (Maxwell 1996, 161). Food security is a multi-faceted concept. It is defined in various ways over time depending on the approach chosen to address food insecurity (Frankenberger and Maxwell 1992). Following the 1974 World Food Conference, a number of definitions of food security have emerged. In the 1970s the food security definition focused on the long-term physical *availability* of food at the global level through increasing production and storage (Saga 2012). This implies that achieving food security is a function of the aggregate amount of food produced. It was accordingly argued that increasing total food production through the application of modern scientific techniques was the solution to enhance food security. FAO (2003, 27) thus adopted a prices and supply-based food security definition: "Availability at all times of adequate food supplies of foodstuffs to sustain a steady expansion of consumption and to offset fluctuations in production and prices".

In the 1980s, the macro or global-level approach to ensure food security was revised by focusing on "national food supplies" which includes food reserves and aid, intensification of agriculture by increasing farm input application and irrigation and exports and imports from surplus to deficit regions (Bals et al. 2008; Sage 2012; Westengen 2012). The national level food security analysis primarily aims to increase the food available at national markets by increasing production. Despite its positive effect on food supply, the food production and exchange-oriented approach to achieve food security pays little attention to the complex and dynamic nature of food insecurity, to *local differences* and to different socio-economic *groups*. This is evidenced by the views of interviewed farmers.

Climate change-driven shortfalls in production could be adjusted through imports. However, addressing the national food supply deficits through imports is not an easy matter. There are a number of barriers that prevent the movement of food products. As indicated in *Article 1*, an example is the diverse agro-ecological conditions of Ethiopia: "Some regions produce food surpluses each year, while others face chronic food insecurity" (FTF 2011, 6). Another important explanation is that although Ethiopia's food production and availability have progressively increased for the last two decades (Article 7, Figure 23), the number of people who are chronically food insecure remains high (ACAPS 2016; IFRC 2016; UNICEF 2017). The findings in *Article 4* suggest that polices should go beyond concerns about food availability at national level and focus at the problems of *access* to sufficient food throughout the year for poor people. The crucial reason is that "the impact on hunger and malnutrition can only be well estimated, if the effects on the household level are taken into consideration" (Bales et al. 2008, 17). FAO (2016a, 1) similarly indicates:

> What is needed is not only enough food being produced globally – enough food is produced globally now but there are still almost 800 million hungry people – but that everybody has access to it, in the right quantity and quality, all the time. `

Sen (1981) changed the dialogue about food security by bringing attention to the question of individual access and entitlement. His argument about food security is relevant in order to understand the multidimensionality of food insecurity, which differs over space and time. Sen revealed that famines are not always a result of food shortage. Rather, households' or individuals' food security status can be determined by the distributional effect of food supply and the differences in physical, social, and economic access to food rather than national food availability. Sen's entitlement analysis was criticized because of its emphasis on "access to food as defining characteristics of food security" (Maxwell 1996). In this regard the study of Deverux (2001) notes "individuals as socially embedded members of households, community and states" [and the international …] that famines are political crises as much as they are economic shocks or natural disasters" (259). What happened in the 1984/85 Ethiopian famine is an example of this. Besides, seasonal rain failure and drought-induced production failure (Table 2), studies (Edkins 2000; Graham et al. 2012) indicate aggravating factors of the famine which includes war and conflict, land reform policies favouring state farms, a government failure not only to reveal the famine to the public but also to provide urgent response to the situation. The latter source further notes that market restrictions in terms of grain movements between regions were another contributing factor of the famine.

Based on the criticisms on entitlement theory, Swift (2006) conceptualizes a model that includes three assets (investment, stores, and social claims) in determining household food insecurity. Swift maintains that when a household is able to produce more than their basic need requirements, then they use the surplus to invest in assets in the three forms. The assets are a buffer in time of food shortages. The model shows that the role of social claims is important, mainly for resource poor farmers in times of entitlement failure. In recognizing the complex social reality and the multifaceted and dynamic causes of food insecurity, post-structuralists and post-modernists similarly criticize the food production-oriented approach to food security in favour of complexity and diversity of perceptions of the food insecure themselves. The positivist universalism assumption to the problem of food security has been criticized by political economists. They argued that hunger and food insecurity persist in an alarming rate in many developing countries when food is adequate at the national level (Maxwell 1996; Westengen 2012).

The discussion shows that food insecurity occurs when household "entitlement sets do not provide them with adequate food" either from own "production-based", "exchange-related", "employment-based" or "transfer entitlement-related" (Devereux 2000, 19). The present study findings (*Article 2, 4* and *5*) explain the existence of food insecurity because of a range of interconnected complex structural factors at higher geographical levels and local processes such as population pressure on land, production failure, environmental conditions, climate change impacts, power relations, gender and season and other context specific issues that are not applicable to other places determine access to safe and adequate food. This is done after identifying the food insecure households' typical characteristics and the intensity of food insecurity among these households. The analysis further looks at whether or not the different intensities of food insecurity correlate with household characteristics (Article 4).

Although food security is still defined in different ways, most of the definitions accept the 1996 World Food Summit definition: "secure access at all times to sufficient food" (Frankenberger and Maxwell 1992, 8) at all geographical levels. The food security concept recently includes "the biological utilization of food consumed" and a "balanced nutritious diet" in ensuring overall food security (WFP and FAO 2008, 4). The notion of nutritional diet "suggests that it is not just the quantity of food entitlement that matters, but also the *quality* of entitlement" (Maxwell 1996, 159). Frankenberger and Maxwell (1992) summarize the literature on food security:

> First, 'enough' food is mostly defined in the food security literature at the individual rather than household level, with emphasis on calories, and on requirements defined in terms of calories needed for an active, healthy life rather than simple survival—although this assessment may in the end be subjective. Second, access to food is determined by food entitlements which are derived from human and physical capital, assets and stores, access to common property resources and a variety of social contracts at households, community and state levels. Third, the risk of entitlement failure determines the level of vulnerability and hence the level of food insecurity, with risk being greater, the higher the share of resources … devoted to food acquisition. And finally, food insecurity can exist on a permanent basis (chronic) or on a temporary basis (transitory) or in cycles. (48).

FAO (2007, 6) puts forward a comprehensive and widely accepted definition:

> Food security exists when all people at all times have physical or economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. To achieve food security, all four of its components must be adequate. These are: *availability*, *stability*, *accessibility* and *utilization.*

The above quotation reflects four key, albeit interrelated concepts. First, *sufficient* food is sufficient calorie intake for a healthy life; second, *access* is the ability of a household or an individual to acquire sufficient food from production and purchase as well as gifts, loans, and transfers from governments; third, *security* refers to secure access to sufficient food; and the *utilization* dimension of food security includes the nutritional value, food value and safety. The multidimensionality of the concept of food insecurity has been increasingly emphasized as it is experienced differently by different people. Chikhuri (2013) defines food security in terms of self-sufficiency and food-self-reliance. The former concept is the production of food for home consumption. The latter concept on the other hand is implying food availability for consumption from either production and/or imports. These concepts and approaches have been used in the articles.

1.4.2 Climate change coping and adaptation strategies

The study looks at the coping and adaptation strategies of the studied households regarding climate change impacts. It defines adaptation strategy as a process of adjustment in order to respond to the socio-economic and environmental changes (both experienced and expected) of moderate harm. The IPCC (2007) distinguishes the various types of adaptation. These are: *anticipatory*, *autonomous* and *planned* adaptation. Anticipatory (or proactive) adaptation takes place before impacts of climate change observed. Autonomous adaptation refers to "actions undertaken by affected people without planned interventions" (Forsyth and Evance 2013, 2). It is triggered, for example, by changes in weather pattern results in changes market prices, the occurrence of diseases and changes in farming practices. Forsyth and Evance argue this form of "adaptation is driven by how environmental change and scarcity present livelihood risks, rather than physical risks alone" (2). Also referred to as spontaneous adaptation (IPCC 2007). Planned form of adaptation, conversely, refers to deliberate policy interventions based on understanding on the changing condition. Put differently, this form of intervention starts after the impact of climate change risks has been felt by the people. The government's PSNP which was designed in order to build the resilience of chronically food insecure households is an example of planned adaptation (Article 2). It has been indicated in the *Articles* that there is a need to better understand the local vulnerability in order to formulate a more sustainable adaptation practices. In this connection, Forsyth and Evance (2013, 2) illustrates:

> … adaptation among vulnerable populations 'should be done with a deeper awareness of the social, economic, cultural, and political factors that frame their actions, incentives, opportunities, and limitations for action' … and that 'adaptation always has, and arguably should, refer to more than just responses to climate change'. … Indeed … development planning should assume not predefine the nature of risk and adaptive responses arising from environmental changes or scarcity, but instead ask 'what' is being adapted to (i.e. the experience of risk); 'who' adapts (what are the socio-economic barriers to adaptation); and 'how' (how do these actions, adopted by certain groups, reduce vulnerability to environmental change).

The concept of coping strategies, on the other hand, refers to short-term responses in order to absorb the adverse effects of shocks which likely to undermine future adaptation. A study made by Eriksen et al. (2005, 291) pointed out that:

> Coping strategies refers to activities aimed at obtaining food or income during times of stress, either through production or through formal and informal exchange and claims. Coping strategies can be characterized as relating to production (agriculture

and economic), social adjustments (reciprocal economic exchange), and biological strategies, including changing the diets or reducing consumption.

Article 5 discusses the farmers' varied forms of production-related adaptation strategies and consumption coping strategies to deal with the structural and local processes. In connection with the theoretical framework for understanding farmers' resilience to climate change risks and other factors (Figure 6), the analysis illustrate that the complex and interrelated factors influence the studied farmers' ability to adapt the changing contexts which includes socio-demographic characteristics, limited access to productive assets and social services, socio-politico and institutional factors as well as farmers limited access to weather information, among many others.

1.4.3 Resilience framework

A study of Huang (2014, 657) suggests "long-term climate change and extreme events will bring greater fluctuations in crop yield and food supplies and higher risk of food insecurity in the world". However, climate change and its impact on agriculture vary across regions. The USAID and UKaid (2012, 1) discussion paper indicates:

> In recent decades the Horn of Africa … have faced continuous cycles of crisis. These are the result of interaction between political, economic, social, and environmental factors. In spite of efforts to respond to these indications, the recent drought crisis coupled with conflict and chronic poverty in the region is estimated to have threatened the lives of millions people.

As shown in Figure 6, climate change and other factors can influence famers' food security conditions by limiting the availability of and access to food. There is evidence that changes in temperature and rainfall, in intensity and seasonal distribution as well as extreme events can have adverse impact on agricultural production (FAO 2008; OECD 2014; FAO 2016a). It impacts land on productivity. Climate change may also increase the effects of weeds, pests and diseases on production (Kilawe et al. 2016). The economic impact of climate change also affects farmers' ability to buy fertilizer and quality seeds. Moreover, climate change impacts on yield of grazing and fodder and water sources can change cattle production (Melissa et al. 2017). Production pattern of change can have a negative effect on intra and inter-household reciprocal social networks and in turn influence the farmers' participation in social activities (Figure 5). This is evidenced by the findings in *Article 4*.

A FAO (2008, iii) study notes climate change will have an impact on human health, livelihood assets, distribution channels and changing purchasing power and market flows. Also, the risks of climate change can have an impact on food prices by reducing production and food availability both at the household level and at the local markets. High dependence on local markets increases farmers' vulnerability to price fluctuations on staple foods. The effect of climate change risks can also have adverse implications on producer prices through its effect both on production quantity and on food quality (ODI 2009; Haggar and Schepp 2012). Moreover, climate change extends its effect not only on agricultural livelihoods but also on other income-generating activities. FAO (2016a) summarizes the possible effects of climate change on food and nutrition security of farmers:

> Climate change is profoundly impacting the condition in which agricultural activities are conducted. … The effects of climate change on production are translated into social and economic consequences through a range of different pathways that can result in changes in agricultural incomes, food markets, prices and trade patterns, and investment pattern. They can impact physical capital. They can force farmers to sell productive capital, for instance cattle, to absorb income shocks. They can reduce the capacity to invest. This directly bears social impacts on households, limiting their capacity to face other expenditures, such as health and education. … Ultimately, the impact of climate change risk on agricultural incomes depends on the effects on production, on markets and prices. … These risks can impact directly the four dimensions of food security and nutrition: agricultural production (availability), access to food (sufficient income), utilization (nutrition, quality) and stability. (3-25).

Based on the perceptions of the studied households, the study findings illustrate the effects of climate change and climate extremes on the food security and nutrition.

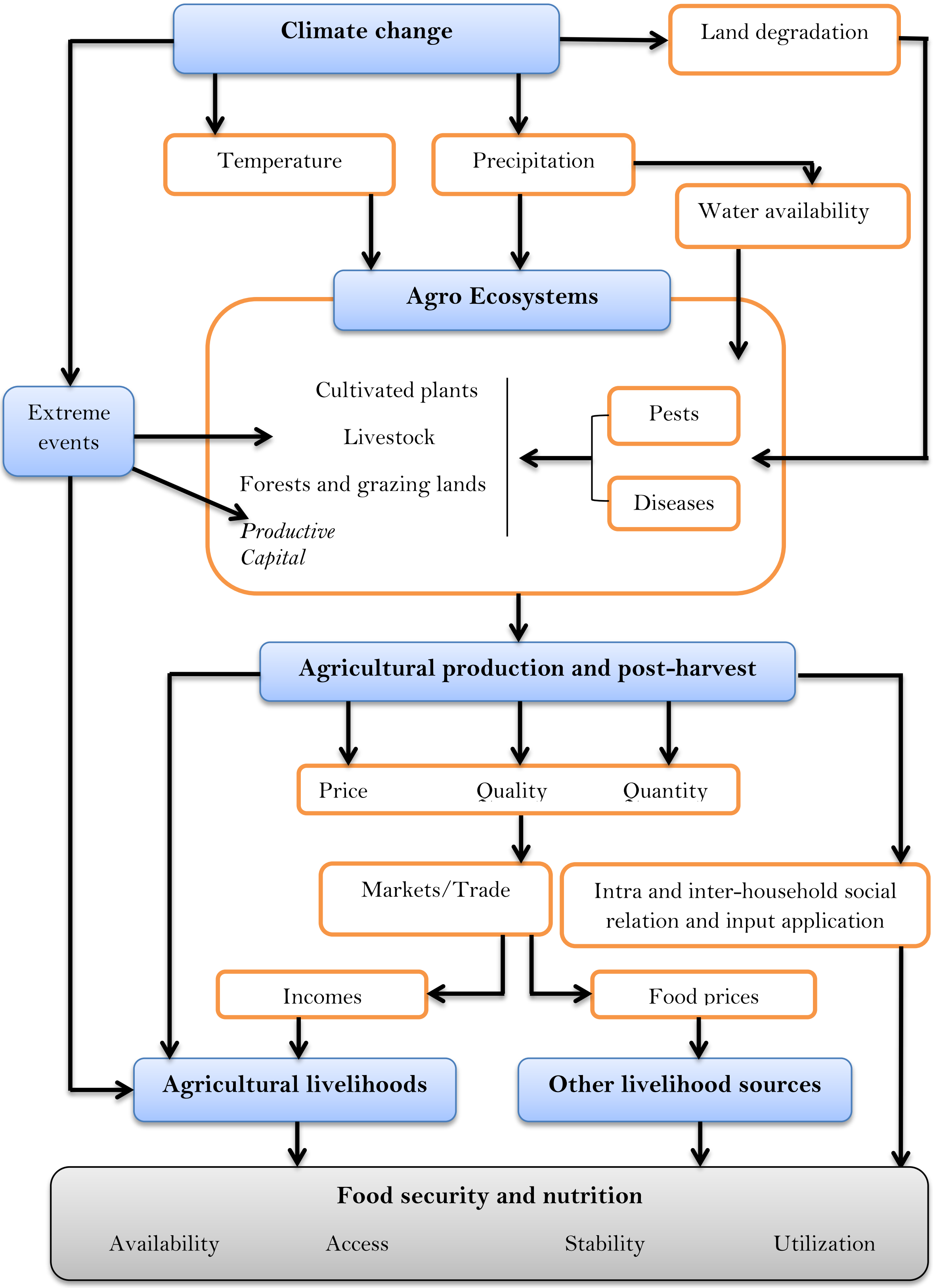

Figure 5: Theoretical framework on the effects of climate change on food security.
Source: Adapted FAO (2016a, 4).

The impacts of climate change and farmers' responses are expected to differentiate not only *between* communities but also *among* socio-economic groups within a community (Baptiste and Kinlocke 2016). As mentioned above, this is due to different household characteristics, access to productive assets and resources, income sources and opportunities, access to social services and community support traditions. Studies indicate farmers' food security depends not only on the intensity and severity of shocks and stresses but also on their vulnerability and adaptive capacity to deal with disturbances (DFID 2012; TANGO 2012; OECD 2014). FAO (2016a, 24) indicates the need for considering social vulnerability in a similar way as one considers climate change impacts on food security:

> Social vulnerability examines the demographic, social, and economic and other characteristics of the population that affect their exposure to risk and their ability to respond to and cope with negative shocks. [Moreover], a social vulnerability lens is essential to understand why certain individuals, households or communities experience differences in impacts even when they are in the same geographic region.

The FAO study uses the resilience framework for data organization. Frankenberger et al. (2012) suggest the relevance of using the framework to obtain comprehensive understanding of the factors influencing vulnerability and resilience to food security at the household level. An in-depth understanding of the complexity and inter-linkages of different factors for farmers' poverty and food insecurity that hinders their adaptive capacity to deal with the changing conditions will help in designing effective food policy interventions targeted at the local level. According to the same study:

> Within constantly changing natural, social and economic environments, a conceptual framework for resilience assessment can help to understand how shocks, stresses and long-term trends affect livelihoods and to determine whether households, communities and larger populations are on a trajectory towards greater vulnerability or greater resilience. …It helps identify gaps in key livelihood assets, the functioning of structures and processes of key institutions, and the livelihood strategies of vulnerable households. The extent and nature of community household responses to shocks and stresses will result either in increased vulnerability or increased adaptive capacity and resilience over time. (2-3).

Table 3: Resilience framework elements.

Context refers to the complex interconnected environmental, economic, social, and physical factors that affect households' adaptive capacity to deal shocks and stresses.
Level of aggregation is refers to the unit of analysis at different sectors or geographical levels. Household is the unit of analysis for this study.
Disturbance can occur in the form of slow onset or rapid onset shocks or long-term stresses (TANGO 2012). The earlier concept refers to sudden events such as droughts with negative impact on people's means of living. While long–term trends are environmental degradation, loss of production, population growth and climate change. The study of OECD (2014) identifies three types of shocks. First, *covariate* shocks are frequent events that affect a wider geographical area. Second, *idiosyncratic* shocks affect only a specific groups such as the elderly, children, and people with disabilities and chronically ill who cannot participate in income-generating activities. Third, *seasonal* or *recurring* shocks occur at some time of a year. Annual food price rise and flooding following rainy season are examples.
Exposure is a function of the magnitude, frequency, and duration of shocks. *Sensitivity* refers to the degree to which farmers will be affected by climate change risks.
Adaptive capacity is determined by farmers' ability to adjust or cope with the impacts of climate change. It is a function of exposure, sensitivity and adaptive capacities to deal with disturbance. The concept of adaptive capacity encompasses two dimensions play an essential role in resilience (FAO 2016a): *recovery from shocks* and *response to changes*. The concept includes three interconnected elements. *Livelihood assets* include the tangible and intangible assets such as financial; physical; political; human; social and natural. *Structures and processes* is refers to the formal and informal institutions relevant to manage economic and environmental risks. *Livelihood strategies* represent the distinct or combined strategies that households pursue to make a living and cope with shocks.
Sensitivity is determined by the degree to which household will be affected by a certain shock or stress meaning that greater sensitivity implies a lower degree of resilience whereas lower sensitivity implies greater resilience.
Resilience and vulnerability concepts are viewed as processes rather than static states. Farmers who are able to use their adaptive capacity to manage the shocks are less sensitive and are on a resilience pathway. On the other hand, households that are not able to use their adaptive capacity to manage shocks or stresses are sensitive and are on a vulnerability pathway. As figure 6 shows farmers on the resilience pathway can be divided into two: bounce back better and bounce back better but worse than before. Households on the vulnerability pathway similarly grouped into two: recover but worse than before and collapse.
Food security outcomes refer to resilient farmers will be able to meet their food security needs and will have access to adequate nutrition, health security, educate their children and their environment will be protected as well as participate in the decisions. Vulnerable households on the other hand experience deficits in each of these aspects.

Source: Complied from DFID 2012; TANGO 2012; OECD 2014.

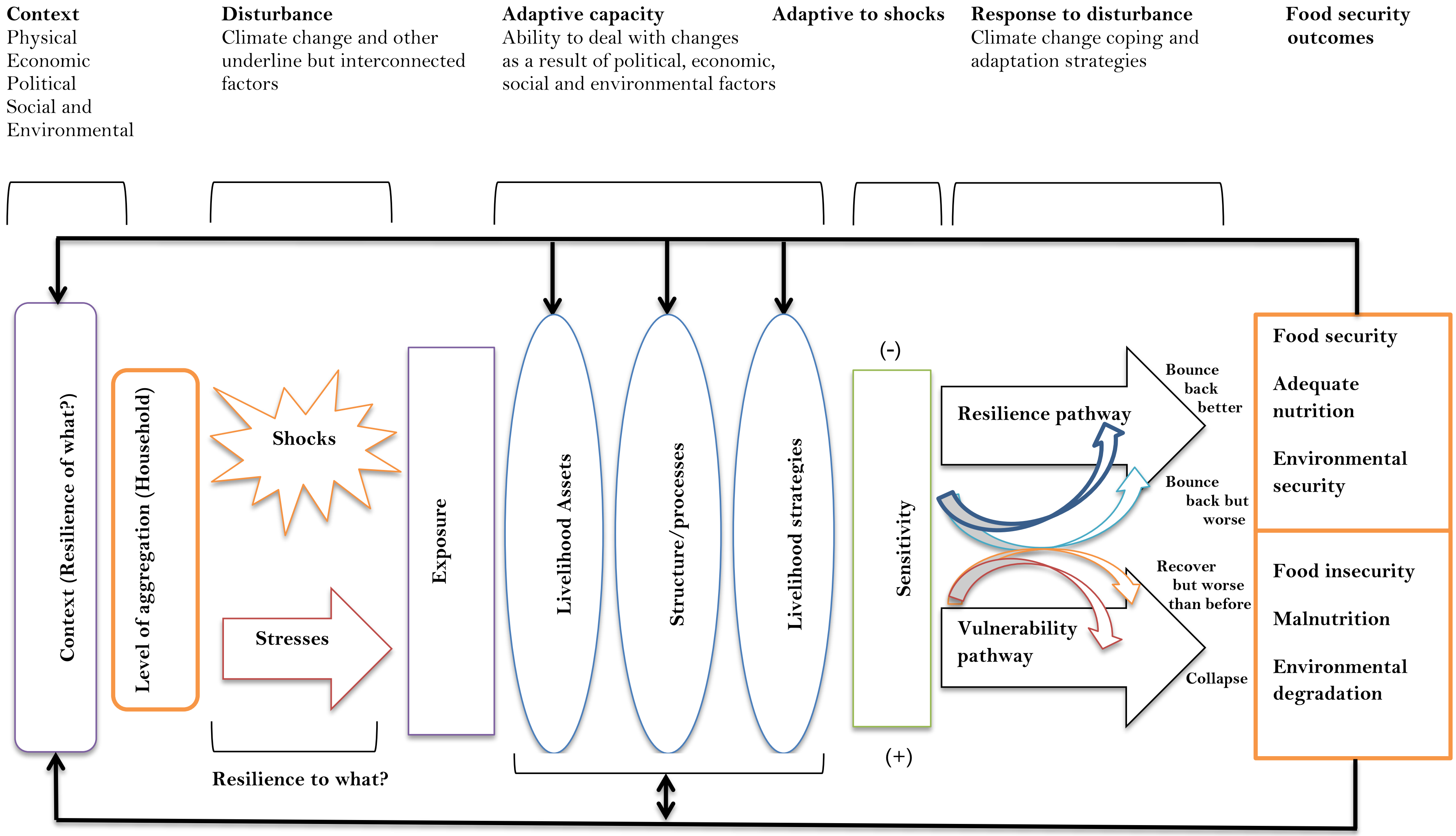

Figure 6: A framework for understanding farmers' resilience to climate change risks and other factors.
Source: Adapted from TANGO. 2012.

