Climate risk and food security in Ethiopia:

Analysis of climate impacts on food security and livelihoods

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This analysis is part of the Resilience Project Initiative coordinated by WFP's Office for Climate Change, Environment and Disaster Risk Reduction. The Resilience Project is a collaborative effort between WFP, the Swiss Agency for Development and Cooperation and partners to strengthen the capacities of governments and other key partners to provide effective support for greater resilience in the context of food and nutrition security.

This analysis is also part of the Climate Adaptation, Management and Innovations Initiative (C-ADAPT), funded by the Government of Sweden's fast-track climate financing. C-ADAPT is a collaborative effort between WFP, the Government of Sweden and partners to strengthen capacities of governments and other partners to improve climate risk analysis for adaptation planning and programming.

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Executive summary

Food security is highly sensitive to climate risks in Ethiopia. Historical and more recent climate-related events such as the 2008/2009 and 2011 food security crises in the Horn of Africa have highlighted the impact of droughts and floods on food production, access to markets, and income from agricultural activities. However, assessing the ways in which livelihoods and specific vulnerabilities are linked to climate is a difficult task given the complex relationships between other environmental and socioeconomic factors in determining food security outcomes.

Recognising these challenges, the purpose of this analysis is to contribute to a quantitative and qualitative assessment of climate risk impacts (including climate variability, change, and extremes) on food security and livelihoods. The analytical method carried out for this research consists of two main components: (i) a dynamic analysis to evaluate the relationship between historic and current climatic variability and food security indicators, using long-term historical data; and (ii) a descriptive analysis to establish a baseline against which vulnerability to future risks can be assessed.

The analysis highlights the following trends:

Climate: Recent rainfall data show trends of overall declines in rainfall between March and September from 1980 to the present. These declines have been most marked in *belg*-dependent areas leading to more intense and frequent droughts across different the country. In addition, some analyses suggest that there has been a shift in the timing of rainfall, leading to more erratic and unpredictable precipitation patterns.

Climate impacts on food production: With a predominantly rain-fed agricultural system, rainfall is one of the main climatic determinants of food production in Ethiopia. Wetter years are generally associated with higher food production; conversely dry years are linked to lower production.

Climate impacts on food access: Access to markets is critical for food security in Ethiopia: even in the most productive areas, poorer farmers purchase some of their food. This is especially the case in the pastoral areas, as well as in agricultural areas where rainfall has become increasingly erratic. Households depend heavily on markets and in-kind contributions during the agricultural lean seasons. If March-September precipitation continues to decline, food access could be affected in two inter-related ways. First, reduced crop production due to lower precipitation would force households to purchase more of their food. Second, climate-induced food price volatility could require households to spend more of their income on food. In addition, climate-related disasters limit physical access to markets.

Climate impacts on livelihoods: Across most of Ethiopia, households report lack of/erratic rainfall as the main risk contributing to their food insecurity and overall vulnerability. The poorest farmers rely especially on food-based coping strategies such as reducing the quantity or quality of meals. Similarly, they rely on livestock sales – often selling their last productive female – or temporary labour migration. In recent years, however, there has been limited capacity of host areas to offer employment due to increasingly erratic rainfall which is reducing labour availability.

Based on these trends, the following recommendations to manage climate risks are proposed:

Mainstreaming climate risk management into development and food security strategies
Integrating climate risk management structures into broader development pathways offers a cost-effective manner to address multiple development challenges, while accounting for the emerging risks posed by climate variability and change. Disaster risk reduction structure, social protection and safety nets offer critical platforms and vehicles for investing in risk management for the most vulnerable and should become a policy priority. Scaling up risk management is critical in view of a changing risk environment characterised by increasing risks as well as larger numbers of people exposed to these risks. Successful scaling up should be implemented at the community level, as well as at the national, regional and global levels by adapting successful experiences and best practices in resilience building.

Focus on the most vulnerable
All rural livelihood systems in Ethiopia are highly sensitive to climate given the dependence of cropping, pastoral and agropastoral communities on rainfall. Recent climate trends show that rainfall is decreasing in the south-central, southeastern, and northern parts of the country, while the western parts of the country have been receiving more rainfall potentially increasing the magnitude of droughts and floods. Strategies for *livelihood and income diversification* are critical to ensuring resilience against more intense climate-related risks. For example, migration (both seasonal and permanent) has become an important source of household income for at-risk populations. *Landscape transformation* through land rehabilitation can also be a cost-effective solution to manage climate risks, by contributing to both drought and flood risk management.

Manage uncertainties associated with climate change
Both droughts and floods can occur in the same growing season, with potentially devastating impacts on crop and livestock production. Strategies to address climate risk should focus on developing capacities to better analyse and anticipate risks. The introduction of *early warning systems and contingency plans* can support climate risk management and food security strategies.

Summary of climate-related vulnerabilities

The following table summarises some of the key findings of this analysis.