Figure 6 illustrates farmers' vulnerability to the effects of climate change are determined by their level of exposure, sensitivity and adaptive capacity. UNFPA et al. (2011, 24) indicates the need for understanding the social dimensions to adapt climate change:

> Adaptive capacity, exposure and sensitivity are shaped by many non-climatic, socio-economic factors, such as access to and control over economic, social and institutional resources. These resources comprise: human capital, such as good health, skills, knowledge and education; social capital, including the power to influence decision-making …; physical capital, such as shelter, farming tools, but also community infrastructure such as embankment or terraces that protect a watersheds and healthcare facilities …; natural resources, including land and water; and financial capital, such as income, savings or credit. Weather or not people have access to these resources in turn depends on greatly on social, political and economic conditions and institutions at both local and global levels … that shapes peoples' lives. An enabling institutional environment that empowers people and allows them to gain access to the resources they need for their well-being and the resilience of their livelihoods is therefore crucial for adaptation.

Bedi et al.'s (2014) study on coping with shocks in rural Ethiopia suggests that "acquiring a greater understanding of the risks, vulnerabilities, and coping mechanisms available to deal with the range of shocks faced by households is essential to prioritise and design appropriate social safety nets" (1009). Huang (2014) arrives at a similar conclusion that "understanding the impact of and adaptation to climate change by region is critical important for climate change policy" (657). The findings of the present study (Table 6 and 9) illustrate the more and less important structural and local factors that explain farmers' food insecurity levels and their responses to these factors in two different farming systems in the *Sidama* zone of southern Ethiopia.

1.4.4 Strengthen and weaknesses of resilience framework

The ODI report on a comparative overview of resilience measurement frameworks written by Lisa, Schipper and Langston (2015) show the advantages of using resilience framework beyond climate change including in the development and humanitarian indicators and social protection. Critics of earlier understandings and approaches to address the problem of food security offer a base for the need for another approach in favour of resilience building. An example is the Sustainable Livelihoods Approaches (SLA) used for food security analyses by focusing on the factors affecting people's livelihoods, assest and strategies and their inter-linkage at different geographical scales (Maxwell 1992; Scoones 1998; DFID 1999) are today less important than before (Alinovi et al. 2010). In this regard Yaro (2004b) notes that the SLA is criticized for "linking micro realities with meso-or macro policy levels"—with less emphasis on local causes of food insecurity—and "as having little to say about distributional issues" (28). Moreover, as discussed below, in the SLA power relations within a community are not sufficiently acknowledged. The approach is more open for questions: Sustainable for whom? By what criteria? In the short term or the long term?[3]

Literature indicates reasons for a shift of emphasis from "sustainable livelihoods" to a "livelihoods approach" for resilience analyses. First, resilience building "recognize[s] the dynamic nature of livelihood strategies and people's flexible response to changing [politico-socio-economic] situations" (Alinovi et al. 2010, 6). Second, resilience is concerned with farmers' capacity to resist and recover from the effects of exogenous and endogenous factors as well as anticipate future negative events (Dooley et al. 2012; FAO 2013; Frankenberger et al. 2013). Third, lack of longitudinal data and early warning systems to predict shocks make a humanitarian response ineffective (Romano et al. 2009; Pasture 2011). Fourth, it has been well recognized that the emergency responses have saved lives but do not prevent a crisis (Frankenberger et al. 2012; FTF 2013). In the contexts of emergency and relief responses to the 1984/85 Ethiopian famine and later, Edkins (2000, 7-8) argues:

> Humanitarian aid addressed crisis … but it did not resolve or prevent them. In the same way that famine relief was seen in the 1970s and 1980s as not addressing the root causes of famine, humanitarian assistance in the 1990s was seen as an external response that did not tackle the problem of long-term political and social crisis.

This call of the need for resilience building which is more cost-effective than emergency responses by linking short-term responses and more long-term development activities to avert future crisis (DFID 2012; Frankenberger and Nelson 2013). Stein (2013, 11) indicates that "resilience is a related, but different, concept from vulnerability." A FAO (2016a) report notes resilience "... encompassing adaptive capacity it adds a time dimensions to the concept of vulnerability (35). Stein further illustrates resilience and vulnerability concepts:

[3] Chronic Poverty Research Center (CPRC): www.chronicpovrty.org/page/toolbox

> … share a common set of parameters such as the shocks and stresses to which a social-economic system is exposed, and the response and adaptive capacity of the system. Nevertheless, vulnerability analysis often tends to measure only the susceptibility of an individual/household to harm and the immediate coping mechanisms adopted. Resilience analysis tries to identify the different responses adopted by a household and capture the "dynamic" components of the adopted strategies. A resilience approach investigates not only how disturbances and change might influence the structure of a system (for example, a household or a community), but also how its functionality in meeting these needs might change …

The outcome of resilience building is an improvement in farmers' ability to be able to move away from vulnerability pathways to resilience pathways (FAO 2012; ODI 2012). As was indicated in Table 3, the concept of "pathway" refers to the idea that farmers' food security is a process rather than a static state meaning that food security interventions need to consider food insecure farmers' needs and priorities that may change over time with environmental and politico-socio-economic shifts.

Literature show the social critique of the concept of resilience (Cote and Nightingale 2012; Boonstra, Galaz and Olsson 2014; Brown 2014; Olsson et al. 2015). Boonstra, Galaz and Olsson (2014, 2-3) points to the social critique of resilience:

> The early form of resilience theory could be criticized for being vague on the relationship between the resilience of social and political systems and the resilience of the social-ecological system of which these subsystems are part. One of the most frequently raised objections is the neglect of the working of power in resilience studies. In its less constructive form, resilience theory is criticized for stabilizing and reinforcing "an incumbent (capitalist) political economy". … A more useful critique raises concerns that by not accounting for power dynamics, managing for resilience runs the risk of reproducing inequality and domination. It is therefore suggested that resilience theory needs to address the wider political contexts in which social-ecological change is embedded.

Brown's paper on "A social turn of resilience?" (2014) indicates limitations of the concept of resilience "for undertheorizing social dimensions and … highlighting the omission of social, political and cultural dynamics from different resilience literatures" (107). She illustrates the perceived three points of limitations of resilience concepts.

> First, there is the failure to recognize resilience as socially contingent, rarely addressing the question of 'resilience for whom?'; second, its mainstream usage is conservative, focused on the persistence of a 'system'; third, it focuses on a system which is disturbed by external or exogenous forces, so it underplays the internal, endogenous and social dynamics of the system. … A common criticism is that resilience fails to take account of politics and power relations. (109).

Cote and Nightingale (2012, 479-480) points out that "the treatment of ecological and social dynamics with a single epistemology is an important challenge." They elaborate:

> The reliance on ecological principles to analyze social dynamics has led to a kind of social analysis that hides the possibility to ask important questions about the role of power and culture in adaptive capacity, or to unpack normative questions such as 'resilience of what?' and 'for whom?' when applied to the social realm.… [R]esilience analyses within the operation of power/knowledge relations in institutional dynamics opens up issues around values, but also about equity and justice, which allows … to formulate questions about which resilience outcomes are desirable, and whether and how they are privileged over others.

Similar to Cote and Nightingale, Olsson et al. (2015, 9) provides critiques of resilience from the social sciences by raising issues: agency, power, and knowledge:

> The most fundamental obstacle here … is the difference in how resilience theory and the social sciences understand society—in terms of social systems, social relations, and social change. … The resilience vocabulary does not fit into the social sciences, whereas core concepts and theories in social science—such as agency, conflict, knowledge, and power—are absent from resilience theory.

Regardless to the social critiques of resilience, the framework appropriate to understanding climate change impacts and adaptation (Figure 6). Moreover, the findings, focusing on the different factors that influence food insecurity, respond to these social critiques of resilience.

1.5 Methodology: Design of the case study

A case study research design is used in various disciplines in the social sciences when an in-depth explanation is sought. Yin (2009, 18) defines a case study as an empirical inquiry that investigates a contemporary social phenomenon in-depth within its real-life using multiple sources of evidence. Karlsson et al. (2005) similarly describe that a case study design have the following characteristics: "study of the cases in their natural environment, orientation towards understanding, 'thickness' and theory-generating" (158). Yin noted the advantages and disadvantages in using a case study design. First, it helps for in-depth understanding of the phenomenon in its natural settings. Second, it provides holistic and in-depth explanation by closely examining the topic in question through individual perspectives. Third, a case study researcher selects a small geographical area for intensive study by asking *how* and *why* questions. Another advantage of a case study research design is that it combines qualitative and quantitative methods for data gathering. For this study a combination of qualitative in-depth interviews and a quantitative survey were employed to better comprehend the varied perceptions and priorities of the studied households. Using these methods in tandem is helps to achieve detailed contextual analysis of the sites. Likewise, Zainal (2007, 4) summarizes the advantages of using a case study design:

> [T]he detailed qualitative accounts often produced in case studies not only help to explore or describe the data in real-life environment, but also help to explore the complexity of real-life situations which may not be captured through explanatory or survey research.

Yin (2009) distinguishes between single and multiple case studies. The former is relevant for critical cases that aim for theory-testing while the purpose of latter is theoretical replication (Karlsson et al. 2005). This study adopts a multiple case studies design aiming to gain in-depth insights into the complex food security challenges at micro level.

Yin describes *three* categories of case studies: *exploratory*, *descriptive* and *explanatory*. Exploratory case studies focus on exploring a phenomenon by asking open-ended questions. Before the survey began, I was asking people: Why the prevalence of food insecurity persists in the studied sites? How do people perceive the impacts of and respond to certain adverse events? This method was helpful to obtain general information about the study localities and to shape and re-shape the research questions. Descriptive case studies refer to describing the general physical settings which include the study sites characteristics such as the history of food insecurity, temperature, rainfall pattern and its seasonality, deforestation, population pressure and soil fertility. Explanatory case studies help to closely observe the data in order to give explanations. Using the household questionnaire data, I examined the prevalence of food insecurity between the communities and socio-economic groups within a community.

Yin also identifies three criticisms in using a case study design. First, it is impossible to make generalization of the results to a larger population through representative sampling. This study aims to make analytical generalization rather than statistical generalization from the findings. The second criticism is related to the researcher bias that may influence the findings. To address the criticism, I used different data collection methods. This method was helpful not only to triangulate the results but also to increase the data validity. The third criticism is that a case study design produces a large amount of information which is difficult to manage. This was partly mitigated through categorizing the data into different themes.

1.5.1 Data sources

The following section briefly presents the different methods used for data collection. The progressive methodological change in food security analysis highlights the importance of understanding the diversity of individual reality (Chamber 1997). Qualitative research is particularly needed for understanding the subjective reality of people's lives and the context from the "inside". This method is useful to better understand the complex determining factors that cause farmers food insecurity and coping strategies. This understanding cannot be achieved through the "effects-of-causes" approach which aims verifying (not falsifying) hypotheses that are derived from theories with the help of empirical data obtained at the macro level. Put it differently, the "effects-of-causes" approach aims to achieve breadth of understanding through the use of randomized controlled trials or survey-based regression analyses (Patton 2002; Mahoney and Goertz 2006).

Since the purpose of this study is to gain in-depth understanding from the data, the "cause-and-effect" approach is best suited in order to obtain in-depth information (Mahoney and Goertz 2006) and an understanding of the nature of food insecurity by identifying who is and who is not food secure, and why. The purpose of this method is to develop knowledge from empirical data at the micro level. The other important point is that sensitive topics require qualitative data collection (Hesselberg 2015). *Article 2* provides an example of this. During fieldworks accessing government data related to food insecurity was difficult and sensitive because of the political nature of the content. Furthermore, the complexity and multidimensionality of the issue being studied explain the need for qualitative data. As

Maillet et al. (2017) indicates I employed different qualitative techniques for data collection aiming not only to increase data validity but also to meet some ethical practices such as ensuring the result is both robust and relevant enough to justify conclusions. Although the literature delineates a boundary between qualitative and quantitative research methods, in food security study using these methods in tandem contributes to more valid findings (Yaro 2004). Table 4 provides a brief explanation of the methods used for data gathering.

Table 4: Methods and data overview.

Research tools	**Number of participants in two fieldworks**	
	Fero-two **PA**	***Hanja-Chafa*** **PA**
Questionnaires	176	200
In-depth interviews	43	37
Key informants	14	18
Group interviews with farmers	3(n=4)	5(n=5)
Discussion with officials	1(n=3)	3(n=4)
Household visits	Researcher	Researcher
Field notes	Researcher	Researcher
Photographs	Researcher	Researcher
Informal dialogue		

Note: n = refers to the total number of participants involved in the research process.

1.5.2 Open-ended interviews

A total of 43 and 37 in-depth interviews were conducted among the coffee growers and maize producers respectively. I used asset-based method coupled with location specific criteria in order to identify food insecure households for qualitative interviews using a semi-structured guide. This is done to achieve what Hesselberg (2015, 14) calls "maximum variance" to acquire different information on the topic. This is to mean that the studied informants were selected purposefully based on their characteristics intended to describe the variations in the group (Patton 2002). Patton notes that considering variation among the participants is an important step to understand their varied experiences on certain events that affect their sustenance negatively. I was conscious that the place where interviews were conducted may have an impact on the answers (John and Philip 2012) given that most of the interviews were conducted at the participants' home. This method offered insight into not only the everyday lives of the participants but it was also conducive for them to take time to discuss the questions in-depth and the conversation can not be disturbed. It also ensures participants confidentiality. Moreover, informants were contacted during land preparation in order to better understand their farming practices. However, they were invited to select the location for the interview. As discussed later, I started the interviews after introducing myself and informing them about the research topic. The heads of the households were the study participants.

1.5.3 The household questionnaire survey

To supplement the qualitative information, a random sample of 176 and 200 households were made in the *Fero-two* PA and the *Hanja-Chafa* PA respectively. A combination of long-time and short-time recall questions was included in the survey. The three frequency-occurrence questions of the Household Hunger Scale (HHS) which focuses on the food quantity dimension of food access were adopted. The HHS can be used to assess the prevalence of household food insecurity in resource poor areas (Coates et al. 2011). Another key reason for using the HHS questions (instead of the nine HFIAS questions) is that some of the HFIAS questions are included in the Coping Strategy Index (CSI) questions which are part of the questionnaire (Coates et al. 2007). The HHS questions referred to how often the studied situations occurred during the past 30 days. The CSI recalls questions on the other hand asked about the situations that occurred during the past 7 days.

The questionnaire variables were selected prior to the fieldwork and sorted out with the group participants. The discussion was helpful in order to identify which questions were more relevant in the study sites. I asked the participants to ensure that the predetermined questions were well understood by the farmers. Yet, there were some differences among the participants in their understanding of some of the concepts. Moreover, the questionnaire gathers information about the respondents' characteristics in access to productive resources, physical and social services, income sources of activities, access to loan and credit services, and household plot size, types of production and stores. The data correlations show that the HHS and the CSI, which have been used only in a few cases in Ethiopia, are valid measures of food security in the study sites.

1.5.4 Focus-group discussion

The study includes group-discussions with farmers and development facilitators from MKC-RDA to shape and identify concepts that were vital to the study. The selected participants had similar background and experiences to discuss the research questions (Patton 2002). The method were applied to understand the differences and commonalities of the informants' experiences and perspectives on the causes of food insecurity, the farmers vulnerability to adverse events and their coping strategies. Moreover, this method was found to be helpful to understand the participants' knowledge and opinions regarding the topic in their locality.

This method validates the different information collected by the open-ended interviews and the household questionnaire.

1.5.5 Key–informant interview

As Patton (2002) notes, the fieldwork began by speaking with key informants, "who knows a lot about" the study topic in question. I contacted diverse people with specific knowledge on important aspects of policy ranging from the district's Agriculture and Rural Development Offices, Disaster Risk Management and Food Security Sector, Development Agents (DAs) and Peasant Association (PA) officials to teachers, health extension workers, researchers and people working in different local NGOs. This method complements other methods and thus enhances the data quality collected.

1.5.6 Field observation and note

One of the advantages of using a case study design is that the researcher can observe the subjects within their environment (Yin 2009). I made field observations by walking through the communities with someone who knew the place well, asking questions and take notes about *what* the farmers do for their living. The method is important in order to understand the complexity of the topic studied: the level of poverty, environmental degradation, and the forms of transport and other social services. I made observations during land preparation to obtain an insight into the production of different crops and to identify the farmers' problems with low productivity. I also visited the health posts and markets. Moreover, the study benefited from extensive informal discussions at tea-houses, on walks and on the farms by asking "grand tour questions". Household visits method provided important insights into the households' assets and the incidence of poverty (Abebe 2010). Furthermore, photographs were used as a method of data documentation. Other sources of data such as published and unpublished NGOs and government reports, news, and raw metrological data from NMA of Ethiopia were used.

During the fieldwork I took notes regarding the ways in which informants articulate their experiences and feelings, and the general field settings. This is to mean that the first step of data analysis was carried out every day after fieldwork. Using different data sources in the same research and checking data convergence with other data sources as well as using extensive quotations were used as a means of data triangulation (Patton 2002). Patton notes that triangulations strengthen a study by combining methods which in turn maximizes the data reliability. Therefore, the data used in this study are valid and reliable and can be used to make analytical generalization.

1.5.7 Data coding and analysis

Qualitative data can be analyzed in different ways. Patton (2002) identified some important steps in a qualitative data analysis. He refers to this as an inductive analysis meaning that the patterns, themes, and categories found are inherent in the data. The first step is read and annotate transcripts. At this step, I read the whole data, elaborated and added remarks and questions using colour pens. The second step is identifying the common themes meaning a summary to observe the data pattern. I developed a list of themes according to the research questions, for examples, factors, coping and adaptation strategies. This step is followed by data categorization that include identify the convergence and divergence of the participants' views. Data categorization was made between the study sites and the socio-economic groups within the sites. I then interpreted the themes by giving explanations. The final step was to bring the whole analysis together. In the qualitative data analysis the researcher look at the data in multiple rounds. All through the write-up, I was visiting and revisiting the data to create connections between the themes. Moreover, the analysis involves thinking back to the whole fieldwork situation such as the interview situation, the physical settings, informants' expressions, as well as looking repeatedly at the photographs.

The household questionnaire data analysis was made using SPSS software. As was noted, I used the full set of HHS questions. The respondents responses were organized as 0=none, 1=rarely (1-2 times), 2=sometimes (3-10 times) and 3=often (>10 times). As described in the field manual by Coates et al. (2011), the three steps were followed to organize the data. First, the three frequency categories were converted into *two* categories: *sometimes* and *often.* Then new variables were created for each frequency question: NEWQ1, NEWQ2 and NEWQ3. Second, a coded response of *rarely/sometimes* (originally coded as—1) is coded as—1. A frequency response of *sometimes* (originally coded as—2) is coded as—1 and a response of *often* (originally coded as—3) is coded as—2. For the respondents who replied *No* to the questions the code—0 was added. The third step was that the value of the NEWQ1, NEWQ2 and NEWQ3 were summed for each respondent in order to make the HHS indictor. Finally, the two cutoff values (> 1 and > 3) were used in order to define food insecure farmers and categorize them according to the intensity of food insecurity. Unlike to the Household Food Insecurity Access Scale, the new HHS classifies households into three groups such as: *food secure*, and *moderate* and *severe* food insecurity. Moreover, different year agricultural sample survey reports of Central Statistical Agency of Ethiopia were used. The trends of major cereals crop production, area cultivated under improved seeds, local seeds, types of fertilizer and applied areas and the consumer price index in Ethiopia were calculated and presented using Microsoft EXCEL software.

1.5.8 Ethical issues

Johnes and Phillip (2012) note ethical issues which occur during a fieldwork, are complex. However, they suggest unintended harm on the participants can be reduced by following appropriate ethical principles. A way of solving this potential problem is by having a clear understanding of how to conduct fieldwork. As was mentioned, I started fieldwork after institutional research permission was granted from both the district authorities and the PA administrations. I used the letter of institutional consent in my contacts with the DAs working in each PA and outside of the study PAs. I also contacted local NGO workers in the *Boricha* district and asked them to introduce me to the community leaders and elderly people. This was an important entry point to the field. Although a fieldwork has a positive intention, I met people with openness; "dignity, privacy and basic rights" to ease unintended negative consequences (Johnes and Phillip 2012, 70). I explained to the study participants' who am I, what I was doing and how the result would be used. I also informed them of their right not to participate in the interviews.

In February (2014), a community-based natural resource conservation program was launched at national level. I asked the *Boricha* district's officials to introduce me to the community members in their general meetings about the program. They told them that I was there to collect information for an academic study only. This was an important step to get to know a large number of people. It made me feel safe to walk and contact people freely. However, I did not get this chance at the *Wensho* district. Partly because I started fieldwork there after the conservation program was completed. Another reason is that most of the conservation practices were made outside of the studied PA. Nevertheless, I told the PA administration, DAs and nurses to inform people that I was doing research. I always asked people for an informed consent before beginning to discuss any personal matter.

The negotiation was central for the subsequent steps. As mentioned earlier, I stared every interview with "grand tour" questions for two reasons. The first was to increase the participants' readiness to take part in the interview. Secondly, I wanted to learn about their food insecurity experiences without hesitation. Moreover, I walked and interviewed people together with a person who knew the locality well and was familiar with the language. It is worth to mention that during the interviews I was served coffee with *enset* products such as *Kocho* or *Omolcho* or roasted grain in most of the farmers' homes. In the *Sidama* culture it is common for a farmer to invite a visiting person by saying '*menumineno ae*' meaning that someone (a woman), who can make coffee, is at home. I was accepting their invitation with full respect. This is not only ethically sound but it was also an excellent opportunity to talk about matters openly and in-depth. It created a fertile ground for my contacts with others. During the interview, I gave women a chance to participate in the interview, even in the presence of their husbands. This method is sound methodologically and ethically.

Reciprocity was a methodological challenge. Some of the participants were expecting monetary payments after the interview. The challenge was addressed by telling informants from the onset that there would not be any financial returns after the interview. I also told them that the research was conducted for knowledge production, for use to policy makers to improve their future lives. Some informants perceived that the research was conducted for the government and that their participation might put them in danger. Similarly, some considered that the information was gathered for NGOs ready to help them.