REGION	RAINFALL TREND	LIVELIHOOD ACTIVITIES	VULNERABILITY
 Northeast	March-September rains have declined significantly since the mid-1990s	Primarily pastoral, some cropping and agropastoral zones towards the south	**Disaster risk trend:** Potential increase in drought risk, which could affect migration patterns of Afar pastoralists into cropping areas and exacerbate conflict. **Income sources:** High reliance on livestock sales. Livestock could decrease in quantity and quality if availability of pasture decreases as a result of lower rainfall. **Food sources:** Households across all wealth groups depend on markets. Food price increases could be linked to climate variability, and could have a negative impact on these households. Households also depend on their own milk and meat production, which could decrease in quantity and quality if pastures become limited.
 Northwest	March-September rains have remained relatively constant, and appear to be increasing	Cropping	**Disaster risk trend:** Potential increase in flood risk. **Income sources:** High reliance on crop sales, labour migration, and agricultural labour. Availability of agricultural labour is linked to climate trends, so erratic rainfall could affect the poorest households that depend on this type of labour. **Food sources:** Poorest households depend on market for over half of their food. Food price increases could be linked to climate variability, and could have a negative impact on these households.
 Southeast	Rainfall has been declining constantly since the 1980s, with the last few years being particularly dry	Primarily pastoral, some cropping and agropastoral in the northernmost parts of this region and along the rivers	**Disaster risk trend:** Potential increase in drought risk, associated with a northwestward retreat of *belg* rains. Drought risk could also be linked to higher incidence of livestock diseases. **Income sources:** High reliance on livestock sales and self-employment. Livestock could decrease in quantity and quality if availability of pasture decreases due to lower rainfall. **Food sources:** Households across all wealth groups are especially dependent on markets. Food price increases could be linked to climate variability, and could have a negative impact on these households.
 Southwest	Rainfall has been declining steadily since the 1960s, and this trend has accelerated since the mid-1990s	Cropping and agropastoral	**Disaster risk trend:** Potential increase in drought risk, associated with a northwestward retreat of both *belg* and *meher* rains. **Income sources:** High reliance on crop sales and agricultural labour. Crop production could decrease as a result of lower rainfall. Availability of agricultural labour is linked to climate trends, so erratic rainfall could affect the poorest households that depend on this type of labour. **Food sources:** Poorest households depend on markets and food assistance. Food price increases could be linked to climate variability, and could render these households increasingly dependent on food assistance.

Part I: Introduction and context

Summary

- Food security is highly vulnerable to climate-related risks in Ethiopia.
- There are multiple drivers of food insecurity in Ethiopia – including drought risk, environmental degradation, demographic pressure, rural-urban migration, and conflict. In the absence of adaptation measures, climate variability and change act as risk multipliers, exacerbating the conditions which affect food security trends.
- Rainfall patterns are extremely complex in Ethiopia. Recent trends show that rainfall in the period March-September has decreased significantly since the 1990s across most of the country (particularly in northern, south-central and south-eastern parts of the country). There is also high inter-seasonal variability with *belg* rains (February-May) being more variable than *meher* rains (June-October).

Introduction

Climate trends are important in Ethiopia. The World Bank (2006) has linked changes in economic productivity to rainfall variability such that years with higher economic growth are associated with years with higher rainfall (cf. Figure 1). Food security is among the most climate-sensitive sectors in the country; the National Adaptation Programme of Action (NAPA) prioritises agriculture and food security as the most vulnerable sectors to the adverse effects of climate change and variability.

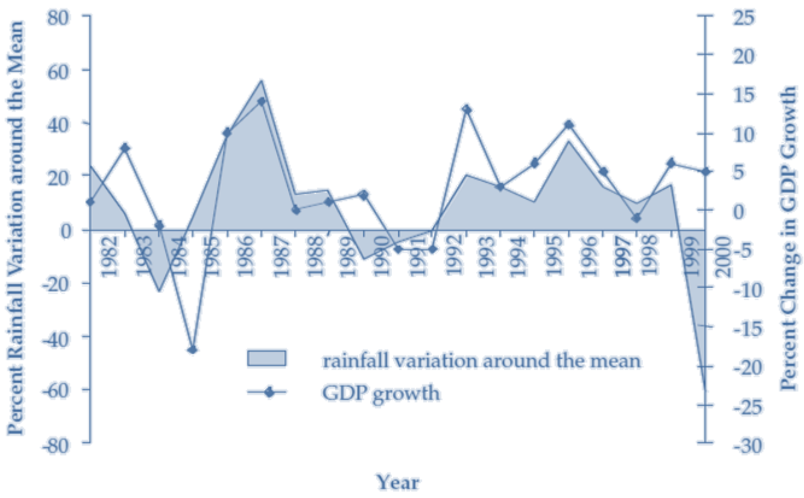

Figure 1. Relationship between rainfall variation and GDP growth. [Source: World Bank, 2006]

This report presents the findings of an analysis carried out to identify relationships between climate and food security. Any such analysis is inherently complex given that it is difficult to isolate the impacts of climate trends on socioeconomic issues, particularly food and nutrition security. In the context of Ethiopia, in particular, the geography and topography, as well as the complexity of the livelihood systems add layers of complexity. Moreover, it is difficult to isolate impacts at the national level from regional and global trends such as market and trade relations.

Recognising these limitations, the analysis presented here provides a foundation to better understand the links between climate risk and food security. The analysis has three main objectives.

(1) Identify spatial *and* temporal relationships between food security and climate.

(2) Establish a vulnerability baseline to assess the factors that contribute to household vulnerability to climate risks.

(3) Identify a set of key policy priorities to build adaptive capacity and reduce climate-related food insecurity in the most vulnerable communities.

National context

Demography

Ethiopia is a landlocked country in the Horn of Africa with a population of approximately 82.9 million (UN, 2010). Population density, especially in rural areas, is linked to land use. The majority of the rural population lives in the highlands and middle highlands which comprise less than one-third of inhabited surface area of the country (Figure 2). In parts of the Southern Nations, Nationalities and Peoples Region (SNNPR), population density is as high as 300 people per square km. The lowest density, with less than 10 people per square km, is found in the pastoralist areas. There is also very low population density in the remaining areas of original rain forest in north-west SNNPR and western Oromia, where the indigenous population practices shifting cultivation and also depends heavily on honey production and gathering forest products.

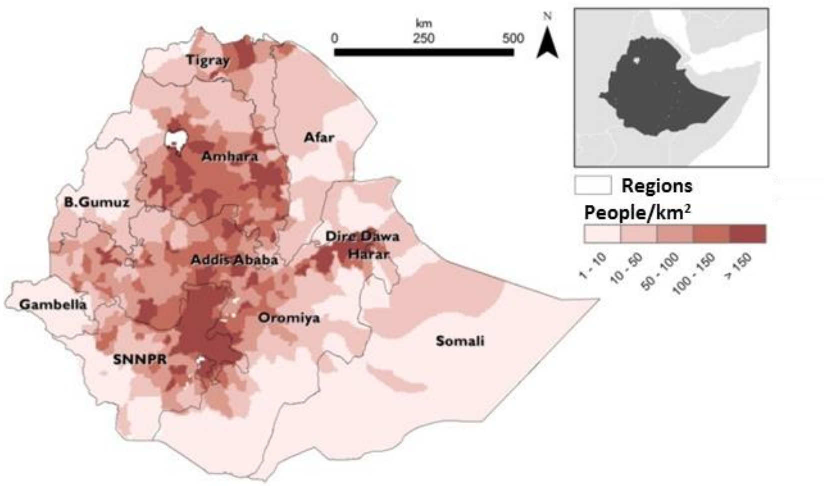

Figure 2. Population density in Ethiopia [Source: LandScan, 2011 and GAUL]

Ethiopia has one of the highest population growth rates in the world (3.18 per cent, 5th in the world; UN, 2010). Growth rates are higher in the central parts of the country, and are driven primarily by rural-urban migration. Though Ethiopian policies consider population as a resource, population growth continues to outpace growth in agricultural production and hence the challenges of addressing poverty and food insecurity have increased. In addition, population growth, agricultural expansion and urbanisation contribute to land degradation (Fransen and Kuschminder, 2009).

Food security context

Ethiopia has emerged as one of the fastest growing economies globally with an average GDP growth of 11 per cent per annum during 2005-06 to 2009-10 (MOFED, 2010). Despite high economic growth and significant progress in reducing food insecurity, undernutrition is an issue of significant concern. The 2011 Demographic and Health Survey of Ethiopia (CSA, 2011) measures three indicators of nutrition: height-for-age — where low height-for-age (stunting) is considered an indicator of chronic undernutrition, weight-for-height — where low weight-for-height (wasting) is considered an indicator of acute malnutrition, and weight-for-age — a composite indicator which considers stunting and wasting. The DHS highlights that 44 per cent of Ethiopian children are stunted (low height-for-age), and 21 per cent are severely stunted. In addition, 10 per cent of children are considered to have low weight-for-height (wasting), and 29 per cent of children are considered underweight (low weight-for-age). Undernutrition is predominantly rural: stunting, wasting, and underweight rates are higher in rural (46%, 10%, and 30% respectively) compared to urban (32%, 6%, and 16%) areas (CSA, 2011).

FAO/WFP estimates reveal similar results: over 41 per cent of the population is considered to be undernourished (FAO/WFP, 2010). In addition, an estimated 7.6 million (or 11 per cent of the rural population) are currently considered chronically food insecure, meaning each year they are relying on resource transfers to meet their minimal food requirements. Over the past four years between 2.2 and 6.4 million additional people were food-insecure or not able to meet their food needs in the short term due to transitional factors. They are temporarily dependent on relief food assistance (FAO/WFP, 2012).

Food security trend

Both the number of undernourished people and the prevalence of undernourishment have declined steadily since 1990 (FAO/WFP, 2010; Figure 3). Despite significant progress in reducing undernourishment by 28 per cent in the period 1990-2005, Ethiopia is considered a least developed country and is ranked 174 out of 187 on the Human Development Index (UNDP, 2011).

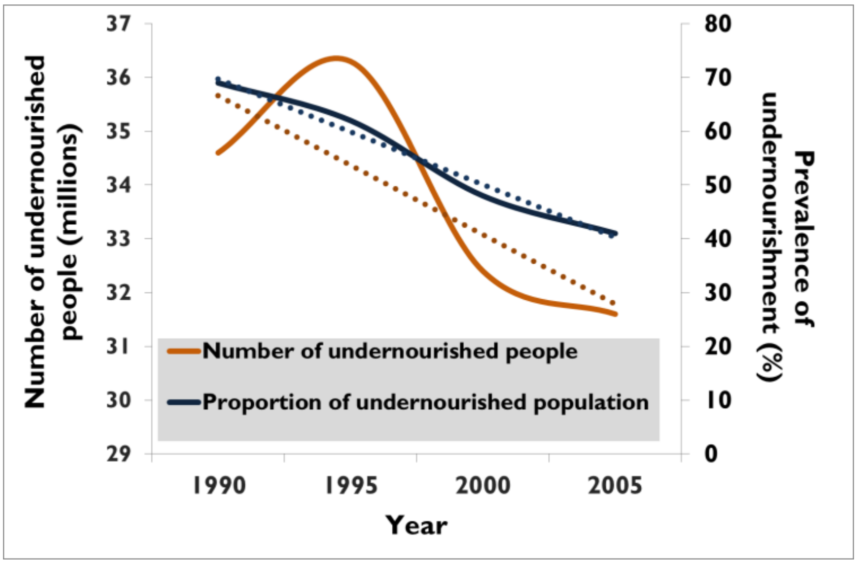

Figure 3. Trends in undernourishment. [Source: FAO/WFP, 2010]