1.6 Site selection

I conducted two fieldworks averaging four months per trip (February–June 2014 and March–May 2015). As part of the fieldwork, I contacted offices to address the reviewers' comments on the articles in my revision from August-December 2016. I used an ethically sound site selection strategy. The site selection process began after obtaining institutional research permission from Addis Ababa University, and the Research and Development Directorate of the *Hawassa* University. However, *Article* 2 indicates that the site selection was not straightforward for two important reasons. The findings show that the prevalence of food insecurity in the *Sidama* zone presents a formidable challenge to the site selection. The second explanation is that most of the *Sidama* zone districts are covered by different LZs and have shared characteristics in terms of the farmers' production type and their response to the existing physical and socio-economic challenges.

Social reality is complex. However, this complexity can be maintained by carefully selecting sites and understanding the phenomenon within the natural settings (Karlsson et al. 2005). During the site selection I put an emphasized on getting 'thick' description to understand the food security problem. One important step I took was instead of deciding the field sites based on the number of the PSNP beneficiaries and emergency relief programs, I visited some of the food insecure districts and spoke with officials from the maize LZ and the coffee LZ including *Aleta-Wendo*, *Aleta-Chuko*, *Boricha*, *Dara*, *Hawassa-Zuria*, *Dale*, *Wensho*, *Shebedino* and *Lock-Abaya*. Through discussions and field observations, I identified the major characteristics of these districts, what had changed and the complexity of the challenges that caused the farmers' livelihoods to be at risk.

During the site selection, I asked people: could you tell me about this locality? Who is food insecure and why? How do people make a living? What has changed regarding food security? How food insecure farmers identified and by which criteria NGOs provide relief support? These questions were helpful to better understand the socio-economic structure of the study sites (Article 2). Put it differently, the sampling strategy was determined by the purpose of the study (Yin 2009). Since the study aims to get an in-depth insight into the contemporary food security condition of the farmers, ethically selecting appropriate sites to explore the study questions is imperative (John and Philip 2012). Through considering the farmers' type and goal of production, the climatic conditions, food insecurity incidence, the presence/absence of relief programs and responses to socio-economic and environmental changes, the *Wensho* district in the coffee-based farming system and the *Boricha* district in the maize-based farming system were *purposely* selected to identify a Peasant Association (PA) in each district as the study sites.

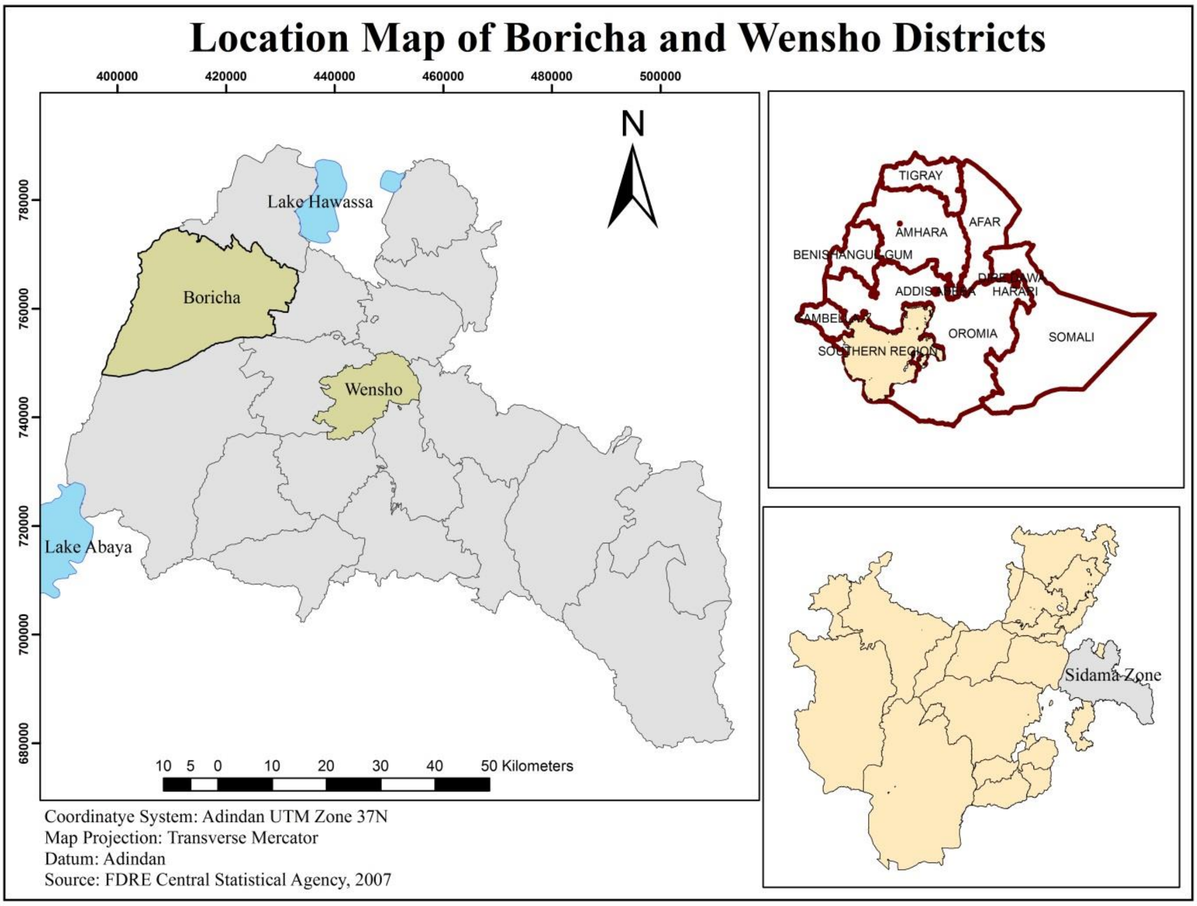

Figure 7: The administrative division of the Ethiopian territory and the study sites.

Food insecurity experiences are local and specific and vary between groups of individuals (Article 2). With this understanding, I selected two communities that vary in topography and production pattern to identify food insecure households to be studied intensively. During the fieldwork I was aiming to get places to explore the similarities and differences of the factors causing farmers' food insecurity. In this regard, Patton (2002) argues that when selecting sites of diversity the data collection yield two kinds of findings. First, the data yield detailed description as well as the uniqueness of the sites. Second, from the data it is possible to observe important shared patterns that are created across the heterogonous sites.

1.6.1 The Sidama zone

The *Sidama* zone of SNNPR is classified into three livelihood zones (LZ): the *Sidama* maize LZ, the *Sidama* coffee LZ and the *Sidama-Gedeo* highland *enset* and barley LZ (USAID 2009). In the *Sidama* zone population density per hectare is one of the highest in the country (CSA 2016). The zone districts have *differences* and *similarities* in terms of production, farmers' shocks coping strategies in comparison to the cereal-based farming system in other parts of

Ethiopia. The enset-coffee-tree-fruit-crops based farming system makes the landscape of some of the zone's districts more green than the treeless cereal-based farming system dominating much of the agricultural landscape of the country (Bishaw et al. 2013). The zone is particularly known for the production of *enset* (the main staple food); *khat* (a stimulant leaf) and coffee. Cereal crops including *teff*[4], barely, wheat, sorghum and maize are produced in some districts.

The *Sidama* zone has been facing both structural and local problems. Available data from the zone's Agriculture and Rural Development Office indicate that prolonged droughts and erratic rainfall have increased the level of food insecurity in more recent years. The zone districts faced the worst localized drought that caused for *enset* and sweet potato production loss in 2008 (Graham et al. 2012). This environmental change exacerbates the existing socio-economic challenges such as deforestation, population growth, land fragmentation and degradation, access to clean water and grazing. Crop and livestock diseases expand in the face of high temperatures and variable rainfall that in turn increase the vulnerability of the farmers. Based on the USAID (2009) study on the southern region LZs characteristics, I selected two LZs from the *Sidama* zone which are similar and different in some aspects: the *Sidama* maize LZ and the *Sidama* coffee LZ. Besides variation in topography and climatic condition, farmers in the maize LZ are food crop producers while farmers in the latter LZ produce crops for the market.

1.6.2 The Sidama maize LZ

The zone has been facing a combination of interrelated problems. It covers the lowland *Sidama*. The LZ is known by its erratic and insufficient rainfall (Article 4). High population pressure, poor soil fertility, declining landholding sizes, deforestation and land degradation are some of the farmers' socio-economic challenges. The LZ is often affected by malaria and diarrhoeal diseases. Water shortage is critical in some *Kolla* districts both for drinking and livestock. Farmers are grouped into four wealth categories based on the number of cattle and the landholding size. The wealth ranking process considers the household capital, education, and social capital (USAID 2009). Different households have a varied composition of income sources. Rankings indicate significant chronic poverty. The poor farmers comprise 40% of the total population. They have limited access to basic income resources and produce 40-45% of their annual staple food needs. This group obtains a substantial proportion (21-25%) of their food needs from aid. The second group consists of middle-class farmers who constitute

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[4] *Teff* crop grows only in Ethiopia.

40% of the population. They own a larger landholding size and more livestock than the poor. The third wealth group comprise 20% of the population and are better-off. They produce 85-95% of their annual food needs and have better access to other income sources than the middle-class.

From maize LZ, I selected the *Boricha* district. The district has 39 rural and three urban PAs with a total population of 305,451. Data from the district's Agriculture and Rural Development Office (ARDO) show that the district has 39,504 hectares of land. The district's topography is considered to be a plain (77%) with hills and rugged terrain (23%). The district is divided into two agro-ecological zones, *Woina-Dega* (1,500 to 2,300 meters above sea-level) and *Kolla* (500 to 1,500 meters above sea-level). It covers 56% and 44% of the district's areas respectively. Of the area, 75% is cultivated. Figure 7 is the location map of the study areas.

1.6.3 The Sidama coffee LZ

The zone is located in the midland area and faces several socio-economic challenges. Climate change such as high temperature and more erratic rainfall are the farmers' major production challenges (Article 3). Davis et al. (2017, 1) indicate "coffee growing in Ethiopia has been negatively influenced by climate change and deforestation". The size of landholding and livestock number are skewed heavily to the better-off farmers. Coffee and *enset* are the main production crops. Price fluctuation remains challenge for the farmers. The USAID defines the poor (40% of the households) as those who have less than one-quarter hectare of land. They produce less than one-quarter of their annual food needs and most have no livestock. Some have one or two cows. They rely on casual work to obtain 75% of their food needs. The low physical assets suggest that they are much more vulnerable to experience periods of food shortages compared to middle-class farmers. The middle-class farmers comprise 40% of the population and have a larger land size and a higher cattle number. Income sources other than agriculture are the major difference between the middle-income and the better-off farmers (Article 3). The latter do not grow more than 60% of their annual food demand. An explanation is that the local climate is more conducive to grow coffee than food crops. Hence, most farmers rely on the market to access most of their annual food demand. Most people in the LZ are food secure in normal years.

The *Wensho* district was purposefully selected from the coffee LZ to identify a PA for intensive study. The district is divided into agro-ecological zones such as: *Dega* and *Woina-Dega* agro-climatic zones. The rainfall, temperature and production pattern between the two agro-ecological zones of the district are not uniform. Farmers in the *Dega* area are often food crop producers. Conversely, farmers in the later context relied on cash-crop production such as coffee. *Article 3* indicates the agro-forestry farming system make the district's landscape green than the treeless cereal-based farming system of the *Boricha* district. From the *Woina-Dega* agro-climatic zones, five PAs are especially known by the coffee production. These are: *Gajaba*, *Halekena*, *Fero-one*, *Fero-two*, and *Hunkute*.

The study was conducted in the *Fero-two* PA in the *Wensho* district and the *Hanja-Chafa* PA in the *Boricha* district. There are considerable differences and similarities between the sites with some important characteristics for the study. From the selected sites detailed descriptions and explanations produced meaning that gave "information rich cases" which enhanced the analytical generalizability of the results to the population within the study site (Patton 2002).

1.7 The study PAs: Economic activities and income sources

Coffee trees make the *Fero-two* PA look green. Coffee is the *main* income source. *Enset* is the staple food. The PA receives relatively better amount of annual rainfall during the *Meher* (July-September) and *Belg* (February-May). The *Meher* season is the main production period while farmers use the *Belg* rains for soil preparation. This area has recently been facing more erratic rainfall and prolonged dry seasons which affect production. The cultivation is hoe-based. The *Hanja-Chafa* PA on the other hand is located in the *Kolla* agro-climatic zone. The *Belg* season is the main production period for farmers. Here maize is the main production type while *enset* is a co-staple food. In this site, cultivation is plough-based. Much of the PA's landscape is treeless. More frequent droughts and the failure of the *Belg* rains are the main production challenge.

The poverty level is high in both study sites. The farmers own limited productive assets such as land and livestock. They keep only a few cattle around the homestead and a large proportion of the coffee respondents (38%) sold their cattle recently or has not had cattle for a long time. A more similar cattle distribution pattern is observed among the maize farmers. Similarly, land is fragmented and intensively cultivated. The household interview data in the *Hanja-Chafa* PA imply a shortage of land: 45.5% of the household informants owned $\leq$ 0.25 hectare; 38% between 0.25–0.5 hectare and 16.5% between 0.5–1 hectares. The farmers' access to public services such as clean water both for drinking and livestock as well as health services is poorly developed.

Farmers have limited income-generating activities to manage shocks and thus to achieve food security. Table 5 shows lack of income diversification aggravates the effects of climate change on food security. The findings of this section explain the reasons why the studied farmers adopted certain types of coping strategies and how these strategies are used in relation to other strategies. The different strategies employed by the farmers highlight the varying intensity of food insecurity and the pattern of response to periods of annual food shortages. The study found that some of the strategies are similar while some are different between the two sites. The strategies differ depending on the severity and duration of food insecurity, household characteristics, socioeconomic and environmental conditions, gender and season. The data further show that farmers in the two PAs have limited but different coping strategies.

Data in *Article 4* and *5* show that for a large number of the respondents' agriculture is not the main income source (whereas 71.6% of 176 people answered yes to agriculture as an income source in *Fero-two*, and 66.5% of 200 people in *Hanja-Chafa*). This can be linked to the low production per household due to land shortage. Although the income from livestock product sales is small (29% in the *Fero-two* and 18% in the *Hanja-Chafa*), this income source is skewed to the better-off farmers. Another explanation is that a small proportion of the respondents (8%) replied that they earn an income from renting out plow-oxen. Since agriculture is hoe-based, the coffee farmers do not earn an income from animal ploughing.

Table 5: Economic activities and income sources.

	***Fero-two* PA (n = 176)**			***Hanja-Chafa* PA (n = 200)**		
	Percentage of respondents			**Percentage of respondents**		
Income sources	**Yes**	**No**	**Irrelevant**	**Yes**	**No**	**Irrelevant**
Coffee picking	46	54	--	--	100	--
Enset processing	23.3	76.7	--	16	84.0	--
Livestock products sale	29.0	33.5	37.5	17.5	41.0	41.5
Agriculture	76.1	23.9	--	66.5	33.5	--
Processed food sales	1.7	98.3	--	3.0	97.0	--
Public relief payment	--	--	100	44	56.0	--
Purchase & sale goods	26.7	73.3	--	25.5	74.5	--
Rent traction animals	--	--	100	8.0	50.5	41.5
Firewood sale	100	--	--	4.5	95.5	--
Work at coffee site	36.4	63.6	--	--	100	--
Farm employments	44.3	55.7	--	33.0	67.0	--
Handcraft sales	14.0	86.0	--	24.0	76.0	--

Source: Article 5, Field data.

Off-farm income is the main income source for the poor farmers. The data show that earning an income from working on other farmers land is higher among the coffee growers (44%) than the maize producers (33%). An explanation is that hoe-based agriculture requires more labour than plow-oxen agriculture. Unlike the maize farmers, a large proportion of the coffee growers family members (46%) are participating in the coffee picking job. It was mentioned that today members including children from the food secure households earn an income from the coffee harvest. It is also an income source for seasonal migrant labour. Although income from this source is declining, the *enset* processing job is lower among the maize farmers than the coffee growers. This is mentioned by 16% and 23% of the respondents respectively. The variation can be explained by the limited availability of the *enset* plant in the former place. The study found that few of the respondents work in the production of coffee-seedlings. In both sites, the food insecure people participate in the non-farm income sources more than other socio-economic groups.

Small-scale non-farm activities are a key income source for the poor farmers. An example is petty trade which includes purchase and sale of goods, retail of *Luuollo* (wet-coffee) and of *enset* products as well as of maize flour. Although the income from these sources is small, it contributes to access food. Sale of avocado and banana is another seasonal income source in the coffee growing area. Some people buy avocado directly from the farmers and sell to traders who further retail it in urban areas. These people buy the avocado on the tree before it reaches maturity. In my informal discussions, some of them told me that obtain a better price were their challenge. An informant said: "… a bag contains up to 70-80 kilograms. … The quality of the today's avocado is good. My plan is to sell each of the bags up to 250-260 Birr[5]". I went to the market to better understand how traders negotiate. I observed that the final decisions were more often made by buyers than sellers. Only a few buyers control the markets. They work together and set the prices based on the supply. After a sustained negotiation, the above informant sold two bags at the price of 160 Birr and the third bag at 185 Birr. Finally, I asked him why he sold at this price. His response describes the limited market access and their unequal bargaining power:

> I cannot return it back to home. I have to sell it with the market prices. … I cannot keep it for the next market day [because of its perishability]. If I go to the *Yirgalem*

[5]Birr is the Ethiopian currency. 1USD = 19 Birr at the time of the fieldwork.

[town to find a better price], I meet the same people [traders]. They know each other. … They exchange information before I reach there. [Also], they know that we do not have an option other than to sell them. … I sometimes sell with a small profit. … [But], we hear how much 1 kilogram [avocado] is sold for in Addis Ababa. It is expensive.

The narrative further shows that farmers end up with only a small profit. This is especially true for the coffee farmers. Limited market information is also a key explanation for their weak position in the market. I observed that people exchange information about prices on the way to the market. The perishability of the product, once it is collected, exacerbates the problem in the sense that farmers do not have an option other than selling what they bring to the market.

The survey data show that a small proportion of the respondents earn an income from processed food sales. A key reason is that the income source is highly seasonal. It tends to increase during the harvest season. This is particularly true for the coffee growing area. It was said that the sale of processed food increased during the coffee harvest partly due to an increase of migrant workers. I observed that in both study sites quite a few of the *Tsehay-bet* (meaning tea houses) were functioning during the lean season.

Working in the coffee plumping site (the place where the *Luuollo* coffee is processed: plumped, fermented, washed and dried in the sun) is another seasonal income source for both migrant and local workers. This job opportunity decreases after December. I observed that a small number of women work sorting dry unwashed coffee (locally named *Jenfel*) which was collected by the cooperative after February. Storing the *Jenfel* coffee is an important wealth indicator. Put it differently, the better-off farmers are able to wait until the coffee price increases after January. Yet, the majority of the respondents sell *Luuollo* not *Jenfel* coffee.

As mentioned earlier, income from self-employment is limited in the study sites. A small portion of the respondents earns an income from transporting materials by renting out a donkey for a day. Selling drinking water at the market is newly emerged income source for a few household members in the maize growing area. The evidence shows that an income earned from renting out a horse-cart was mentioned by a few maize farmers.

There is no forest for communal use in the study sites. It was said that previously the *Hanja-Chafa* PA was covered by acacia forest. Conversely, inter-planting the coffee with over-head shade trees was common in the coffee-based farming system. Despite the fact that the intricacies between population growth and environmental degradation are not obvious

(Willis 2011), Najam's (1996, 2) article: "A developing countries perspectives on population, environment, and development" indicates:

> The recent growth of popular interest in environmental issues has generated a renewal of concern about rapid population growth, which is seen as being largely responsible for global trends of environmental degradation… The actual relationship between the two seems intuitively obvious. Yet it is being contested by a number of critical interests. … Most surprising is the reaction of developing countries. … Many of them have very high population growth rates and are most immediately vulnerable to its consequences.

The resilience framework (Figure 6) shows the relationship between household with greater sensitivity to shocks and environmental degradation. Willis (2011, 165) similarly illustrates the relationship between poverty and environment:

> [Although] the relationship between poverty and environmental degradation is a complex one, it is clear that there are some connections. … People living in poverty can often not afford to improve their local environment and in many cases they forced to contribute to environmental degradation through, for example, using local forests resources for building materials and fuel.

The interview result shows poverty and population growth is a cause of both the natural resource degradation and land use as well as production pattern of change (Article 4 and 5). This has a negative effect on the local climate and the poor who used to rely on the forest. One of the explanations is that now only a few numbers of respondents in the *Hanja-Chafa* PA have firewood sale as a source of income. Few of the respondents instead buy firewood from local markets, often outside of their PA, such as *Belella*, and retail it further in the *Yirba* market. In response to the shortage of fire wood, farmers use dried maize stems for cooking. By contrast, fire wood sale to traders, who sell it further on urban markets, is an income source for the better-off coffee farmers. An explanation to this is that the ownership of the matured eucalyptus trees is skewed. Today, ownership of the eucalyptus trees is a key wealth indicator. Planting of eucalyptus trees is expanding due to the rise of pole prices. Firewood and timber preparation are income sources for the poor farmers in the coffee growing area. Handicraft sales, including pottery and trade, contribute to food security for some of the households. These income sources are mentioned more in the maize growing area than by respondents in the coffee growing area.

It is vital to note that other external sources such as support through cash/food-for-work programs, contribute to the livelihood for some of the food insecure farmers in the *Hanja-Chafa* PA. This type of relief program was widely implemented in *Sidama* following the 1999/2000 drought. Available data from the *Boricha* district's ARDO show that in 2015, 88 food insecure households benefited from the government's public works program. In the referred year 22 households received direct cash transfers without public work participation. A cash-for-work program lasts six months starting from January to June. The ARDO data show that in 2013/14, 450 non-PSNP beneficiaries, who faced short-term food shortages, were targeted to benefit from 20% of the PSNP budget that was set aside for contingency purposes. NGOs similarly support food insecure farmers during the lean season. Cash-for-work programs are functioning by an aid funded local NGO: *Meserete Kiristos Church Relief and Development Association* (MKC-RDA). In 2015, a total of 350 households benefited from the program. In addition, in 2014, there were 78 households that received food relief from the World Vision Program. The *Hanja-Chafa* PA is one of the three PAs in the district that benefited from the WFP's school feeding program.

The progressive reduction in farm size forces members of the poor families to adopt outmigration as a pathway out of poverty. As *Article 5* discusses rural-to-urban and rural-to-rural migration are another source of income for some households. The findings show that *Hawassa*, *Wilkeite* and *Werabe* towns are the common destination for the migrants. Migrants from the maize growing area move in search of job to *Methara* and *Tendaho* government owned sugar factories. The reduction of the *enset* plants causes women to migrate in search of a job. Informants told that women often migrate with their children for weeks to the *Hurufa* and *Sama-rukessa* areas of the *Hawassa-Zuria* district. However, individual networks determine the access to jobs. Some argue that job opportunities are now less because of more droughts. Female migration to other places was not reported by the studied informants in the coffee growing area.