Drivers of food insecurity

Discussions about causes of food insecurity in Ethiopia have always been complex (e.g. Webb et al., 1992; Markos, 1997) given that multiple factors affect food security. However, **drought risk** remains one of the key drivers of food insecurity in Ethiopia. Since 1950, twelve major drought-induced food security crises have occurred (

Table 1), highlighting the sensitivity of food security to climate-related risks. As Woldeamlak (2009) mentions, 'once every three or four years is a drought year' in Ethiopia. **Environmental degradation** is also a critical factor which exacerbates soil loss, deforestation, and pest incidence – all of which affect food security. In addition, **rapid population growth, poverty, rural-urban migration,** and **conflict** can contribute to food insecurity.

Table 1. Chronology of drought-related food security crises since 1950 in Ethiopia. [Source: Compiled from Markos (1997), Webb et al. (1992), Cochrane (2011)]

Year	Major incidences
1953	Food security crisis in Wollo and Tigray.
1957-58	Food security crisis in Tigray, Wollo, and south-central Shewa. About 1 million farmers in Tigray might have been affected, with about 100,000 being displaced.
1962-66	Many parts of the northeastern Ethiopia suffered from droughts and Food security crisis. Tigray and Wollo were severely hit.
1973-74	This was one of the most significant food security crises which affected parts of eastern Harare, SNNPR and the Bale lowlands. About 100,000 to 200,000 people died as a result of this extensive crisis.
1977-78	Most parts of the Wollo were severely hit by food security crisis owing to erratic rainfall, pest damage, and frost actions. About 500,000 farmers were affected.
1984-85	Most parts of Ethiopia including relatively food secure areas like Walaita, Kambata and Hadiya were affected by severe food insecurity. Drought and crop diseases were the main drivers of the food security crisis in this case. It is estimated that over 1,000,000 people died.
1987-88	Tigray, Wollo and Gonder were severely affected due to drought and civil wars.
1990-92	Rain failure and regional conflicts resulted in approximately 4,000,000 people being affected.
1993-94	Widespread food insecurity, but few deaths or cases of displacement were reported because of early responses by the government and international aid organizations.
2003-04	Over 13 million people affected, but the response mitigated the worst potential outcomes.
2008-09	Almost 3 million people were affected.
2011	Severe food security crisis occurred in the southeastern lowlands. This was linked to unprecedented drought.

Disaster risk trends and impacts

Climate-related shocks such as droughts and floods affect the ability of households to meet their food requirements, and can lead to food insecurity. Disaster reports released by the Office for Coordination of Humanitarian Affairs' (OCHA) ReliefWeb, and the International Disaster Database (EM-DAT) reveal that both floods and droughts have occurred regularly over the past 20 years (Figure 4). Figure 4 indicates that floods have occurred almost every year since 1990, and suggests that more people have been exposed since 2000 (possibly due to a growing population). Figure 4 also highlights that drought risk is significant – single events have the potential of affecting millions of people.

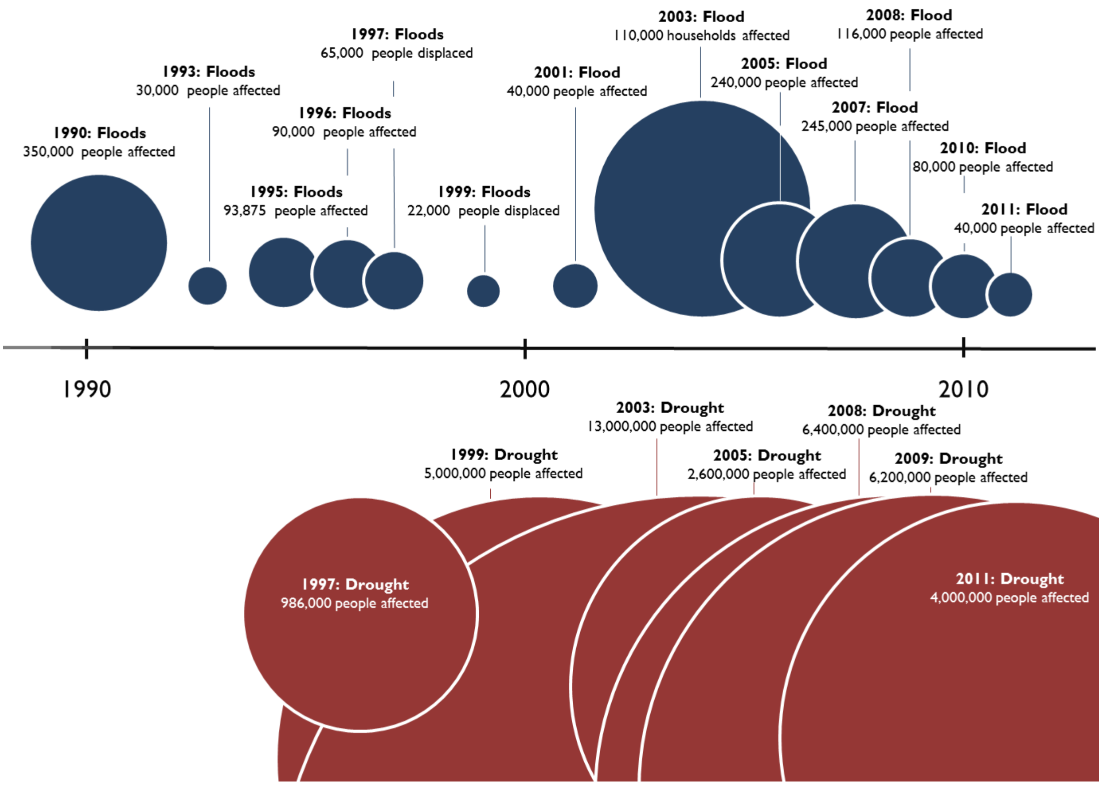

Figure 4. Flood and drought frequency between 1990 and 2011. The diagram shows the frequency of floods and droughts, as well as the number of affected people as reported in OCHA's ReliefWeb. The available data do not capture the intensity or duration of disasters which are needed to identify trends in magnitude. [Source: ReliefWeb, 2012; EM-DAT, 2012]

Box 1.1: Impacts of drought in crop-producing areas: the case of Raya Azebo

Drought is one of the major risks in Raya Azebo Wereda of Tigray Region. It is estimated that currently 72% households in this wereda are vulnerable to drought risk. Drought occurred several times, including in 2003/04, 2005/06, 2008/09 and 2009/10. The last one is considered as the most devastating event that hit almost all kebeles of Raya Azebo.

The main impacts of drought in the wereda include crop damage, loss of pasture and water sources, loss of animals, food shortage, disease outbreak, asset depletion, social unrest (including theft), malnutrition (particularly among the children), and migration of household members to other areas.

The community perceived erratic and uneven distribution of rainfall and increasing temperature over time. In addition, the level of deforestation has been reported to be very high during the last decade.

Source: WDRP/DRMFSS (2012)

Drought is a key risk to livelihoods and food security in Ethiopia, particularly in the regions of Afar (which has a climate similar to that of the Sahel), Somali, and south and eastern Oromia (which have a climatological pattern similar to that of the Greater Horn/equatorial Eastern Africa) (cf. Jury, 2010). Recently, however, drought risk has also affected highland areas and trends suggest that the risk has been increasing (Box 1.1; Riche et al., 2009). This is consistent with community perceptions of changes in drought risk. For instance, in Borana, communities have reported that “previously there was one drought every eight years. Now six out of eight years will be drought. Changes have become very obvious in the past 16 years” (ACF et al., 2009).