1.8 Categorizing farmers

The farmers' wealth status is often measured in terms of household assets. I applied the development workers' classification of wealth status, which fits better with the USAID wealth ranking (USAID 2009). The study identified wealth groups based on three main criteria to show the level of the farmers' self-sufficiency: Landholding size; livestock number;

and number of mature *enset* plants. The coffee production volume and number of eucalyptus trees are indicators of the farmers' cash earning capacity. The better-off farmers, having more land and cattle, comprise 20% of the total population. These farmers have a sufficient number of matured *enset* to feed the family throughout the year and even sometimes to sell on the local market. In addition, they have incomes from a diverse set of other sources. In classifying the farmers' wealth status, I used the views of local farmers.

The farmers used other relevant criteria to improve the definition. Livestock number is today not a proper indicator of wealth. The reason is that there are now better-off farmers who own fewer livestock than some middle-income farmers. Instead the ownership of larger landholdings, eucalyptus trees, coffee production and savings from other investments are the main determining factors for categorizing farmers' wealth status. Put it differently, a range of economic activities, in which the farmers engage, is determining their wealth status. Storing unwashed coffee (locally named *Jenfel*) is an important wealth indicator. The better-off farmers are able to wait until the coffee price increases after January.

It is interesting that the farmers who own land above 1 hectare are today considered to be better-off. The ability to send their children to school in a town or to a college is also a criterion used to determine the wealth status of these farmers. The farmers who have two or more wives are seen to be wealthier than other social groups. It is interesting that the size of *Nefera* is used by the farmers as an indicator of wealth. *Nefera* is an open space in front of the house used for multiple purposes. Moreover, income sources other than agriculture are the major difference between the better-off and middle-income farmers. Middle-income farmers comprise 40% of the population. Unlike the USAID wealth classification, the farmers who own about 0.5 hectare of land are today considered to be middle-income.

The poor group constitutes 40% of the population. Most of them cultivate less than 0.25 hectare. This group produces less than 25% of their annual food needs. A family in this group was often recently established, and thus most of them have a relatively small family. They seldom own livestock. The limited availability of *enset* is a factor of their vulnerability. Most of them own only few matured *enset* plants. Others have no matured *enset* to fall back on in times of food shortages. They harvest immature *enset* to meet their immediate food needs. They must buy a large proportion of their yearly food needs from the market, thus their dependence on purchased food is an explanation for their vulnerability to price shocks.

For a large number of the respondents agriculture is not the main sources of income. Casual work is their primary sources of income. The poor depends on on-farm and off-farm as well as non-farm. Participating in the coffee picking job and working in the plumping sites[6] are their seasonal income sources. The job opportunities decrease after December. The household interview results show that small-scale non-farm activities are another important income source for the poor. An example is petty trade which includes purchase and sale of goods, retail of *Luuollo* (wet-coffee) and of *enset* products as well as of maize flour. For some of the farmers firewood and timber preparation as well as handicraft sales contribute to the household income. In bad farm years, able-bodied family members from the poor households migrate to supplement the household income by non-farm employment in urban areas.

Data in *Article 2* indicates the *Hanja-chafa* PA administration classification of wealth status in 2013/14 was better-off (25%), middle (15%) and poor (60%). Nevertheless, these classifications seem to be general and misleading as it does not tell the *local* socio-economic situation of the poor. Similar to farmers in the *Fero-two* PA, interviewed households used various criteria to classify households into different groups. Better-off farmers are those who have a larger land size and produce food enough for all the year. These farmers own several plots in different places. However, today these farmers are few in number. They live in iron-corrugated house. They own eucalyptus tree and *enset* plants. *Khat* and sugarcane plantations were also used as a criteria in order to identify the better-off farmers. It was said that they often adopt new production strategies to increase production. Some of them have motor-bicycle and participate in businesses.

Middle-income famers own land of a half hectare. Interestingly, it was argued by interviewed farmers that today farmers own land up to half hectare is considered to be better-off farmers. Middle-income farmers own few cattle fed at the homestead. As indicated above cattle ownership becomes a less important wealth. An important explanation is that even the better-off farmers keep a low number of cattle at the homestead today. This group produces food sufficient for most months of the year. The poor have lower income and fewer assets to fall back on compared to the above two groups. They lack livestock and cultivate tiny plots. These groups have immature *enset* plants and produce food sufficient for only a few months. These farmers are too poor to buy fertilizer and quality seeds. They are often sharecroppers. They participate in either off-farm or non-farm wage employments to buy most of their annual food need. They are at risk because they are market dependent. Most of these farmers rely on the government and NGOs'-funded food-for-work and cash-for-work interventions. The wealth ranking and field data suggests that changes in climate variables

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[6]Plumping site is the place where coffee is processed: plumped, fermented, washed and dried in the sun.

have different impacts on the socio-economic groups that have different levels of exposure, sensitivity and adaptive capacity.

1.9 Summary of findings

1.9.1 Factors of food insecurity

As indicated earlier, the research findings responds to the social critique of resilience (Cote and Nightingale 2012; Boonstra, Galaz and Olsson 2014; Brown 2014; Olsson et al. 2015). Table 6 briefly presents the complex structural and local factors that explain food insecurity. These factors are definitely linked to global climate change (FAO 2016a). As indicated in the table, some of the factors causing food insecurity are physical and environmental, social and institutional, economic, and political ranging from local to national and international levels. The interrelated factors weaken the farmers' adaptive capacity to deal with climate change impacts. The findings in *Article 4* show that interventions to improve food security are often short-term and thus of little use for improving the farmers' adaptive capacity to move from the vulnerability pathways to a resilience pathway (Figure 6). Table 3 of *Article 4* indicates some of the factors that cause farmers food insecurity are similar while some differ between the study sites. The level of intensity and severity of food insecurity is also varies between communities and among socio-economic groups.

Table 6: Determining factors to food insecurity.

Factors	Local	National	Global

Physical and environmental	• Climate change:
	  • Unpredictable, more erratic and insufficient rainfall
	  • Drought, prolonged dry season and strong heat
	  • Unexpected heavy rainfall, floods and snow events
	• Low soil fertility partly due to limited compost
	• Natural resources degradation
	• Lack of grazing and fodder
	• Lack of irrigation: Undulating hills hinders irrigation
	• Weather-driven weeds, pests and diseases
	• Year-to-year fluctuation of coffee production
		• Climate change:
		  • Frequent droughts and high temperature
		  • More intense and erratic rainfall
		  • Successive rain-failure
		  • Frost
		  • Floods and land slides
		  • Crop pests and diseases
		  • Poor agricultural performance
			• Climate change:
			  • Global temperature rises
			  • Changes in precipitation pattern and season
			  • Changes in temperature and rainfall
			  • Increase the frequency, duration and intensity of extreme weather events

Social and institutional	• Limited education and trainings
	• Land shortage, fragmentation and degradation
	• High population pressure and chronic poverty
	• Organizational weaknesses
	• Lack of water for drinking and livestock
	• Poor social services such as health services
	• Limited use of improved sanitation
	• Gender inequality in accessing to resources
		• Poor social services
		• Population growth
		• Environmental degradation:
		  • Deforestation
		  • Soil erosion
		  • Overgrazing
		• Lower use of farm inputs
			• The growing food demand due to population growth, income increases and urbanization are driving increased foreign investors land demand to produce food crops for export over that for domestic markets. This changing food and feed demand.

Economic	• Limited assets: land, livestock and *enset* plants • Lack of saving and credits • Lack of storage facilities • Unequal collateral arrangements • Social payments • Low wage rate • Low levels of income opportunities • Costs of fertilizers and quality seeds as well as late arrivals • Seasonal staple crops price rise: diminished purchasing power • Low producer prices • Diesel prices: affect local transportation and food prices	• Reduction of coffee prices • Limited competitive market and crop insurance • Export crop price fluctuation and inflation • Food price volatility: influenced by domestic policies • Lack of well-functioning markets • Chronic poverty • Limited income-generating activities • Diesel price rise due to subsidy removal and the country's vulnerability to price change in the world market as well as large-scale investments • Limited resource available to combat poverty and the effect of climate change	• Coffee price fluctuation • Prices rise on imported food items • Sanitary requirement: hampering to access the world market for the commodities exported from developing countries such as Ethiopia. • Trade restrictions and protectionism
Political	• Lack of *active* participation in decision-making • Corruption and favoritism • Power-relation between the poor and better-off • Lack of weather and market price information • Small-scale agriculture incorporation into the world market: deteriorate farmers food and livelihood security	• Policy shift to large-scale exportable crops including food crops: creating new demand for food in the domestic market • Lack of agricultural subsidies and imported food commodities	• Global trends and food prices: "the triple F crisis – food, fuel and finance" are drivers of commercialization of small-scale agriculture

Source: Field data.

1.9.2 Climate change

Climate data in *Article 1* and *7* show that more prolonged droughts and successive seasonal rain failures, erratic and insufficient precipitation coupled with higher temperature have been the country's major environmental challenges for decades. Table 7 below indicates farmers experienced changes in temperature, precipitation, weather variability and extreme events. Such environmental changes and other complex socio-politico-economic factors, however, affect production pattern and yield, timing of land preparation and planting, plants' growth and the length of maturating periods and traditional work arrangements and farm inputs application (Article 3 and 4).

Table 7: Changes in climate experienced by farmers in the study sites.

Climate change	**Experienced changes**
Changes in temperature	• Local temperature rise • Deplete soil moisture • Reduce water availability for drinking and livestock
Changes in precipitation	• Changes in seasonality: timing, intensity and duration of rainfall • Increase the risks of flooding: damaged cropland • Reduce forages: the leaf of the *enset* plant • Reduced the growing of food eaten during annual food shortages
Extreme events	• Droughts and rainfailure • Occurrence of heavy rains and winds, floods, and snow events

Weather variability	• Changes in seasonal precipitation pattern:
	    • Prolonged dry periods
	    • Erratic and insufficient rainfall
	    • Too early and too late rains
	    • Rainfall duration extended beyond the normal season

Source: Field data.

1.9.3 Climate change impacts on food security

Data in *Article 4* show that drought, unpredictable and more erratic and insufficient rainfall and flooding negatively affect production. *Article 3* indicates that weather-related changes affect not only the quantity but also the quality of production through increasing pests and other diseases. In line to the theoretical framework (Figure 5), the study findings show how the effect of climate change risks on production has adverse implications for producer prices through its effect on production quantity and quality (Article 3). Thus, the climate change impact affects not only the farmers' ability to buy farm inputs to improve productivity but also their demand for fertilizers (Article 4).

The study findings further highlight that the impact of climate change, such as food price spikes, is a challenge to the farmers. Droughts affect food prices by reducing the yield and thus the food availability at the household level and at the local markets. Data in *Article 7*, Figure 24 indicate that the rate of food price inflation in Ethiopia is often higher than the general consumer price inflation. The seasonal food supply variation in the local markets has an implication for price changes (Article 4). *Article 1* indicates the reason is that there is a major price difference between the surplus and deficit markets of the country (Assefa 2013). Moreover, food prices in the local markets are instable because of the production instability. UNFPA et al. (2011, 25) report illustrates that climate change is one of the most significant factors causing price volatility.

> … with local production decline income opportunities and purchasing power of small-scale producers, as well as seasonal workers dependent on harvesting and crop-processing, will decrease. At the same time, prices for the most important crops … could increase …

Climate change impact on production affects intra and inter-household social networks and arrangements, which are vital forms of food security practices (Article 4). These includes the traditional animal sharing is affected due to a climate change impact on livestock production. Moreover, the farmers' participation in social activities is affected because of climate change impacts on production and incomes. A study show that "climate change affects … health, food security, employment, incomes and livelihoods, gender equality, education, housing, poverty and mobility–either directly or indirectly" (UNFPA et al. 2011, 24). The effect of climate change risks on the different sectors in turn negatively threatens farmers' adaptive capacity to shocks that influence food insecurity (Figure 6). As was indicated in the theoretical framework (Figure 5), data in Table 8 illustrates the effects of climate change on the four pillars of food security: production, storage, distribution and trade (availability); affordability and preferences (access); nutrition value, food value and food safety (utilization); and stability.

Table 8: Climate change and food security.

Food security dimensions	Outcomes of climate change
Availability: (production, distribution, storage and exchange/trade)	• Agricultural production (food crops and livestock) reduced and instable • Increases crop pests and diseases • Cause for cropping and land use pattern and farming practices of change • Reduce *intra* and *inter-household* food distribution, exchange, loan and gifts • Reduce food available on local markets • Increase farmers who are seeking food assistance
Access: (allocation, affordability and preference)	• Yield instability increases crops prices • Climate change affect *off-farm*, and *non-farm* income and livelihood sources • Reduce farmers ability to access food due to yield and income instability • Production reduction changes in food preferences and food quantity • Shift to low quality foods: such as *Amicho*, *Rafo*, *Furfurame* and so on • Changes in social arrangements to manage food security risks
Utilization: (nutritional value, food value and food safety and healthcare)	• Reduce water availability: pond water and rainfall harvest • Affect sanitation • Increase the occurrence of diseases: Malaria and other water-born diseases such as diarrheal. • Reduce quality and diversity of food eaten • Exacerbates the prevalence of malnutrition
Stability: (the function of fluctuation in food availability, access, and utilization)	• Changes in food supply both at the household and local markets • Market price inflation on major food crops • These in turn affect the food utilization

Source: Field data: adapted WFP (2012, 5).

As indicated earlier, climate change risks disproportionately affect the food and nutritional security status of children and women (FAO 2016b). In line to the study findings discussed in the *Articles*, UNFPA et al. (2011, 24) illustrates the disproportion effects of climate change on different social groups:

> … the people most vulnerable to climate change are usually poor, undernourished, of poor health, live in precarious housing conditions, farm on degraded lands, have low levels of education, lack of rights, have little opportunities, to influence decision making, work under precarious conditions, and/or reside in countries and regions with non-resilient systems, limited resources and sometimes poor governance systems.

1.9.4 Climate change adaptation and coping strategies

The findings in the *Articles* show that farmers' adopt multiple forms of ex-ante and ex-post coping and adaptation strategies in response to climate change-driven food insecurity. Production-related strategies include altering drought resistant crop varieties, delaying the planting time, soil and water conservation practices. Building of small terraces, mulching, planting trees and small-scale rainwater harvesting and check-dams to prevent flooding are other production-related adaptation strategies. *Article 5* compares the adopted strategies by farmers between the study sites. Some of the production-related strategies are spontaneous and others are planned adaptation (Table 9). However, the farmers adaptation is hampered by different factors as discussed by Eriksen et al.'s (2005, 289):

> The root causes of vulnerability are … embedded in societal processes at broader scales. Hence, coping at the local level is inextricably linked to processes taking place at other geographic scales. Access to assets, for example, is closely related to the political economy of the region and coping options available to food-insecure people are contextual and determined by structural constraints. … This inherent link between processes operating within society and at other scales contributes to the dynamism and complexity in vulnerability and thus coping strategies at the local level.

As shown in Table 9, most of the adopted coping strategies are short-term but vary not only between the two sites but also with the studied farmers' demographic and socio-economic groups. These adaptation strategies are spontaneous (or autonomous). Farmers with limited access to productive assets and livelihood strategies are more sensitive than farmers who are able to use their adaptive capacity to manage the risks of shocks or stresses (Figure 6). In this connection, UNFPA et al.'s document on the social dimensions of climate change (2011, 25) point out that:

> … high-income people can cope with shocks through private insurance, by selling off assets or by drawing on their savings, the poor face a different set of choices. They may have no alternative but to reduce consumption, cut nutrition, take children out of school or sell the productive assets on which their recovery depends.

The findings show different consumption coping strategies are undertaken by food insecure farmers. Data in *Article 2* and *5* highlight women's difficulties with food insecurity and how they adjust to food shortages by eating less preferred food, reduce the food intake, reduce the number of meals, limit the portion size at meals in a day and going a whole day with little food in order to feed their children. Hesselberg's (2017, 43) study in Cameroon notes:

> Hunger is undoubtedly a question of chronic poverty, of not having sufficient buying power to cover the most basic needs. It is not a question of agricultural production, neither today nor in the near future… It is a historical fact that countries specializing in food production simultaneously "specialize" in being poor. Moreover, it is paradox that most people experiencing hunger are themselves food producers.

Seasonal out-migration in search of wages and resettlement is another adopted strategy to deal with climate change-driven food insecurity and other interconnected socio-economic challenges. Data in *Article 5* and Table 9 discuss these strategies used by farmers in order to deal with seasonal food shortages.

Table 9: Coping and adaptation strategies to climate change and food insecurity.

Climate change adaptation strategies	Coping strategies	Out-ward strategies

Production-related strategies
• Delaying the planting time
• Reduce the application of fertilizers
• Switch the use of land from food to cash crop such as *khat* and tobacco.
• Expansion of coffee plants against *enset* plants
• Expansion of eucalyptus tree plantation
• Gradual shift from *enat* (mother) coffee to project coffee
• Grow *enat* coffee with project coffee and intercropping other crops
• Planting trees in-between the coffee plants
• Increase application of chemical fertilizers and non-local seeds
• Intercrop local seeds with improved seeds
• Apply wood ash around the coffee plant to deal with the spared of CBD
• Changes in livestock management: maintain few cattle around homestead
• Apply traditional weather forecasting methods
• Communal collective action: praying together to God (discontinued)
 	
A traditional soil and water conservation practices
• Planting elephant grass against the slope
• Mulching to retain soil moisture
• Cover the soil around the coffee roots with leaves
• Make soil and stone bunds
• Plant tree to stabilize slopes
• Small-scale rainwater harvesting
• Check-dams and build small terraces to prevent flooding and soil erosion
	Consumption-smoothing strategies
	• Eat less preferred food
	• Consume immature *enset* plants
	• Reduce food intake
	• Reduce number of meals
	• Limit portion size at meals
	• Going the whole day with little food
	• Restrict consumption by adults to feed children
	Other coping strategies
	• Work for better-off farmers
	• Reduce non-food expenditure
	• Sales of livestock and possessions
	• Increase petty commodity production and trade
	• Use collateral arrangements:
	  • Contract farming
	  • Access to loan with interest rate
	  • Sell the coffee during the flowering stage and bartering
	  • Use livestock and eucalyptus trees as collateral to access loan
	• Reduce participation in social activities
	• Sales of eucalyptus trees
		• Seasonal migration in search of wage employment
		  • Rural-to-rural migration
		  • Rural-to-urban migration
		• Resettlement

Source: Field data.

1.10 Conclusions and policy implications

The study findings indicate that farmers have experienced food insecurity resulting from a combination of political, physical, economic, environmental and social factors. In response they have developed both ex-ante and ex-post coping and adaptation strategies in order to deal with the changing contexts. However, the findings indicate that most of the adopted strategies are less effective and short-term and do little to help households to exit from their food insecurity. Interviewed farmers have different opinions and priorities regarding the changing environmental risks and other inter-related factors of their food insecurity. The heterogeneity of the informants' opinions shows that a single and short-term intervention is not adequate to improve the farmers' ability to adapt to climate change. The existing "short-term assistance cannot lead to longer term positive change because it does not solve the problem of farmers chronic poverty" (Hesselberg 2017, 57) and of food security. The study findings suggest that there is a need for resilient farmers who are able to deal with not only the predictable and unpredictable climate change events but also other interconnected socio-economic and institutional factors.

The findings suggest that in recognizing the local realities and changing nature of causes, there is a need for varied forms of support in order to enhance the farmers' adaptive capacity to increase their food crop production. Support should also include investments in health and credit services. As indicated in *Article 3*, it is necessary to find ways to diversify the farmers' income sources through implementing effective and sustainable agricultural practices that consider the local agro-ecology, rainfall pattern and farming system. Policy intervention aims to improve the progressively declining mixed (crop-livestock) farming system, the traditional weather forecasting, soil and water conservation practices and gender equality in resource ownership that can reduce the effects of climate change risks and build resilient livelihoods and agricultural practices.

In rural Ethiopia at large, "investments are needed in both manufacturing and food production simultaneously to accommodate the growing young people seeking employment" (Hesselberg 2017, 59). Yet, these interventions are still not sufficient to effectively reduce the complex rural poverty and effects of climate change. There is a need to design diversified risk reduction strategies through combining farmers' access to loans to purchase agricultural inputs, providing irrigation facilities (for coffee farmers), price and weather information, linking the traditional and local weather forecasting methods with the modern ones in order to better predict shocks and their effects. "In particular, there is a need to provide support for vulnerable people in special need of protection, who are not able to cope with the risks of weather and climate change on their own" (Bals et al. 2008, 15). Moreover, long-term and gender sensitive social protection that includes not only weather index crop insurance but also market insurance are needed to increase profitability as a way to reduce vulnerability and to build resilient farmers to address the effects of climate change (Haggar and Schepp 2012; Bogale 2015). Yet, a study by TANGO (2012) evidences that since "resilient household does not necessary result in resilient communities" (5) … interventions should also stretch emphasis on "building resilience across sectors (political, social, human, physical, natural and financial) and levels include household, community and national" (10).

1.11 Articles outline

The articles are structured as follows. The first *Article* review the debates on the effects of agricultural commercialization on small-scale agriculture and food insecurity with a focus on Ethiopia. *Article 2* assesses the challenges and prospects of cash-for-work and food-for-work programs on building household resilience to food insecurity in the *Hanja-Chafa* Peasant Association (PA) of maize-based farming system in the *Boricha* District. *Article 3* provides evidence on the coffee farmers' multifaceted challenges regarding marketing and prices as well as how the farmers perceive and deal with climate change impacts on coffee production in the *Fero-two* PA of the *Wensho* district. *Article 4* identify the determining factors of food insecurity and how these factors are linked to global climate change among farmers in the two PAs. *Article 5* provides evidence of the multiple forms of farmers coping and adaptation strategies in response to climate change-driven food insecurity. This is followed by the data articles (*Article 6* and *Article 7*) derived from a household survey data and analyzed long-term climate data obtain from the National Metrological Agency (NMA) of Ethiopia respectively.

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1.13 Qualitative check list

Grand tour questions

- Could you tell me about this locality?
- How do people make a living?
- What challenges farmers face in production?
- Who is food insecure and why?
- What has changed in the food security of the farmers?
- How food insecure farmers identified and by which criteria NGOs and the government provide relief support?

Informant characteristics

- Age
- Sex
- Marital status and type
- Family size
- Underage children (below 15 years old)
- Education status
- Skills acquired
- Landholding size
- Livestock owned by the household

Income and food sources

- How do you earn income in 'normal' and 'bad' years?
- How do you explain the seasonality of income sources?
- Could you tell me how seasonality affects food access?
- Could you explain why your income source is lost or reduced?
- Has there been any change in the household income/livelihood sources? Why?
- How do the household get food in 'normal' and 'bad' years?
- Why the household is more vulnerable to food insecurity than before?
- Could you tell me the causes for the household food/livelihood insecurity?
- Why production is not sufficient for the household food security?

- Could you tell me the challenges in respect to production (crop and livestock)?
- How do you compare the more or less important causes of food insecurity?
- In your opinion, which production (cash or food crops) is vital to food security? How?
- Why coffee productions show inter-annual-variation?
- Do you think reliance on coffee production affect the household food security? How?
- What do the household do to increase agricultural productivity?
- How do the household deal the reduced income/food supply?
- Could you tell me what have I not asked you, which is relevant?

Market and social services

- Why inter-seasonal variations in food prices happen?
- Could you tell me how the household manage inter-seasonal food shortages?
- In your opinion, how lack accesses to health services affect food security?
- How access and availability of water affect food security?
- How do you explain the severity of your household food security?
- Could you tell me what have I not asked you, which is relevant?