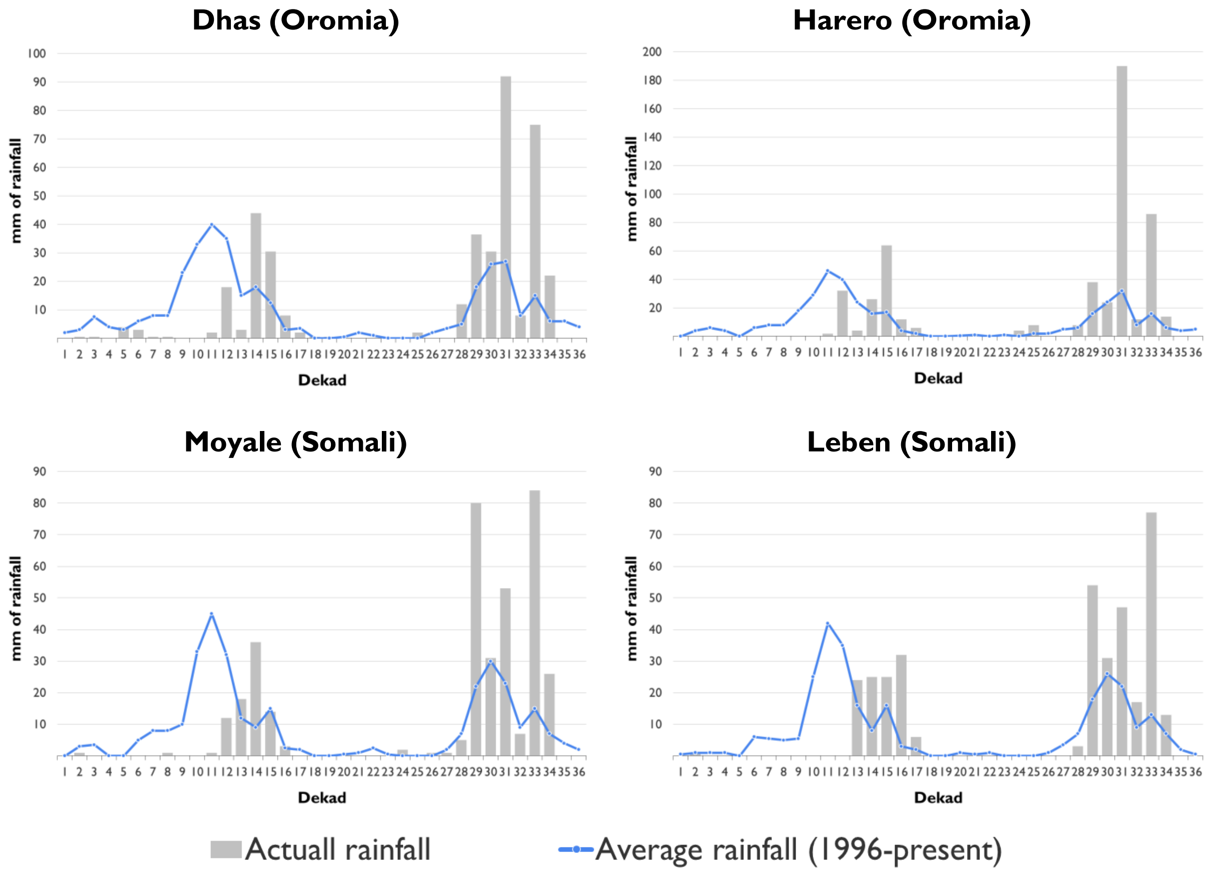

Figure 5. Rainfall trends for Dhas, Harero, and Moyale weredas and Leben zone. The 2011 actual rainfall is shown in grey bars, and the average trend (1996-present) is shown in the blue line. The graphs show that rainfall in key growing months was particularly low, compared to the average, and higher than average towards the end of the year, with potential increases in flood risk. [Source: LEAP, 2013]

Drought is often linked to scarcity of and variability in rainfall. Moreover, drought risk is exacerbated by environmental degradation, demographic trends, and market pressures. Pastoralists are among the most vulnerable groups – but this vulnerability is not distributed equally among all pastoralists: for example, pastoralists with access to river basins are often able to cope with droughts better. According to recent analysis, the areas that were most affected by the recent 2011 drought were the Dhas, and Harero weredas in Oromia, as well as the Leben zone (particularly the Moyale wereda) in Somali (Tolossa, unpublished). This is in agreement with the rainfall situation analysis provided by the Livelihood Early Assessment and Protection (LEAP)[2] platform, showing below average performance of *gu* rains in these areas (Figure 5).

Floods – both riverine and flash floods – are also key risks, affecting water quality and quantity, and resulting in loss of lives and livelihoods, increases in animal disease outbreaks, lower purchasing power, migration, and social disruption. Under a changing climate, flood magnitudes could increase due to more intense precipitation events in a shorter period; in other words, key rainy seasons could become shorter but with the same amount of seasonal rainfall. While flood risk has traditionally been an issue of concern in farming areas, in recent years, pastoralist areas have also been affected by floods – indicating the changing risk environment in Ethiopia (Box 1.2).

Box 1.2: Impacts of floods in pastoral areas: the case of Afambo

Several weredas in the Afar region have become increasingly vulnerable to flood risk as a result of more intense rainfall in shorter periods and land degradation. The Afambo wereda in Afar is especially vulnerable. Five of the eight kebeles in Afambo reported flood as most recent disaster that affected their community. According to the focus group discussions, the communities were hit by severe floods in four consecutive years: 2006/2007, 2007/2008, 2008/2009, and 2009/2010. Floods in the wereda have caused crop and livestock damage, lower access to grazing land, loss of arable land, increased incidence of human and livestock disease, destruction of irrigation structures and houses, destruction of roads and water points, gully formation and human displacement. Water pollution associated with flooding is another environmental challenge that exacerbated incidences of disease outbreaks in the wereda.

The communities in the wereda perceived that rainfall is becoming erratic. Flooding is becoming more common due to two factors: increasing deforestation, and loss of vegetation which occurred during the long period of drought in the 1980s and 1990s. The community also perceived that the quality of the land is deteriorating because of flood and wind erosion as the top soil is washed away. As reported by the community members, the major vulnerability factors for increasing flood risk in the wereda include settlement of people in vulnerable areas (lowlands/plains), absence of flood prevention structures, settlement along the river bank (mainly the Awash River) and the overflow of the river, poor structure housing that cannot withstand flooding, and heavy rainfall in the highland areas of neighbouring weredas.

Source: WDRP/DRMFSS (2012)

Climate trends

Rainfall patterns are highly complex due to the varied topography of the country: the seasonality, duration, and regularity of rainfall vary by both latitude and longitude[3]. Annual rainfall patterns in Ethiopia (and more generally in the Greater Horn of Africa) are linked with regional sea surface temperatures (SSTs) in the Indian Ocean: warmer Indian Ocean SSTs are linked to dryness (Williams et al., 2011)[4]. Variability in the strength of warming of the Indian Ocean strongly influences precipitation totals in Ethiopia and accounts for important climatological phenomena such as the

[2] LEAP (Livelihoods, Early Assessment and Protection) is a food security early warning tool that integrates risk transfer mechanisms, such as weather index insurance, into traditional risk management and social protection schemes. The LEAP platform – managed by the Ministry of Agriculture's Disaster Risk Management and Food Security Sector (DRMFSS) with support from the United Nations World Food Programme and the World Bank – provides intermediary outputs including rainfall data from weather stations, rainfall estimates from satellite-derived data, water requirement satisfaction indices, and river flow trends, among others. The data are available graphically through charts and maps, and are used to complement the analysis presented here.

[3] The mountainous nature of the country contributes to the complexity of agricultural and livestock production systems, including relationships with markets. Moreover, the west-east and north-south rainfall differences affect the types of crops and livestock that are raised. In contrast, the pastoral areas are slightly more homogeneous although there are significant sub-regional differences that affect livelihood activities and livelihood zoning.

[4] Given the strong relationship between warming Indian Ocean SSTs and lower rainfall, and that increasing SSTs of the Indian Ocean are likely under continued global warming, a scenario of declining rainfall is also likely.

decline in rainfall between the 1960s and 1980s (especially in the western parts of Ethiopia) and the devastating drought of 1984. El Niño Southern Oscillation (ENSO) cycles affect rainfall patterns in Ethiopia (Segele and Lamb, 2005; Korecha and Barnston, 2007; Lyon and DeWitt, 2012). In general, chances for flooding during the short rainy season (October-December) are higher with El Niño events (e.g. Philippon et al., 2002), while La Niña events are associated with higher probabilities of drought (e.g Anyamba et al., 2002).

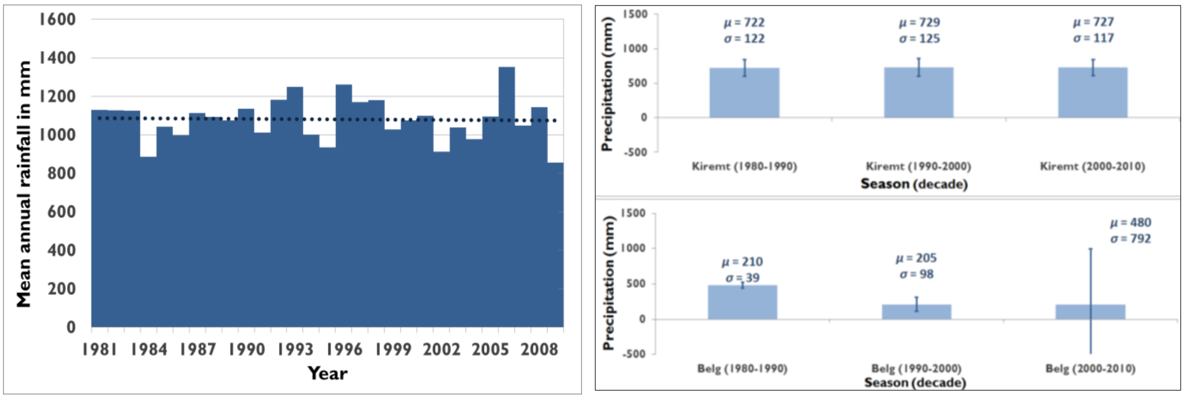

Figure 6a. Annual precipitation trends (left) and seasonal total and standard deviation (right), 1981-2009. [Source: NMA, 2012]

The long rains occur between June and October across most of Ethiopia except in the south-eastern parts of the country. *Kiremt* rains benefit all cropping areas; these lead to the *meher* agricultural season of the country. *Kiremt* rains account for approximately 50–80% of annual rainfall totals. The *belg* rains are the short rains between February-March and May, which provide water to the southern, north-eastern, eastern and north-central parts of the country and form the second most important agricultural season of the country. *Belg* rains are critical for long-cycle crops (such as sorghum and maize) harvested at the end of the *meher* season. Some other rainfall patterns are limited to certain specific areas of the country. The *sapia* rains (January-February) are important for sweet potato cultivation in SNNPR while *gu* (April-May) and *deyr* (October-November) are the main rains for pastoral areas in south/south-eastern parts of the country. In Afar, there is a long *karma* season (June-September) and two shorter seasons, *dadaa* (in December) and *sugum* (March-April).

Annual rainfall across the country has fluctuated significantly since the 1980s (NMA, 2012; LEAP, 2013; Figure 6a and 6b). The coefficient of determination (rainfall regressed over time) is relatively low, R^2=-0.039 ($p<0.05$), suggesting high inter-annual variability with a slight but statistically significant negative trend (Figure 6a). This is in line with previous analyses which highlight the importance of inter- and intra-seasonal rainfall variability over total annual rainfall in determining livelihood and food security outcomes (FEWS NET, 2003). The coefficient of determination in the *belg* season in the period 1981-2009 is very low, 0.009 ($p=0.08$) suggesting that inter-annual *belg* rains are highly variable. In comparison, the coefficient of determination in the *meher* season is 0.135 ($p<0.05$), indicating lower inter-annual fluctuation. This is consistent with other perceived trends (e.g. USGS and USAID, 2012). This indicates high seasonal anomalies in rainfall – a major contributor to food insecurity. Of particular concern is the high variability in rainfall in the *belg* season. *Belg*-dependent areas are typically the most food insecure cropping areas, and are also the most affected during food security crises. Therefore, a failure in *belg* rains could exacerbate livelihood degradation and food insecurity in these regions.