Climate change coping strategies

- How do you explain the history of climate change in this locality?
- Could you tell me the causes of climate change?
- How climate change/drought affect the household food security?
- How do the household manage the effects of climate change?
- Do you think lack access to information increase vulnerability to shocks? How?
- Could you tell me any new strategies adopted in production pattern?
- In your view, how the adopted strategies are productive or long-term?
- Could you tell me why the household are unable to cope with climatic shocks?
- Do you think the adopted strategies have erosive effects on food security? How?
- How do you explain the changes in livelihood strategies after climate change?
- Could you tell me what have I not asked you, which is relevant?

Social networks

- How do you explain the changes in reciprocal arrangements in production?
- In your opinion, how do you explain the importance of these arrangements?
- Why the household participation in social institutions in production changed/reduced?
- How the reduction in participation affects the household food security?
- Why do you borrow money in 'normal' and 'bad' years?
- How do you borrow? From where you often borrow? How do you pay it back?
- How do the household participation in social arrangements affected by shocks?
- Could you tell me in which bartering arrangements do the household participate? Why?
- Do you think these arrangements have erosive effect in food security? How?
- Could you tell me why the household membership in local organizations affected?
- How do the household maintain membership?
- Could you tell me what have I not asked you, which is relevant?

Future

- Could you tell me how do the household plan to restore the lost assets?
- How do you see the future food security of the household?
- In your view, how the household food security situations can be improved?
- How do you expect and plan to reduce the future shocks?
- Could you tell me the determinants to cope future shocks? What should be done?
- How do you explain the future of your children?
- In your opinion, how the household food security can be improved?
- Do the household have plan to stay or leave the place? Where will you go? Why?
- Do you think migration is productive in terms of food security? How?
- Could you tell me what have I not asked you, which is relevant?

Aid intervention

- For how long do your household received cash/food supports? What frequency?
- How do you explain the challenges to participate in the program?
- How do you perceive the role of cash/food-for-work in terms of food security?

- How best Productive Safety Net Program and other supports to address food insecurity?
- For how long your household consume food or buy food from the money?
- What form of supports do your household currently needs to exist from poverty?
- How food insecure farmers in the community are identified for assistance?
- What are the challenges in relation to identifying food insecure farmers?
- How these interventions are productive in terms of food security?
- Could you tell me what have I not asked you, which is relevant?

Key informants

- Why food insecurity persists in this locality?
- Who are the most vulnerable groups? Why?
- How farmers are grouped according to their wealth status?
- What changes in farmers' activity in relation to production?
- In your opinion, what factors are affecting farmers' food security?
- Are these factors regular, seasonal or one-offs? For how long stay (duration)?
- Who are unable to cope and recover when shocks occurred? Why?
- What social services do exist, which are not in the locality?
- What are the most important networks farmers' uses in relation to food access?
- Which food items prices are increased with season? Which are not? Why?
- What traditional arrangements in production are commonly practiced?
- Why food supply in the market changes seasonally?
- What farmers do during high food prices?
- Why coffee production/quality is reducing?
- What opportunities are there to improve coffee farmers' productivity?
- How do coffee farmers' memberships to the cooperative benefit them?
- How do you explain the history of climate change in this locality?
- How farmers' livelihood activities are affected following climate change?
- In your opinion, do farmers understand the causes of climate change? Why?
- Do farmers have access to information to prepare and adapt climate changes?
- How do farmers forecasting the good or bad years e.g., drought or good rain?
- What collective action do farmers use to mitigate the effects climate change?

- Do you think farmers are able to address the effects of climate change? How/why?
- What opportunities are there to improve farmers' resiliency to shocks?
- How do farmers mortgage or sell land to deal with changing conditions?
- How do these arrangements affect farmers' food security?
- How do farmers' food security situations improve in the future?
- What responses are required to improve farmers' food security?
- Could you tell me what have I not asked you, which is relevant?

1.14 Pictures


:

Source: Researcher.

Source: Researcher.

Source: Researcher.

Source: Researcher.

Source: Researcher.

Source: Researcher.

Ashera: a broke coffee with dry pulp.

Source: Researcher.

Source: Researcher.

Source: Researcher.

Source: Researcher.

Source: Researcher.


Khat preparation for market.


Source: Researcher.

Article Seven

Abebe, Gezahegn. (2017). Long-term climate data description in Ethiopia. *Data in Brief*, 14, 371-392.

Long-term climate data description in Ethiopia

Abstract

This article presents long-term analyzed rainfall and temperature data obtained from the National Metrological Agency (NMA) of Ethiopia. Using tables and graphic trends of analysis, the article shows the low and declining level of average annual rainfall as well as the high inter-annual fluctuations for 18 weather stations located in different agro-climatic zones of the country. The high variation of annual maximum and minimum temperature has been similarly observed for decades in the stations. Ethiopia's average annual temperature has risen between 1955 and 2015 by 1.65 ^{0}C. The country's agricultural production depends heavily on local temperature and rainfall. The evidence is clear that a slight change in such climatic elements negatively affects the food security condition of both producers and consumers. Although data from the Central Statistical Agency (CSA) show that major cereal crop production has increased at the national level, partly due to the increasing application of fertilizers and modern seeds, Ethiopia's food security condition is deteriorating due to global climatic events caused droughts and rain failure. The rate of food price inflation is thus often higher than the general consumer price inflation rate.

Keywords: Erratic rainfall, Temperature, Farm inputs; Cereals; Consumer price; Ethiopia.

Specification Table	
Subject area	Environmental studies
More specific subject area	Climate change
Type of data	Figures and tables
How data was acquired	Climate data were obtained following formal application procedure to the authority. Different year agricultural sample survey and the consumer price index data available at the CSA of Ethiopia were used.
Data format	Analyzed
Data source location	18 weather stations: *Addis Ababa; Arba Minch; Axum; Bahir Dar; Beshoftu; Combolcha; Debre Markos; Dire Dawa; Gode; Gondar; Gore; Hawassa; Jimma; Mekele; Methara; Neghele; Nekemte;* and *Robe.*
Experimental factors	Data used in this article were obtained from the NMA and CSA of Ethiopia.
Experimental features	Tables and graphic trends of analysis were employed.
Data accessibility	The data are with this article.

Data value

- Gives information on the changing condition of climatic elements' impact on production and food prices.
- Can be reproduced by researchers and experts working in the field.
- Useful to identify vulnerable communities and social groups to the effects of climate change risk for interventions.

Data

The figures and tables of rainfall and temperature were analyzed based on the data obtained from 18 weather stations located in different agro-climatic zones of Ethiopia. **Figure 1** is the location map of metrological stations. The declining and low level of average annual rainfall overtime as well as high inter-annual fluctuation for 18 weather stations are presented in **Figures 2-20**. Information on temperature are presented in Tables. **Table 1** shows the average annual temperature of Ethiopia (1980-2016). The mean annual temperature of Ethiopia is presented in **Table 2**. The following tables (**Tables 3-19)** present the variation of mean annual maximum and minimum temperatures of the weather stations. In **Figures 21** and **22** area cultivated under improved seeds, local seeds and use of fertilizers and types of fertilizers for cereals crop only are presented. The last two figures (**23** and **24**) demonstrate the progressive increase in agricultural production such as cereals, oil seeds and pulses and the consumer price index respectively.

Methods and materials

The unprocessed long-term elements of climate such as rainfall and temperature data obtain from the National Metrological Agency (NMA) of Ethiopia were analyzed using tables and graphic trends of analysis. Annual rainfall and mean annual temperature of 18 representative weather stations were computed in order to calculate the country's mean annual rainfall and the inter-annual fluctuations and average annual temperature. The article used different year agricultural sample survey reports of Central Statistical Agency (CSA) of Ethiopia. Based on the data, the trends of major cereals crop production, area cultivated under improved seeds, local seeds, types of fertilizer and applied areas and the consumer price index in Ethiopia were calculated and presented. The author used Microsoft EXCEL software to analyze the data and present the result in graphs and tables.

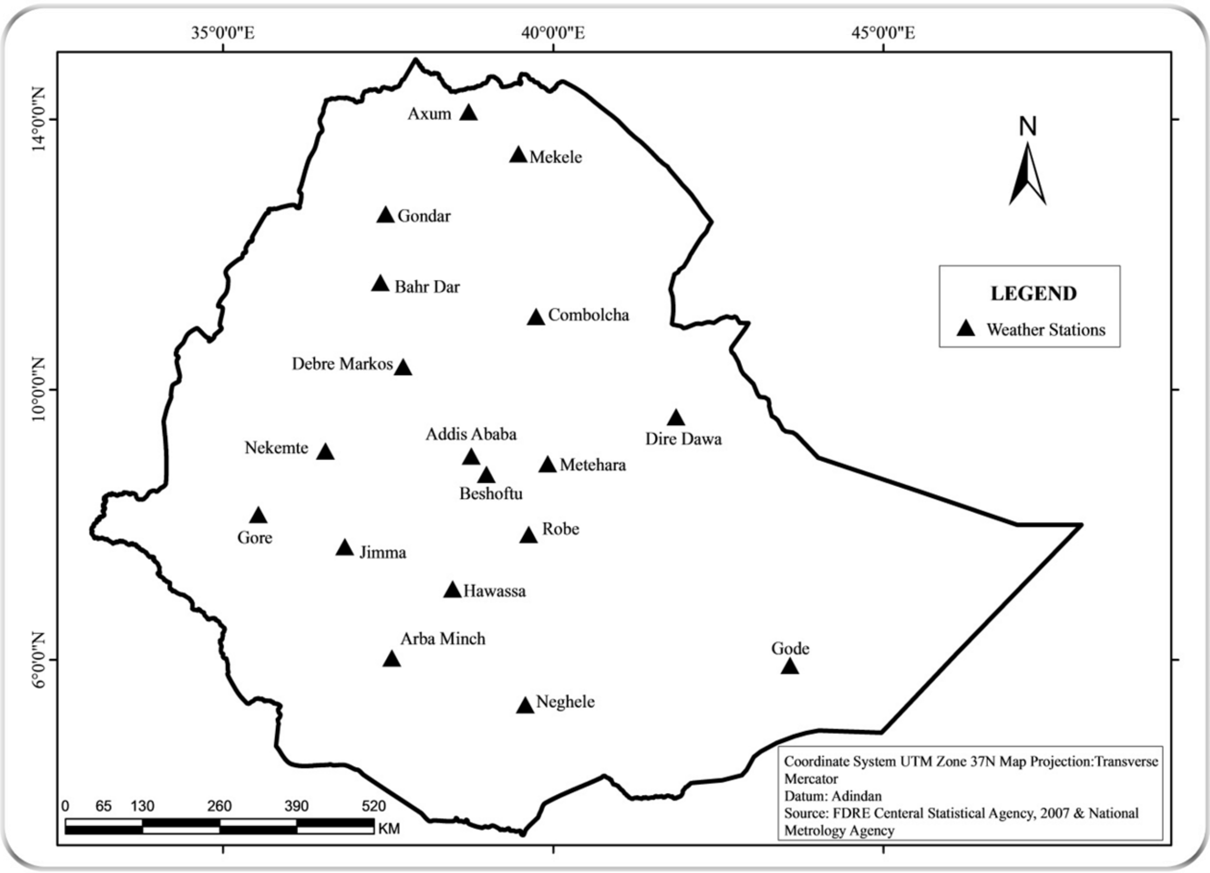

Figure 1: Location map of 18 weather stations.

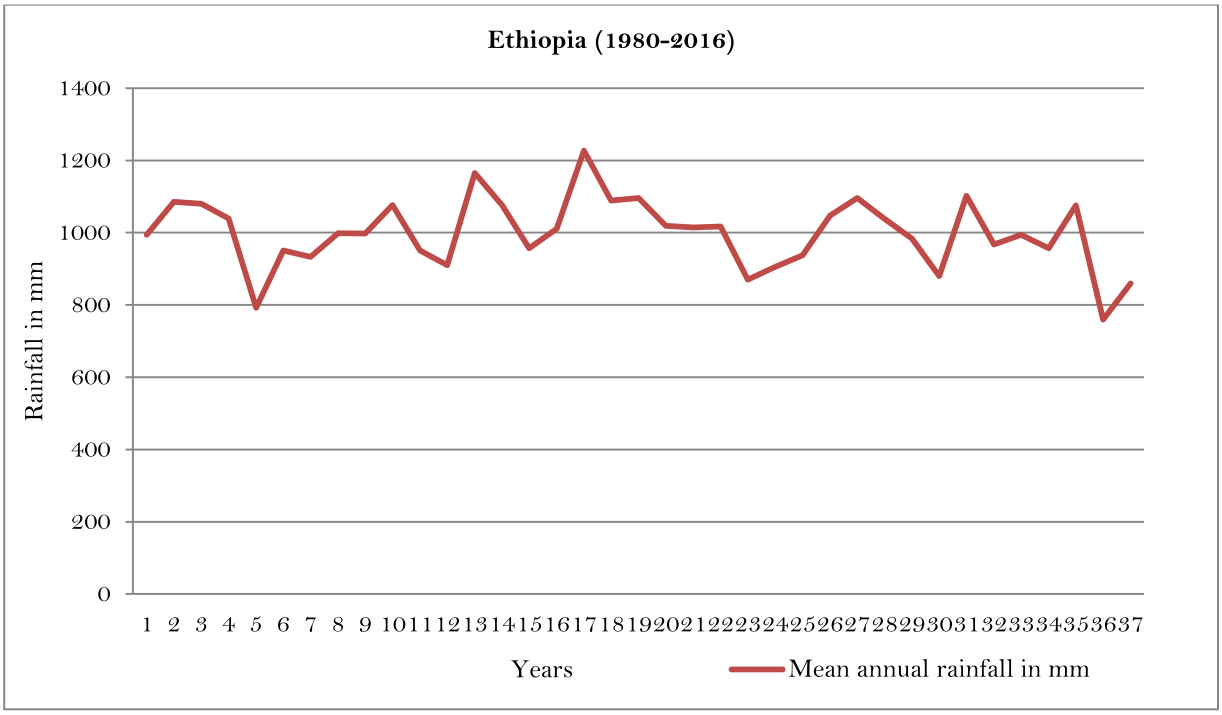

Figure 2: Mean annual rainfall of Ethiopia.
Source: Computed based on raw data from National Metrological Agency (NMA) of Ethiopia.

Table 1: Average annual temperature in Ethiopia: Representative weather stations.

Year	Addis Ababa	Arba Minch	Hawassa	Combolcha	Debre Markos	Debre Zeit	Dire Dawa	Robe	Gode Metekel	Gondar	Gore	Jimma	Mekele	Metehara	Neghele	Nekemte	**Average annual Temp.**
1955	18.9	--	--	17.69	15.24	18.55	24.86	--	--	18.65	17.85	18.54	--	--	18.37	--	**18.70**
1960	18.85	--	--	19.7	15.2	18.87	24.97	12.72	--	18.37	18.17	19.3	17.62	--	19.66	--	**18.49**
1965	18.9	--	--	18.89	15.28	19.09	24.7	12.19	27.98	19.59	17.73	18.82	18.57	--	19.11	--	**19.23**
1970	19.65	--	--	19.2	16.45	19.07	24.93	12.93	28.82	19.9	18.24	18.73	18.63	--	19.38	17.25	**19.47**
1975	19.82	--	18.68	17.82	15.76	18.26	25.02	12.82	28.86	20.03	17.9	18.6	16.99	--	19.17	17.06	**19.05**
1980	19.92	--	19.9	19.07	16.22	18.93	25.4	14	28.92	19.97	18.6	19.19	17.66	--	20.05	18.06	**19.70**
1985	15.72	24.62	18.74	15.82	16.06	18.38	25.17	15.12	28.05	20.16	18.1	18.83	17.21	24.89	19.12	17.65	**19.60**
1990	16.1	24.08	19.76	19.73	16.04	19.13	25.37	15.02	29	19.54	19.95	19.01	11.2	25.37	21.23	18.51	**19.94**
1995	16.6	23.8	20.2	19.49	16.95	19.65	25.85	14.93	--	20.85	19.17	19.94	17.88	26.17	21.12	18.75	**20.30**
2000	16.62	23.66	19.88	19.3	16.35	19.41	25.68	14.08	28.91	19.44	18.82	19.79	18.15	25.42	20.75	18.6	**20.69**
2005	16.89	23.88	20.21	19.73	16.83	18.48	26.06	15.2	29.72	20.67	19.56	19.6	18.01	25.93	21.28	19.0	**20.56**
2010	16.95	23.94	20.62	20.4	17.09	18.78	25.9	15.43	30	20.73	19.42	20.14	18.23	26.07	21.76	18.99	**20.75**
2015	18.55	24.65	21.44	20.48	17.37	20.18	25.71	15.72	29.67	20.67	19.36	20.43	18.23	26.88	22.44	18.57	**20.35**

Source: Computed based on raw data from National Metrological Agency (NMA) of Ethiopia. *Note*: data from *Bahir Dar* and *Axum* weather stations are not included here.

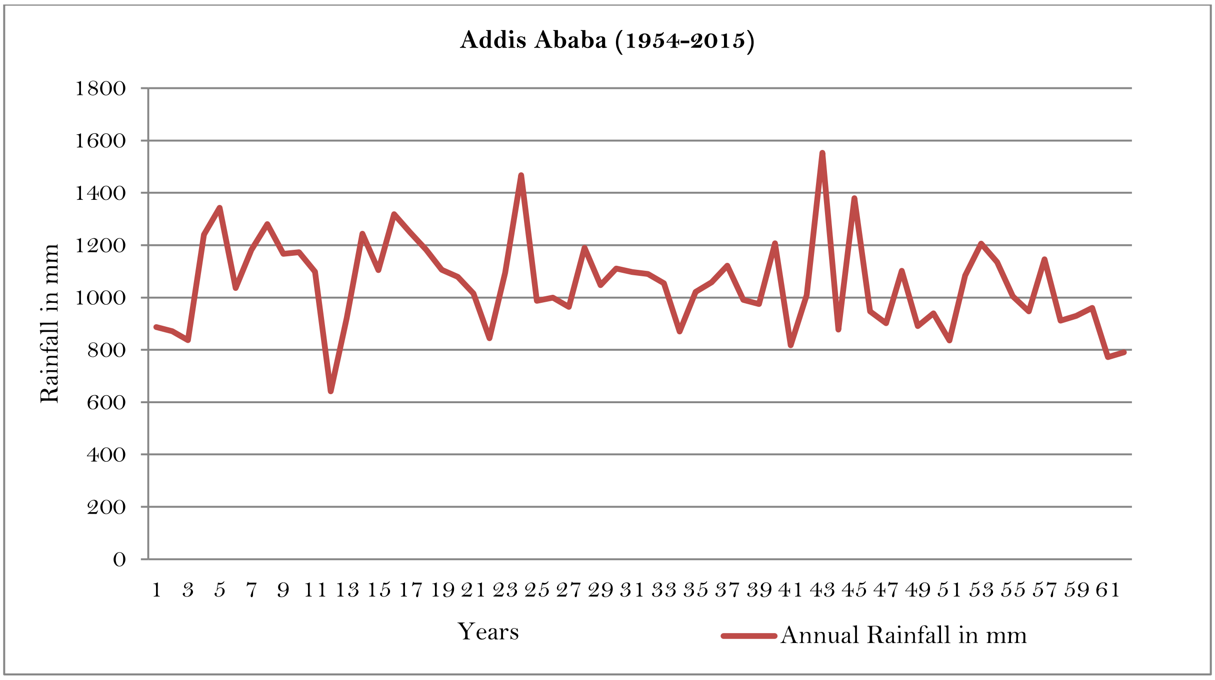

Figure 3: Annual rainfall in *Addis Ababa* weather station.
Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

Table 2: Variation of annual maximum and minimum temperature in *Addis Ababa* (1955-2015).

	Year	**Average Annual Temp. (Max)**	**Average Annual Temp. (Min)**	**Mean Annual Temperature**
Addis Ababa	1955	29.75	8.04	18.90
Addis Ababa	1960	29.80	7.90	18.85
Addis Ababa	1965	30.36	7.44	18.90
Addis Ababa	1970	30.50	8.80	19.65
Addis Ababa	1975	30.97	8.67	19.82
Addis Ababa	1980	30.79	9.05	19.92
Addis Ababa	1985	22.63	8.82	15.72
Addis Ababa	1990	23.19	9.02	16.10
Addis Ababa	1995	23.73	9.48	16.60
Addis Ababa	2000	23.58	9.66	16.62
Addis Ababa	2005	23.80	9.98	16.89
Addis Ababa	2010	22.87	11.04	16.95
Addis Ababa	2015	24.30	12.80	18.55

Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

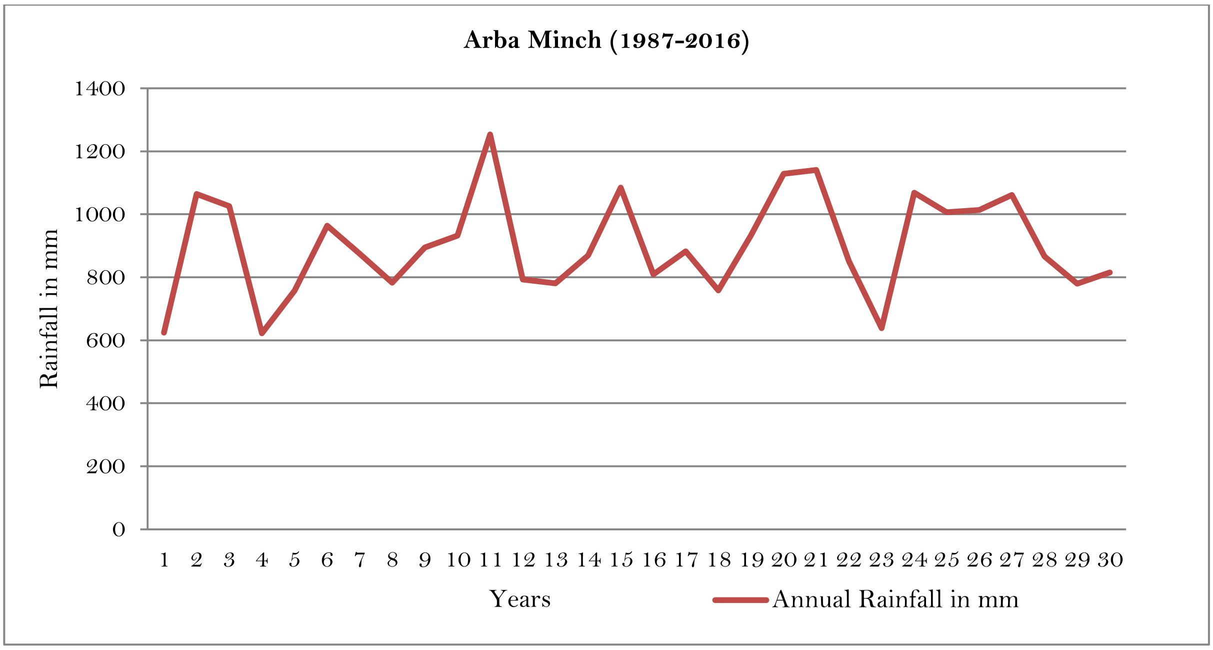

Figure 4: Annual rainfall in *Arba Minch* weather station.
Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

Table 3: Variation of annual maximum and minimum temperature in *Arba Minch* (1975 - 2015).

	Year	**Average Annual Temp. (Max)**	**Average Annual Temp. (Min)**	**Mean Annual Temperature**
Arba Minch	1985	31.06	18.18	24.62
Arba Minch	1990	30.20	17.95	24.08
Arba Minch	1995	30.36	17.23	23.80
Arba Minch	2000	30.65	16.67	23.66
Arba Minch	2005	30.35	17.40	23.88
Arba Minch	2010	29.99	17.89	23.94
Arba Minch	2015	31.38	17.91	24.65

Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

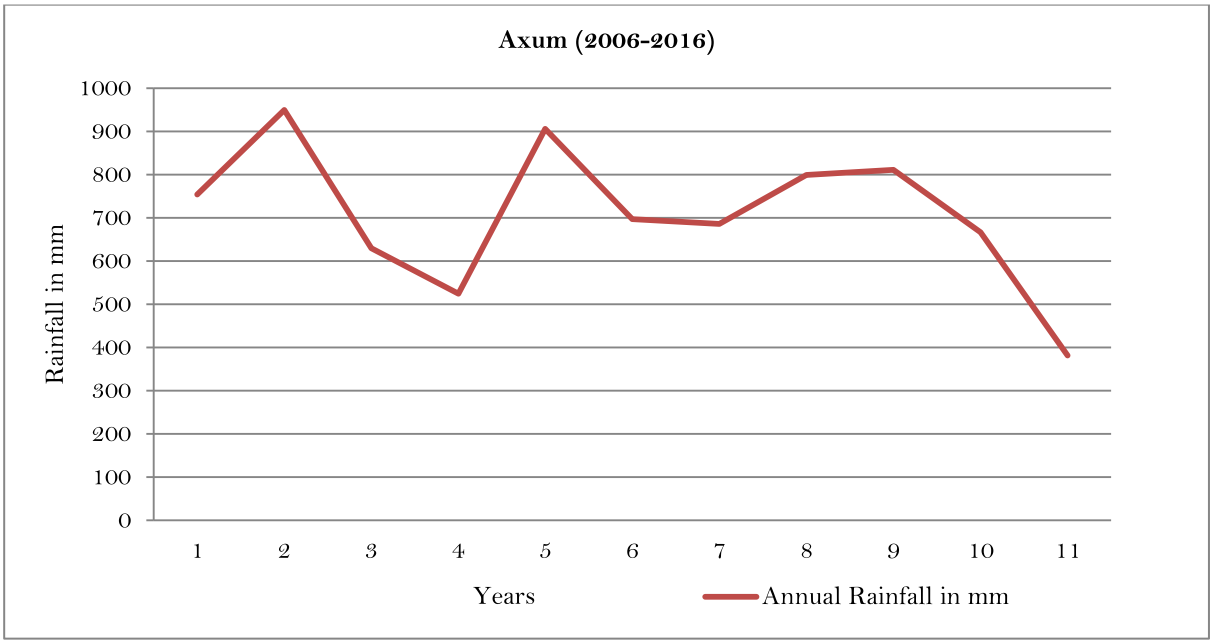

Figure 5: Annual rainfall in *Axum* weather station.
Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

Table 4: Variation of annual maximum and minimum temperature in *Axum* (2006-2016).

	Year	**Average Annual Temp. (Max)**	**Average Annual Temp. (Min)**	**Mean Annual Temperature**
Axum	2006	24.30	12.03	18.16
Axum	2007	26.26	12.28	19.27
Axum	2008	26.30	12.18	19.24
Axum	2009	27.37	12.57	19.97
Axum	2010	26.65	12.19	19.42
Axum	2011	26.05	11.70	18.87
Axum	2012	26.04	11.73	18.88
Axum	2013	26.04	11.90	18.97
Axum	2014	25.94	11.58	18.76
Axum	2015	26.59	11.78	19.18
Axum	2016	26.92	12.33	19.62

Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

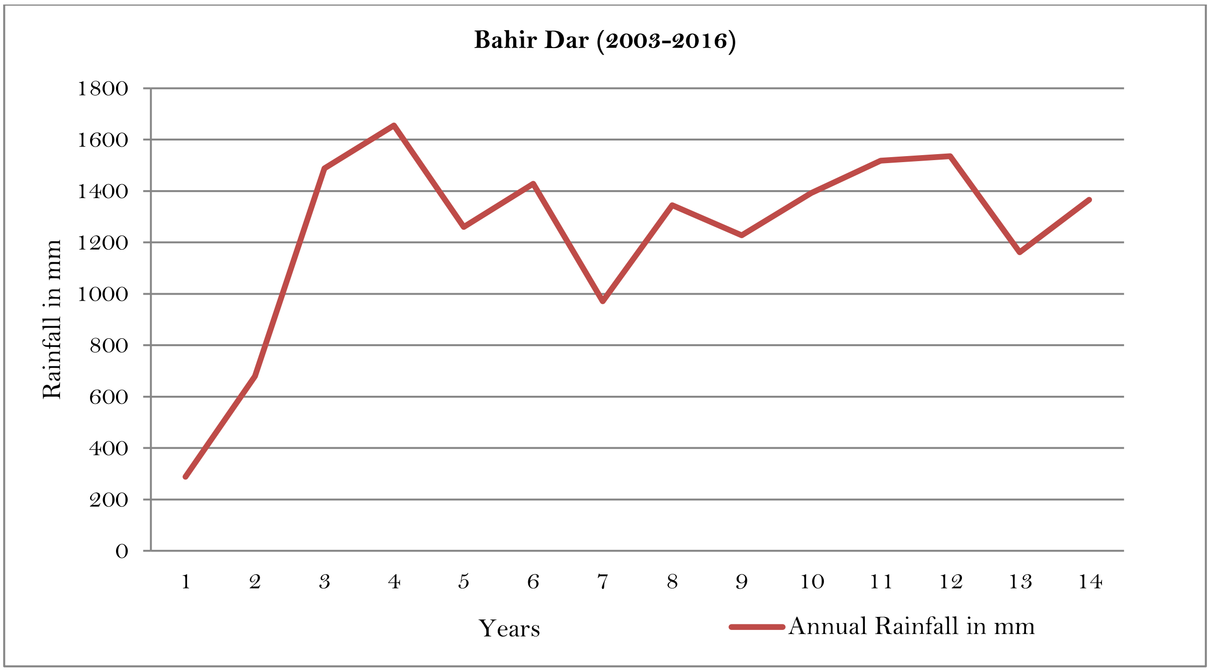

Figure 6: Annual rainfall in *Bahir Dar* weather station.
Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

Table 5: Variation of annual maximum and minimum temperature in *Bahir Dar* (2002–2016).

	Year	Average Annual Temp. (Max)	Average Annual Temp. (Min)	Mean Annual Temperature
Bahir Dar	2002	26.20	7.3	16.75
Bahir Dar	2003	29.55	12.7	21.13
Bahir Dar	2004	25.56	12.68	19.12
Bahir Dar	2005	26.96	12.92	19.94
Bahir Dar	2006	26.75	12.87	19.81
Bahir Dar	2007	26.78	10.32	18.55
Bahir Dar	2008	26.83	11.59	19.21
Bahir Dar	2009	27.60	12.33	19.96
Bahir Dar	2010	27.07	12.52	19.80
Bahir Dar	2011	26.99	11.46	19.22
Bahir Dar	2012	27.68	12.11	19.85
Bahir Dar	2013	28.78	11.61	20.20
Bahir Dar	2014	27.69	14.08	20.88
Bahir Dar	2015	28.50	13.78	21.17
Bahir Dar	2016	27.02	14.68	20.85

Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

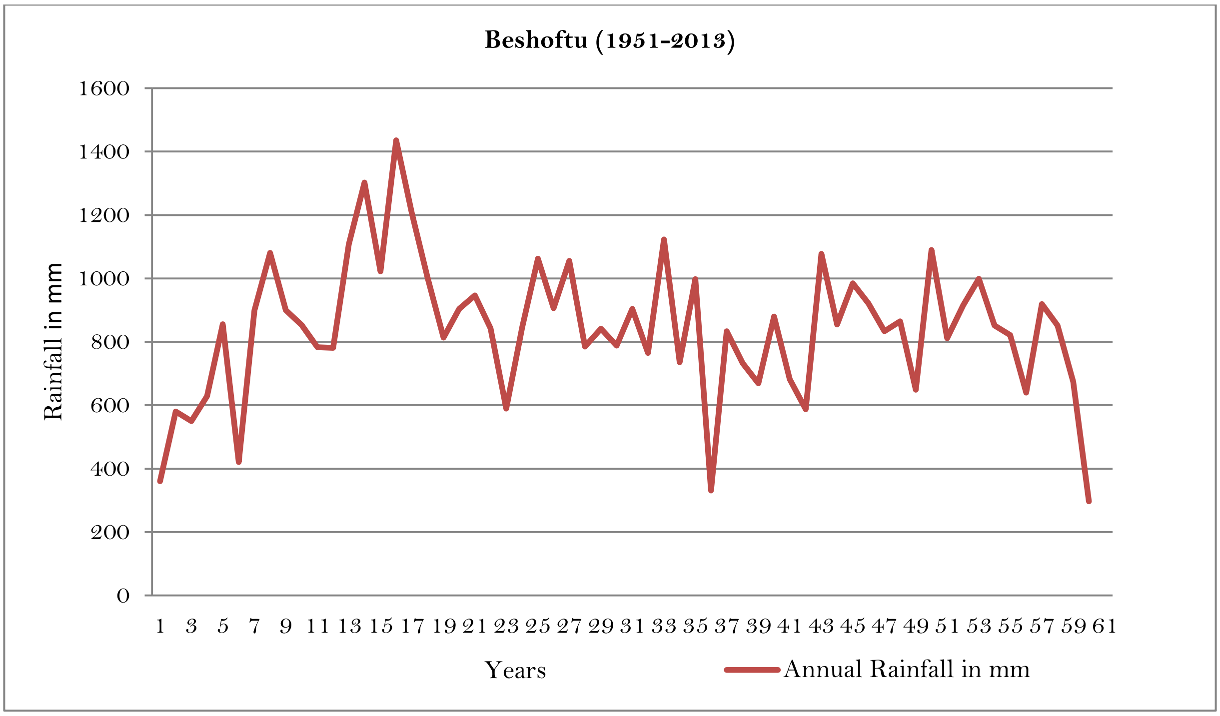

Figure 7: Annual rainfall in *Beshoftu* weather station.
Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

Table 6: Variation of annual maximum and minimum temperature in *Beshoftu* (1951-2013).

	Year	**Average Annual Temp. (Max)**	**Average Annual Temp. (Min)**	**Mean Annual Temperature**
Beshoftu	1951	25.56	9.95	17.75
Beshoftu	1955	26.27	10.84	18.55
Beshoftu	1960	26.19	11.56	18.87
Beshoftu	1965	26.50	11.69	19.09
Beshoftu	1970	26.34	11.80	19.07
Beshoftu	1975	25.49	11.03	18.26
Beshoftu	1980	26.58	11.28	18.93
Beshoftu	1985	25.96	10.80	18.38
Beshoftu	1990	26.30	11.95	19.13
Beshoftu	1995	26.86	12.43	19.65
Beshoftu	2000	26.72	12.10	19.41
Beshoftu	2005	26.60	10.37	18.48
Beshoftu	2010	26.54	11.02	18.78
Beshoftu	2013	29.45	10.91	20.18

Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

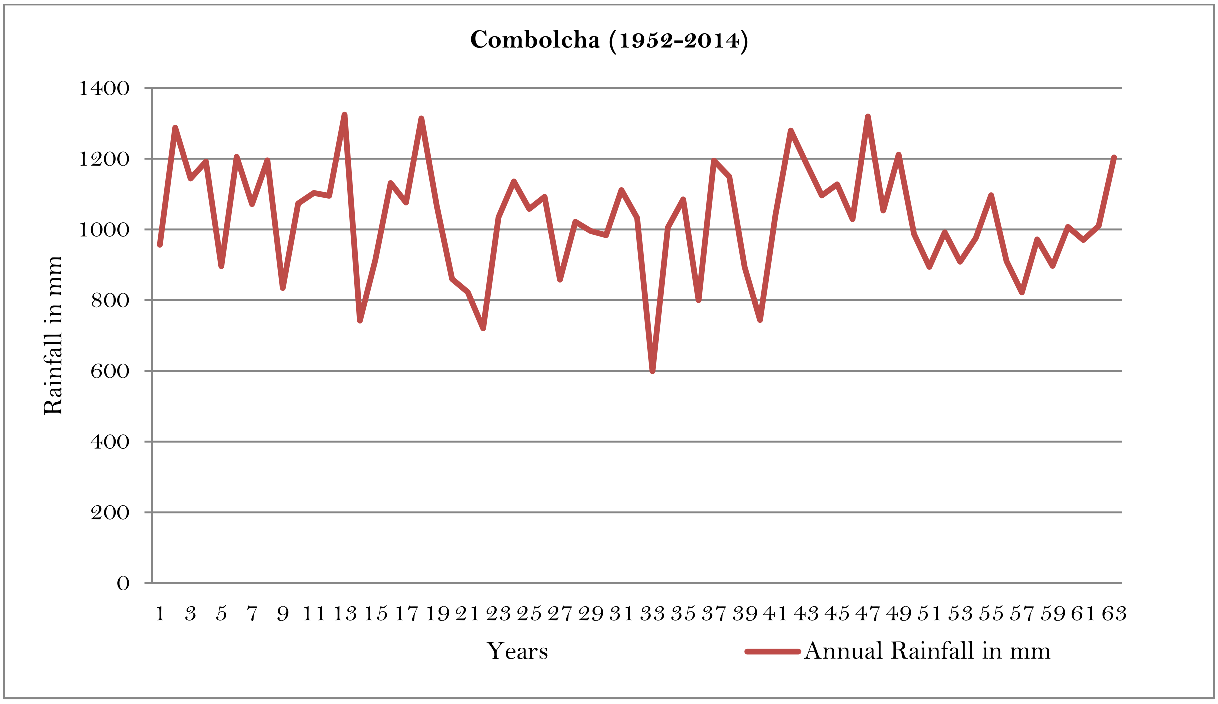

Figure 8: Annual rainfall in *Combolcha* weather station.
Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

Table 7: Variation of annual maximum and minimum temperature in *Combolcha* (1952-2015).

	Year	**Average Annual Temp. (Max)**	**Average Annual Temp. (Min)**	**Mean Annual Temperature**
Combolcha	1952	20.98	8.34	14.66
Combolcha	1955	23.15	12.24	17.69
Combolcha	1960	26.80	12.65	19.7
Combolcha	1965	25.90	11.87	18.89
Combolcha	1970	26.00	12.40	19.20
Combolcha	1975	24.99	10.65	17.82
Combolcha	1980	26.38	11.75	19.07
Combolcha	1985	26.05	5.59	15.82
Combolcha	1990	26.50	12.96	19.73
Combolcha	1995	26.38	12.60	19.49
Combolcha	2000	26.80	11.79	19.30
Combolcha	2005	27.25	12.20	19.73
Combolcha	2010	27.49	13.325	20.40
Combolcha	2015	28.11	12.85	20.48

Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

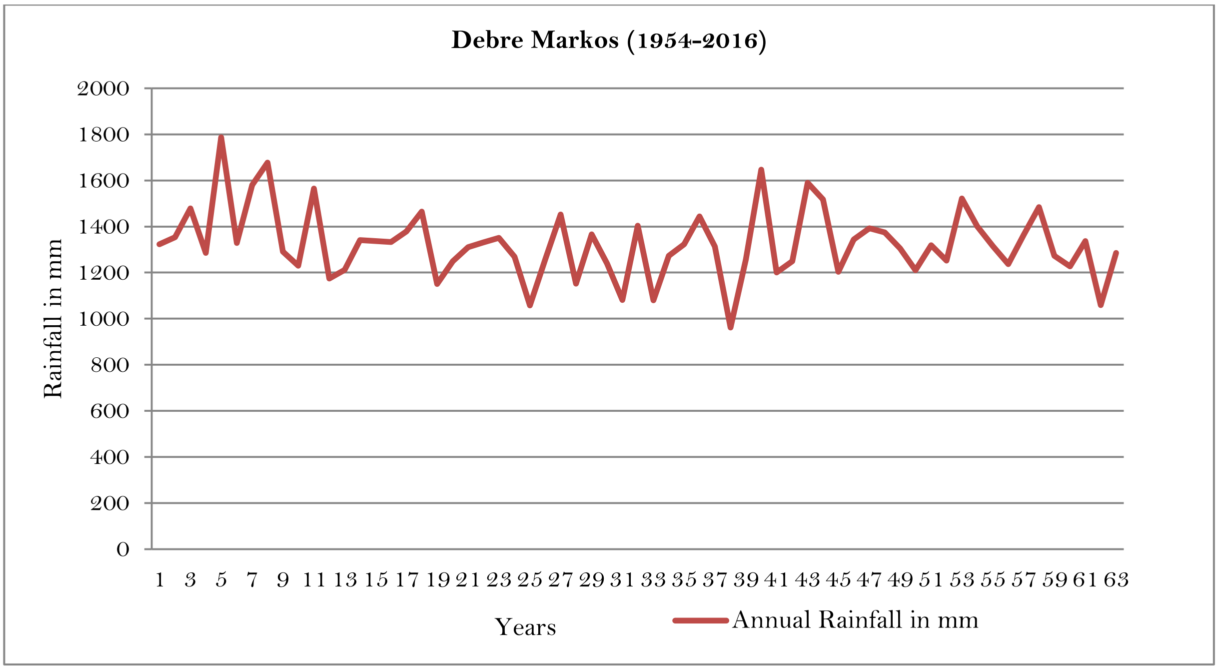

Figure 9: Annual rainfall in *Debre Markos* weather station.
Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

Table 8: Variation of annual maximum and minimum temperature in *Debre Markos* (1955-2015).

	Year	Average Annual Temp. (Max)	Average Annual Temp. (Min)	Mean Annual Temperature
Debre Markos	1955	21.58	8.90	15.24
Debre Markos	1960	22.25	8.15	15.20
Debre Markos	1965	21.98	8.58	15.28
Debre Markos	1970	22.96	9.94	16.45
Debre Markos	1975	22.40	9.12	15.76
Debre Markos	1980	22.45	10.00	16.22
Debre Markos	1985	21.90	10.21	16.06
Debre Markos	1990	22.57	9.51	16.04
Debre Markos	1995	23.34	10.56	16.95
Debre Markos	2000	22.60	10.09	16.35
Debre Markos	2005	23.05	10.60	16.83
Debre Markos	2010	23.05	11.12	17.09
Debre Markos	2015	23.56	11.18	17.37

Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

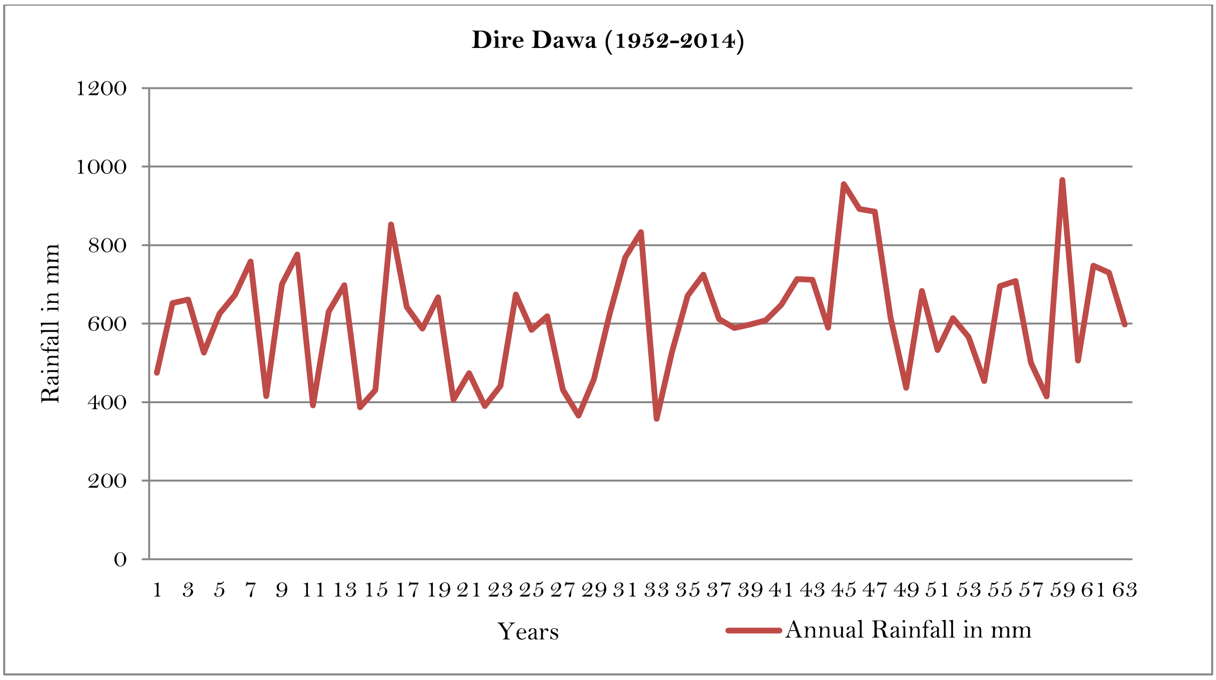

Figure 10: Annual rainfall in *Dire Dawa* weather station.
Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

Table 9: Variation of annual maximum and minimum temperature in *Dire Dawa* (1952-2015).

	Year	Average Annual Temp. (Max)	Average Annual Temp. (Min)	Mean Annual Temperature
Dire Dawa	1952	32.58	12.56	22.57
Dire Dawa	1955	31.69	18.03	24.86
Dire Dawa	1960	31.26	18.68	24.97
Dire Dawa	1965	31.22	18.19	24.70
Dire Dawa	1970	31.07	18.79	24.93
Dire Dawa	1975	31.26	18.79	25.02
Dire Dawa	1980	31.20	19.60	25.40
Dire Dawa	1985	31.21	19.14	25.17
Dire Dawa	1990	31.45	19.30	25.37
Dire Dawa	1995	32.36	19.33	25.85
Dire Dawa	2000	32.58	18.79	25.68
Dire Dawa	2005	32.93	19.19	26.06
Dire Dawa	2010	32.65	19.15	25.90
Dire Dawa	2015	33.00	18.43	25.71

Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

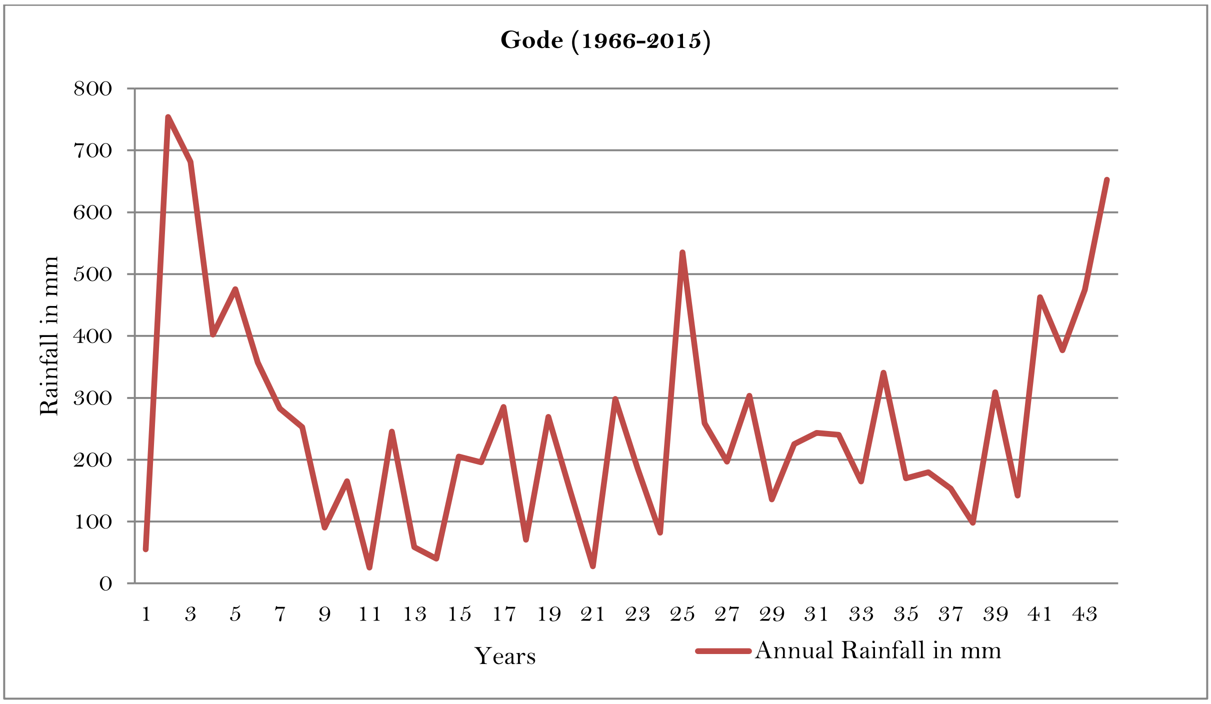

Figure 11: Annual rainfall in *Gode* weather station.
Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

Table 10: Variation of annual maximum and minimum temperature in *Gode* (1966-2015).

	Year	Average Annual Temp. (Max)	Average Annual Temp. (Min)	Mean Annual Temperature
Gode	1966	34.82	21.14	27.98
Gode	1970	35.00	22.63	28.82
Gode	1975	34.80	22.93	28.86
Gode	1980	34.39	23.46	28.92
Gode	1985	34.14	21.95	28.05
Gode	1990	34.62	23.38	29.00
Gode	2000	34.61	23.20	28.91
Gode	2005	35.21	24.24	29.72
Gode	2010	35.56	24.51	30.0
Gode	2015	35.31	24.04	29.67

Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

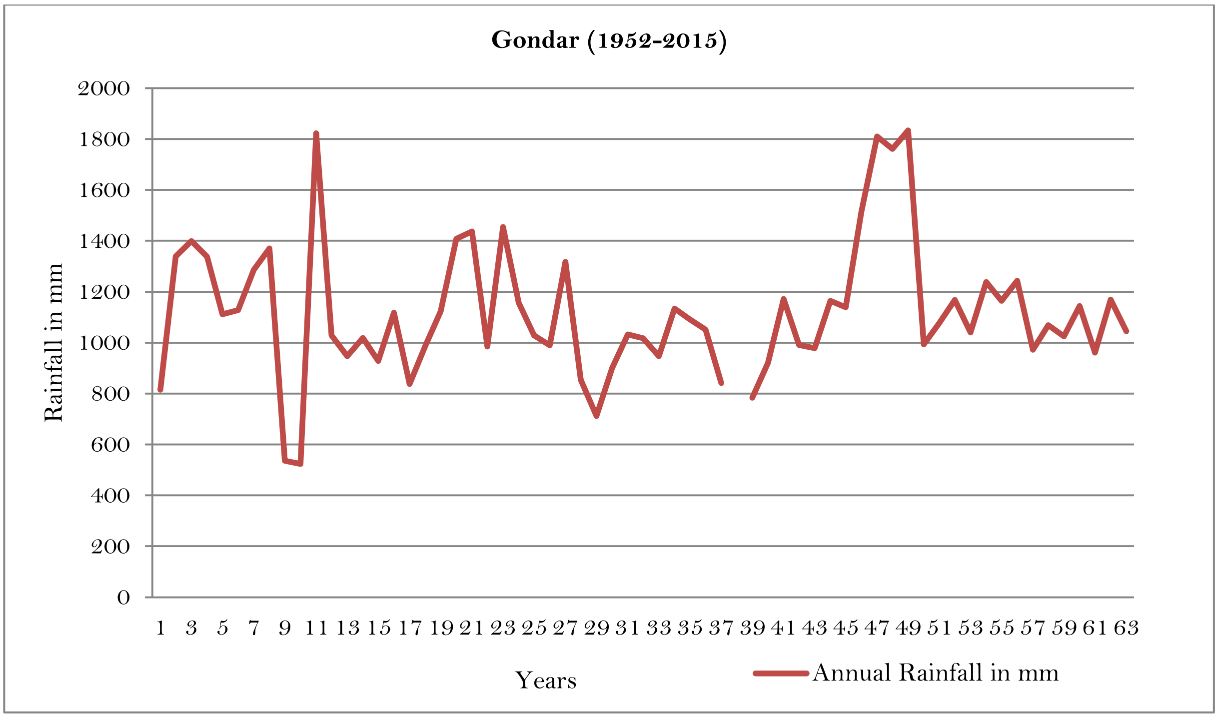

Figure 12: Annual rainfall in *Gondar* weather station.
Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

Table 11: Variation of annual maximum and minimum temperature in *Gondar* (1952-2015).

	Year	Average Annual Temp. (Max)	Average Annual Temp. (Min)	Mean Annual Temperature
Gondar	1952	25.65	11.90	18.77
Gondar	1955	25.87	11.42	18.65
Gondar	1960	25.46	11.28	18.37
Gondar	1965	26.63	12.55	19.59
Gondar	1970	27.04	12.76	19.90
Gondar	1975	26.71	13.35	20.03
Gondar	1980	26.55	13.40	19.97
Gondar	1984	26.77	13.55	20.16
Gondar	1990	26.7	12.32	19.54
Gondar	1995	27.33	14.37	20.85
Gondar	2000	27.30	11.58	19.44
Gondar	2005	27.46	13.88	20.67
Gondar	2010	28.00	13.45	20.73
Gondar	2015	27.40	13.94	20.67

Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

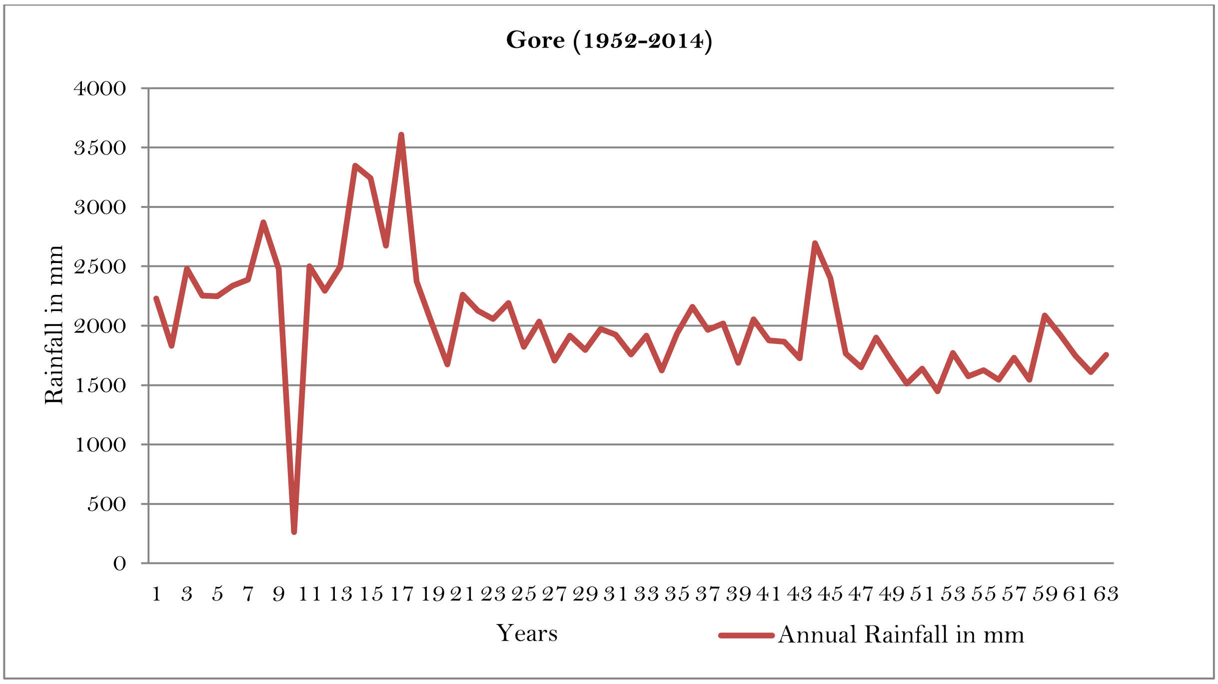

Figure 13: Annual rainfall in *Gore* weather station.
Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

Table 12: Variation of annual maximum and minimum temperature in *Gore* (1952-2015).

	Year	Average Annual Temp. (Max)	Average Annual Temp. (Min)	Mean Annual Temperature
Gore	1952	22.16	12.56	17.36
Gore	1955	22.79	12.90	17.85
Gore	1960	23.40	12.94	18.17
Gore	1965	22.35	13.11	17.73
Gore	1970	23.41	13.06	18.24
Gore	1975	22.67	13.14	17.90
Gore	1980	23.44	13.77	18.60
Gore	1985	22.50	13.70	18.10
Gore	1990	25.20	14.70	19.95
Gore	1995	24.56	13.78	19.17
Gore	2000	24.01	13.64	18.82
Gore	2005	24.50	14.62	19.56
Gore	2010	24.20	14.65	19.42
Gore	2015	24.60	14.12	19.36

Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

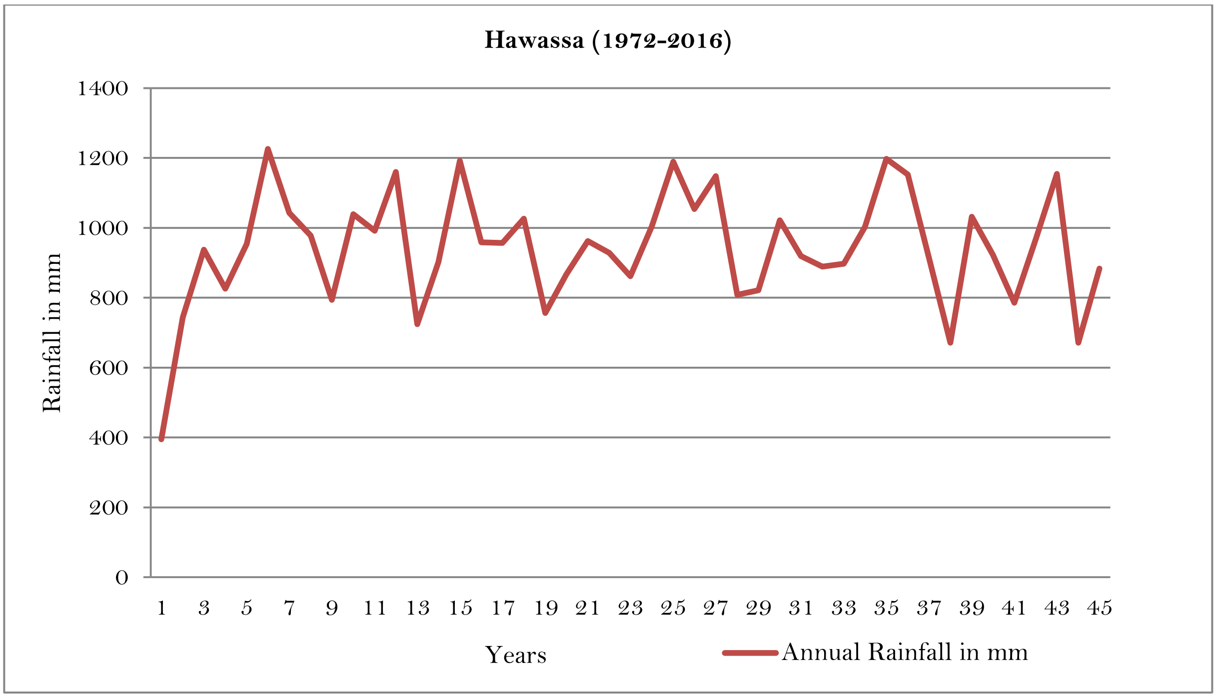

Figure 14: Annual rainfall in *Hawassa* weather station.
Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

Table 13: Variation of annual maximum and minimum temperature in *Hawassa* (1975-2015).

	Year	Average Annual Temp. (Max)	Average Annual Temp. (Min)	Mean Annual Temperature
Hawassa	1975	25.79	11.57	18.68
Hawassa	1980	27.18	12.61	19.90
Hawassa	1985	26.42	11.05	18.74
Hawassa	1990	27.21	12.30	19.76
Hawassa	1995	27.86	12.55	20.20
Hawassa	2000	27.35	12.41	19.88
Hawassa	2005	27.61	12.81	20.21
Hawassa	2010	27.05	14.20	20.62
Hawassa	2015	28.54	14.35	21.44

Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

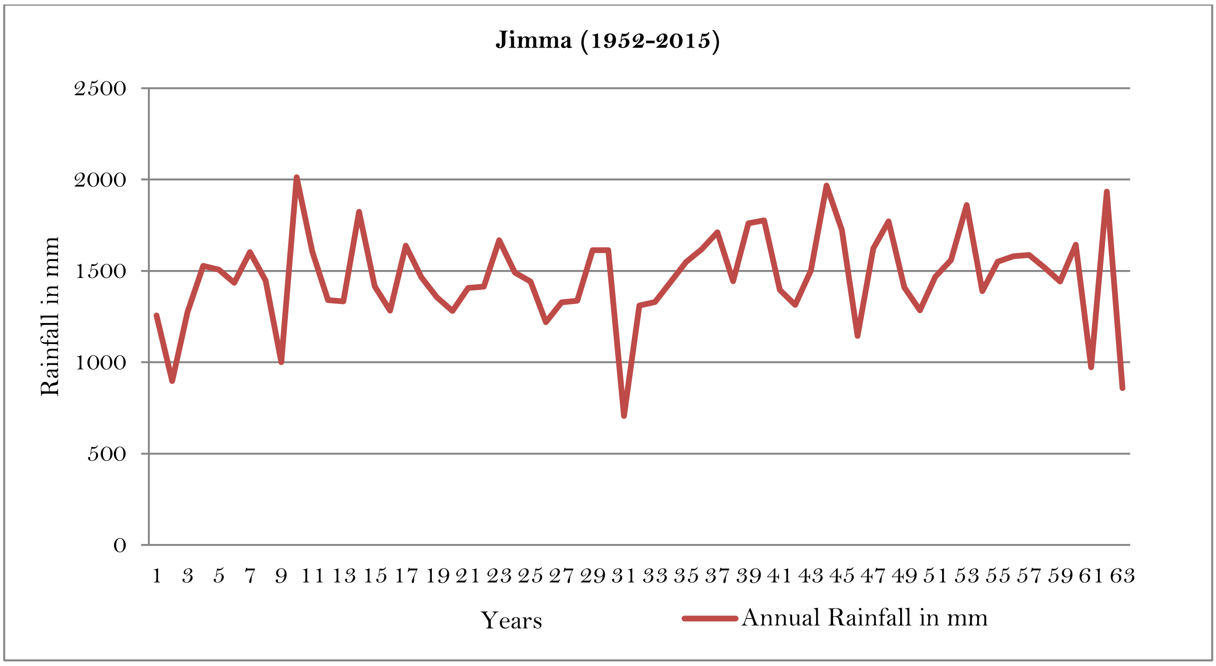

Figure 15: Annual rainfall in *Jimma* weather station.
Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

Table 14: Variation of annual maximum and minimum temperature in *Jimma* (1952-2015).

	Year	Average Annual Temp. (Max)	Average Annual Temp. (Min)	Mean Annual Temperature
Jimma	1952	25.76	11.25	18.50
Jimma	1955	26.95	10.12	18.54
Jimma	1960	28.28	10.33	19.30
Jimma	1965	26.69	10.95	18.82
Jimma	1970	26.18	11.28	18.73
Jimma	1975	26.39	10.81	18.60
Jimma	1980	27.18	11.20	19.19
Jimma	1985	26.97	10.69	18.83
Jimma	1990	26.52	11.50	19.01
Jimma	1995	28.05	11.83	19.94
Jimma	2000	28.62	10.95	19.79
Jimma	2005	27.90	11.31	19.60
Jimma	2010	27.37	12.91	20.14
Jimma	2015	28.54	12.32	20.43

Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

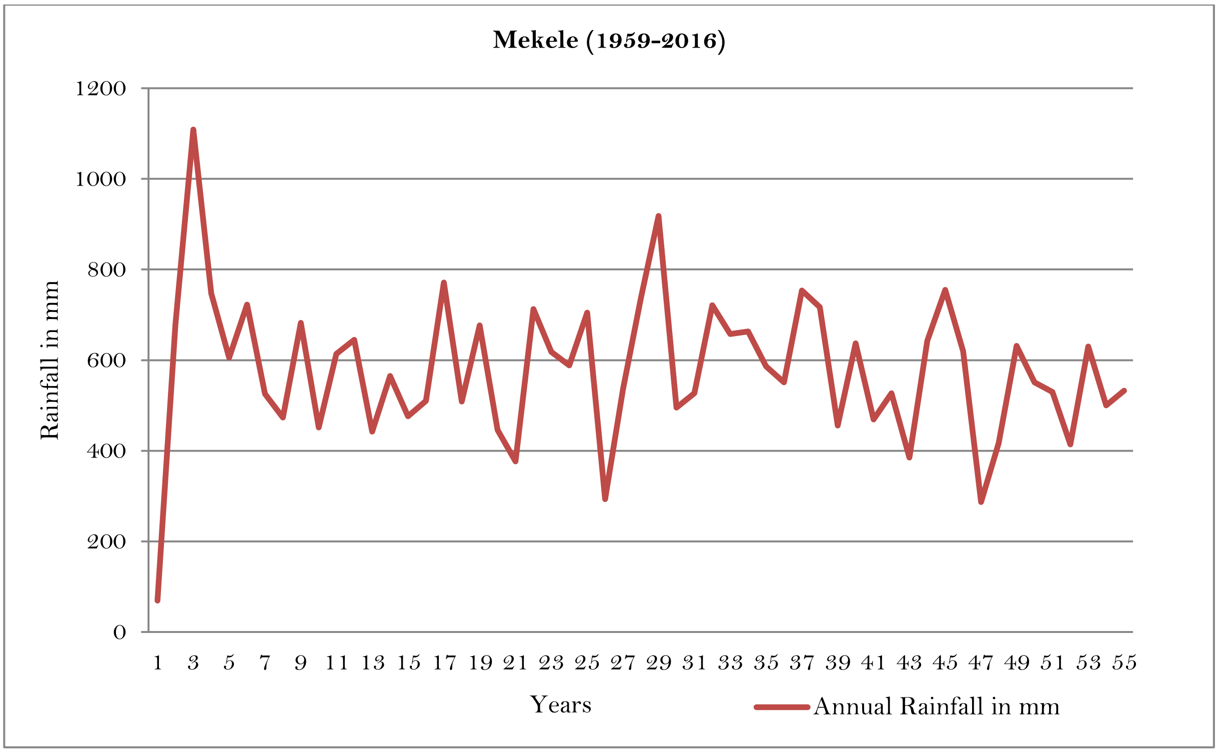

Figure 16: Annual rainfall in *Mekele* weather station.
Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

Table 15: Variation of annual maximum and minimum temperature in *Mekele* (1960-2015).

	Year	Average Annual Temp. (Max)	Average Annual Temp. (Min)	Mean Annual Temperature
Mekele	1960	24.38	10.87	17.62
Mekele	1965	25.53	11.60	18.57
Mekele	1970	25.67	11.60	18.63
Mekele	1975	22.56	11.41	16.99
Mekele	1980	24.21	11.11	17.66
Mekele	1985	24.12	10.30	17.21
Mekele	1990	22.40	11.20	11.20
Mekele	1995	23.93	11.83	17.88
Mekele	2000	24.46	11.85	18.15
Mekele	2005	24.50	11.52	18.01
Mekele	2010	24.45	12.00	18.23
Mekele	2015	24.58	11.88	18.23

Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

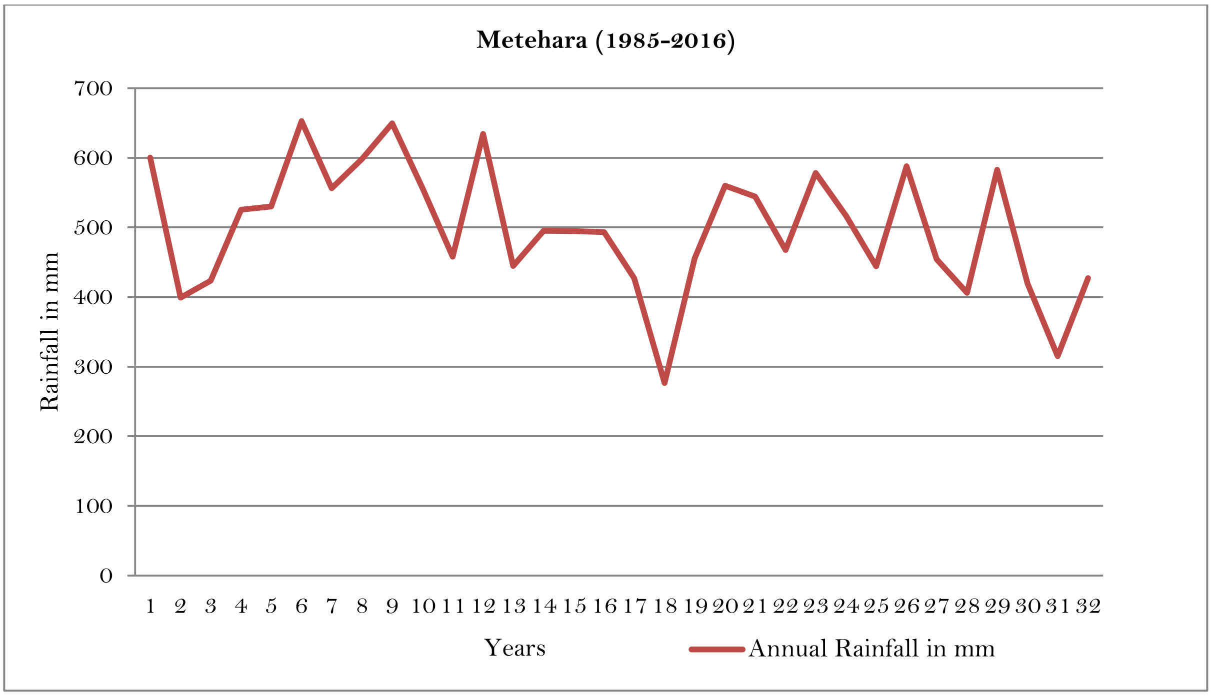

Figure 17: Annual rainfall in *Metehara* weather station.
Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

Table 16: Variation of annual maximum and minimum temperature in *Metehara* (1985-2015).

	Year	Average Annual Temp. (Max)	Average Annual Temp. (Min)	Mean Annual Temperature
Metehara	1985	33.27	16.50	24.89
Metehara	1990	32.97	17.76	25.37
Metehara	1995	33.80	18.55	26.17
Metehara	2000	33.62	17.21	25.42
Metehara	2005	34.06	17.80	25.93
Metehara	2010	33.82	18.32	26.07
Metehara	2015	35.19	18.58	26.88

Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

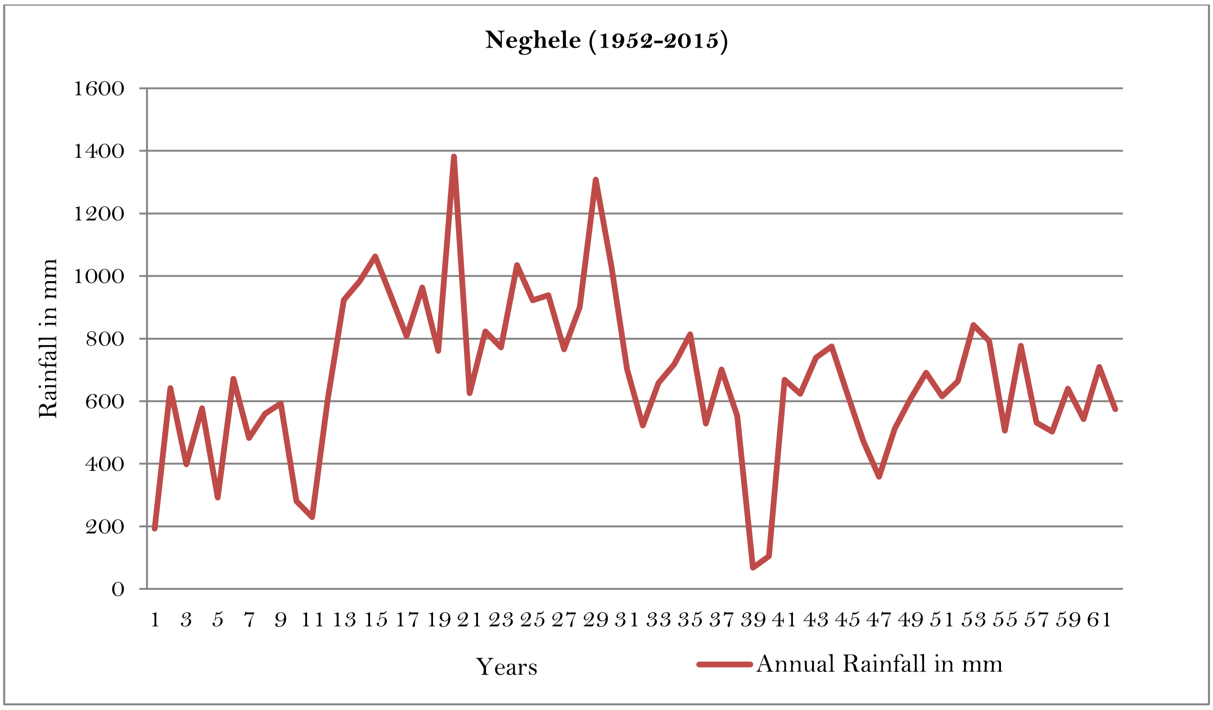

Figure 18: Annual rainfall in *Neghele* weather station.
Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

Table 17: Variation of annual maximum and minimum temperature in *Neghele* (1952-2015).

	Year	**Average Annual Temp. (Max)**	**Average Annual Temp. (Min)**	**Mean Annual Temperature**
Neghele	1952	25.10	12.22	18.66
Neghele	1955	24.88	11.87	18.37
Neghele	1960	25.67	13.65	19.66
Neghele	1965	25.97	12.25	19.11
Neghele	1970	25.31	13.45	19.38
Neghele	1975	25.35	12.99	19.17
Neghele	1980	27.08	13.01	20.05
Neghele	1985	25.03	13.22	19.12
Neghele	1990	27.46	15.01	21.23
Neghele	1995	26.35	15.89	21.12
Neghele	2000	26.64	14.86	20.75
Neghele	2005	26.33	16.24	21.28
Neghele	2010	27.06	16.46	21.76
Neghele	2015	28.22	16.66	22.44

Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

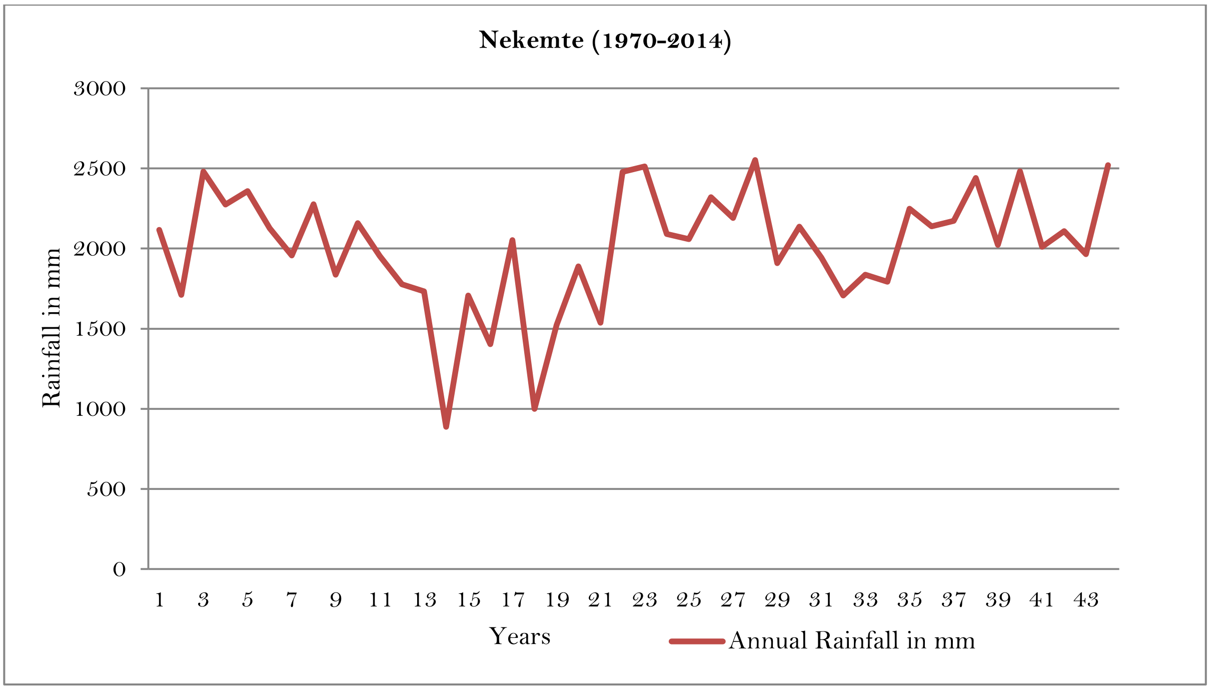

Figure 19: Annual rainfall in *Nekemte* weather station.
Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

Table 18: Variation of annual maximum and minimum temperature in *Nekemte* (1970-2015).

	Year	Average Annual Temp. (Max)	Average Annual Temp. (Min)	Mean Annual Temperature
Nekemte	1970	24.00	10.50	17.25
Nekemte	1975	23.15	10.97	17.06
Nekemte	1980	23.48	12.65	18.06
Nekemte	1985	23.18	12.11	17.65
Nekemte	1990	23.99	13.03	18.51
Nekemte	1995	24.35	13.16	18.75
Nekemte	2000	24.40	12.80	18.60
Nekemte	2005	24.87	13.28	19.00
Nekemte	2010	24.56	13.41	18.99
Nekemte	2015	24.15	12.99	18.57

Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

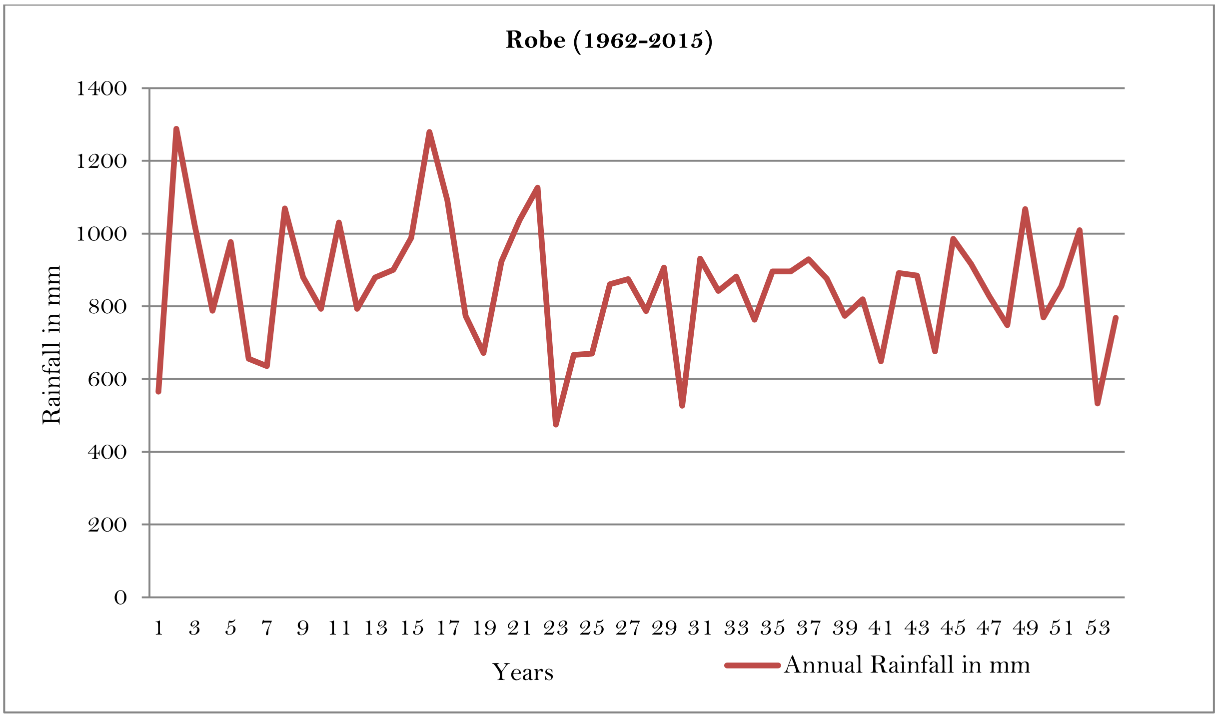

Figure 20: Annual rainfall in *Robe* weather station.
Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

Table 19: Variation of annual maximum and minimum temperature in *Robe* (1962-2015).

	Year	Average Annual Temp. (Max)	Average Annual Temp. (Min)	Mean Annual Temperature
Robe	1962	19.65	5.80	12.72
Robe	1965	18.40	5.97	12.19
Robe	1970	19.40	6.47	12.93
Robe	1975	19.69	5.95	12.82
Robe	1980	21.45	6.55	14.00
Robe	1985	21.22	9.01	15.12
Robe	1990	21.61	8.42	15.02
Robe	1995	21.91	7.95	14.93
Robe	2000	21.99	6.18	14.08
Robe	2005	22.45	7.95	15.20
Robe	2010	21.85	9.01	15.43
Robe	2015	22.83	8.60	15.72

Source: Computed based on raw data from National Metrology Agency (NMA) of Ethiopia.

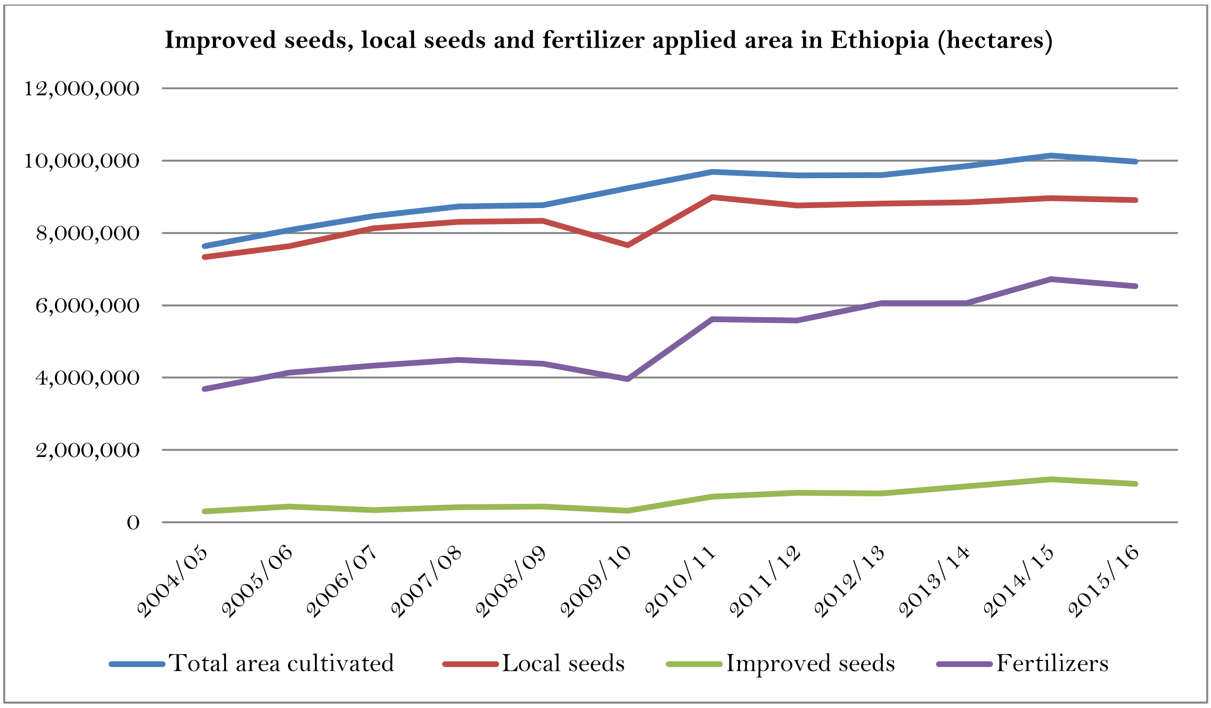

Figure 21: Area cultivated under improved seeds, local seeds and fertilizer for cereals only in Ethiopia.
Source: Computed based on raw data from Central Statistical Agency (CSA) of Ethiopia.

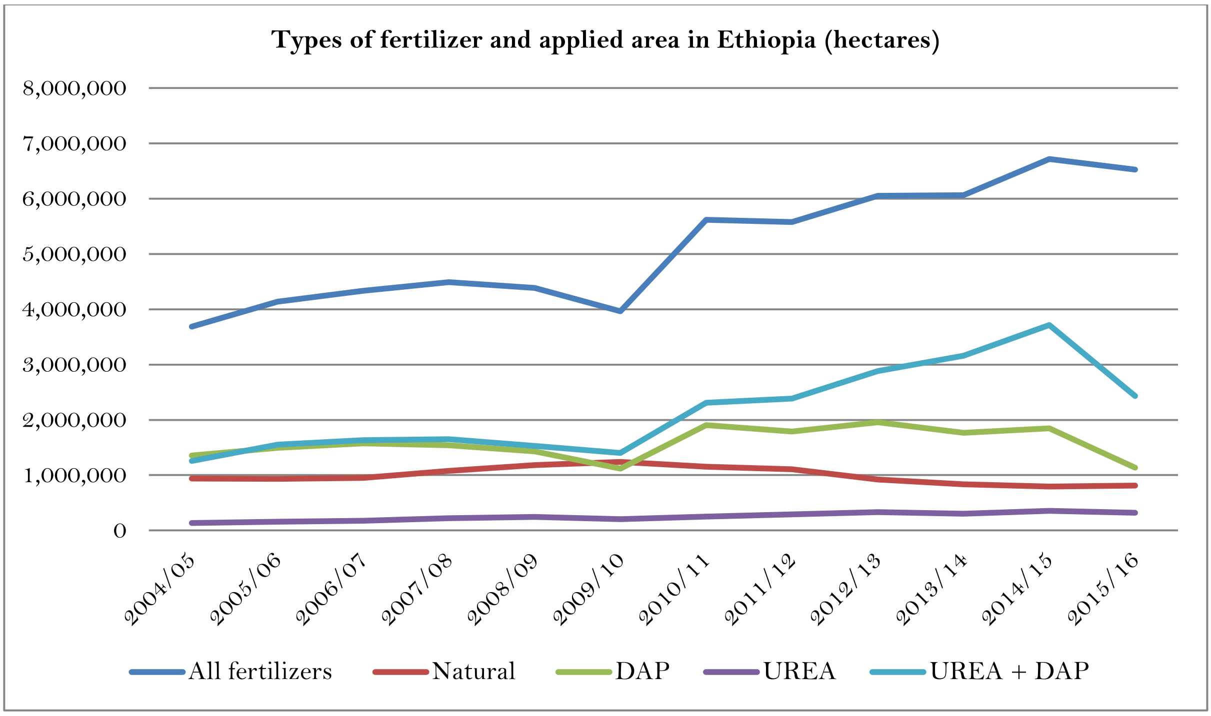

Figure 22: Fertilizer applied area and types of fertilizer for cereals only in Ethiopia.
Source: Computed based on raw data from Central Statistical Agency (CSA) of Ethiopia.

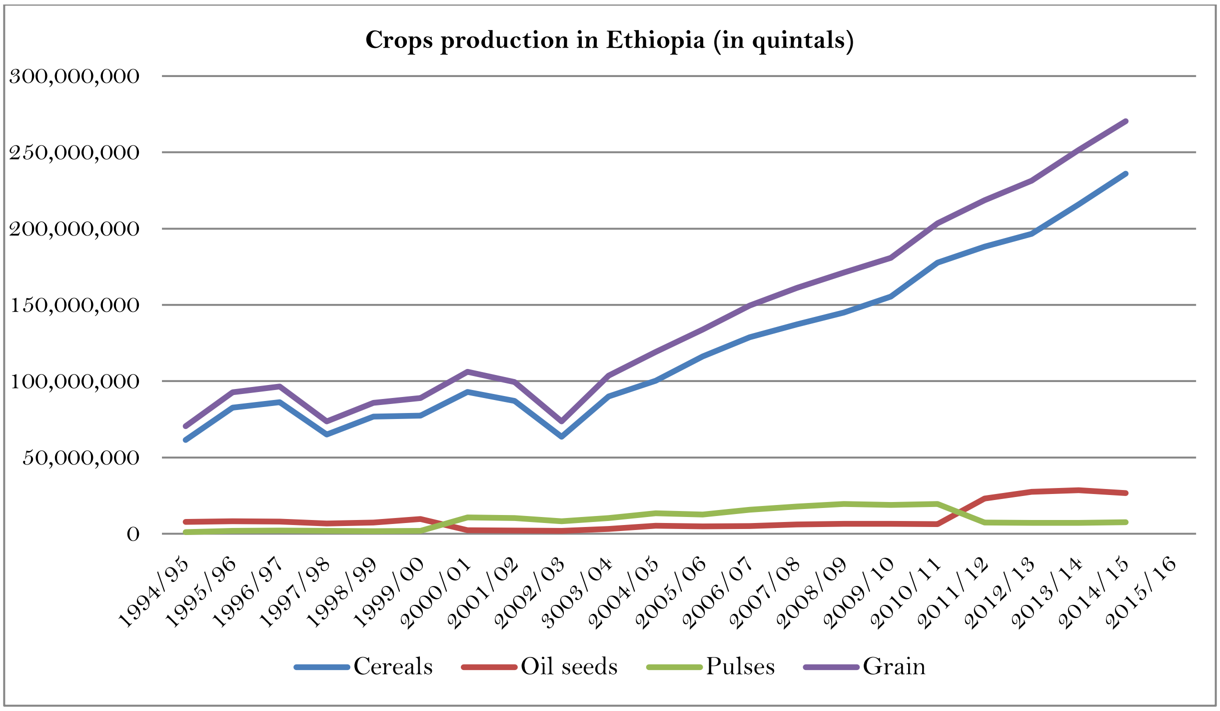

Figure 23: Major crops production in Ethiopia (1994/95–2014/15).
Source: Computed based on raw data from Central Statistical Agency (CSA) of Ethiopia.
Note: Grain refers to all cereals, pulses and oil seeds. 1 quintal =100kg.

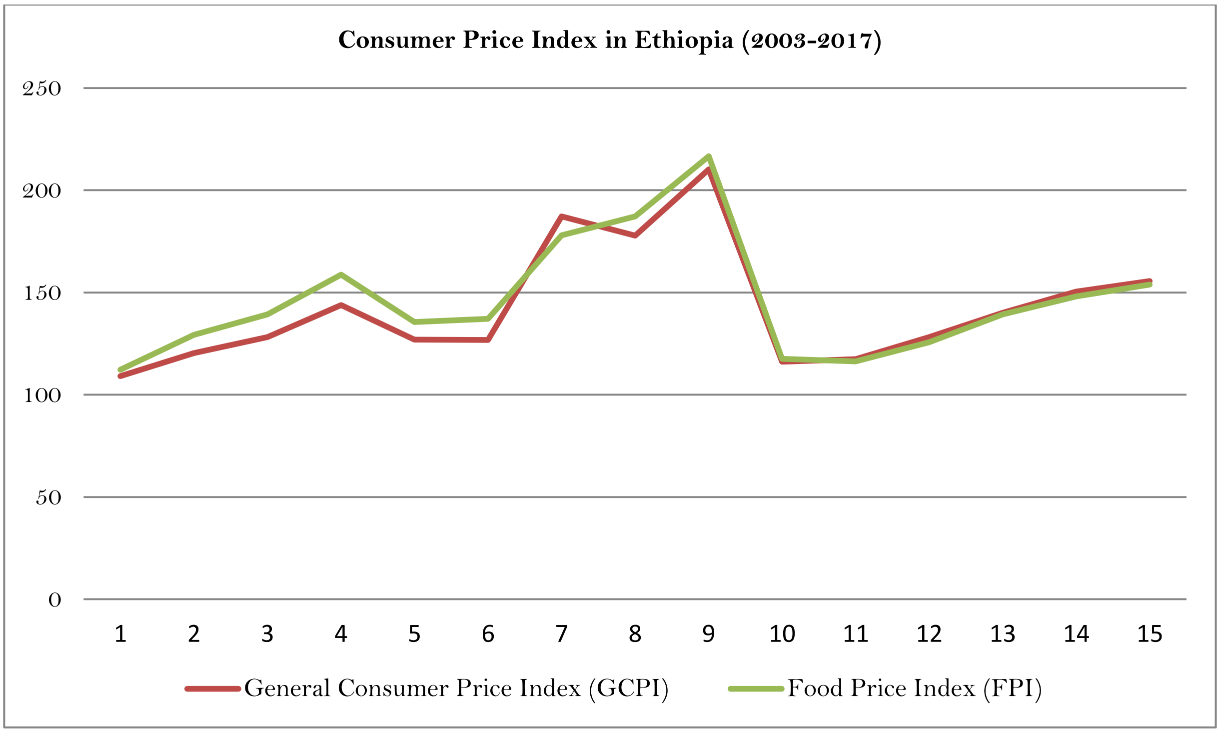

Figure 24: Consumer Price Index in Ethiopia.
Source: Computed based on raw data from Central Statistical Agency (CSA) of Ethiopia.

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