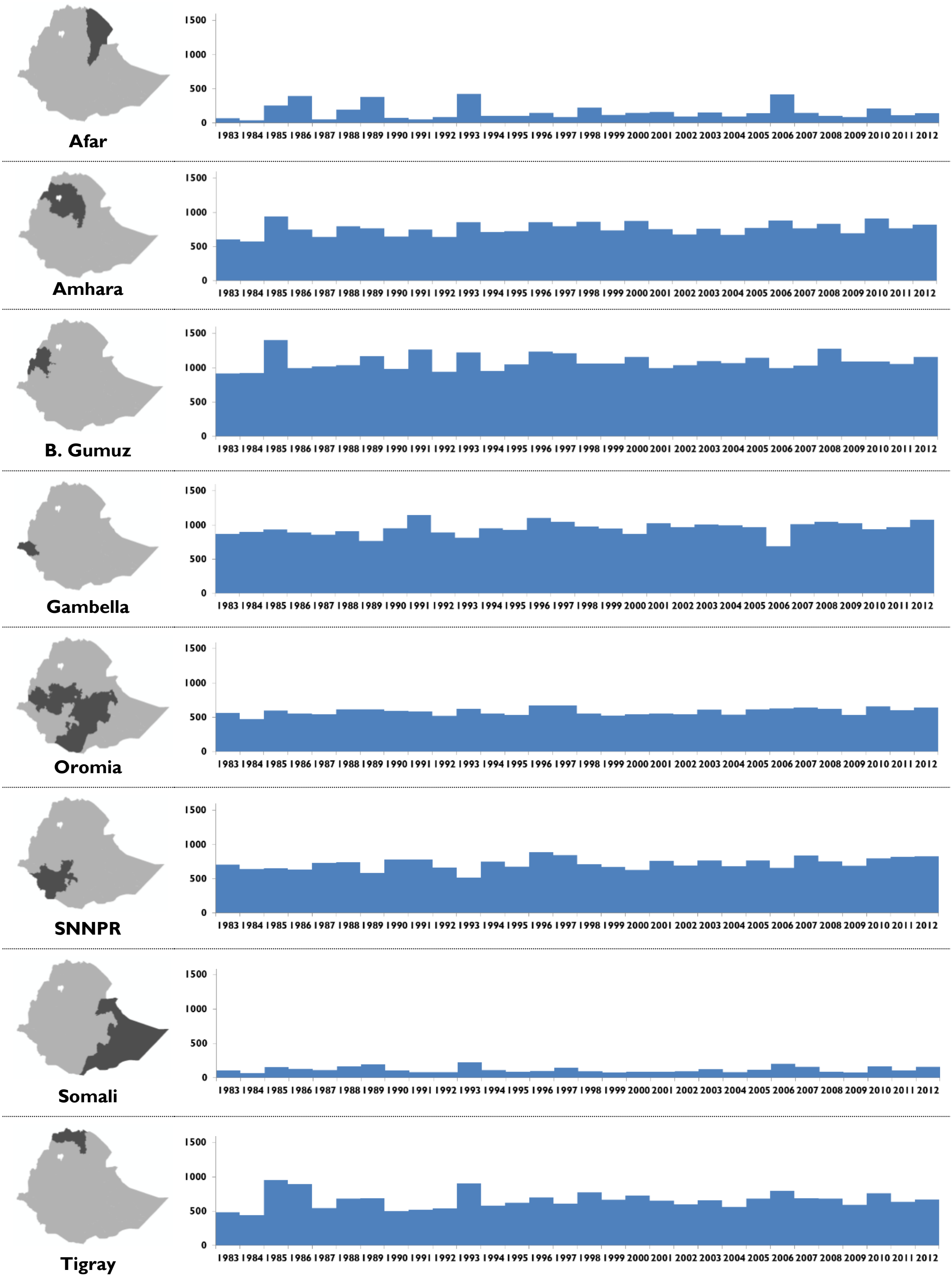

Figure 6b. Growing season precipitation trends, expressed as mm of rain between March and September from 1983-present. [Source: LEAP, 2013]

A long-term analysis of rainfall trends suggests that seasonal rainfall in the main rainy season (March-September) has decreased across most the country, especially since the mid-1990s. March to September rains correspond to the performance of long cycle crops, and observed reductions in rainfall throughout the eastern highlands to south-central Ethiopia could result in crop losses affecting over 20 million people who live in these regions.

Recent data have highlighted some changes in seasonal rainfall patterns over the last few decades, with detrimental impacts on food security. *Belg* rains, which occur between February and May, in particular have been highly variable, especially since 1999. In contrast, the *kiremt* rains (which occur between June and October) have remained relatively constant (Figure 6b).

The *belg* rains are highly unreliable – their late arrival or failure implies significant impacts on food security. A large proportion of total production is harvested in areas where more rain falls in *belg* than *meher*. Therefore, lack of, or erratic, *belg* rains would significantly affect harvesting and planting cycles and would affect food sources, especially among poorer households (i.e. lower harvests imply that poorer households have to purchase more of their food for longer).

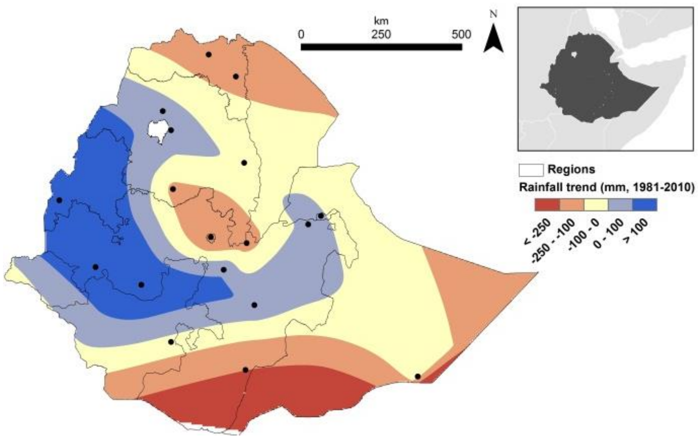

Figure 7. Rainfall trends between 1981 and 2010 using weather station data. The weather stations used for this analysis (shown by the black dots) were selected in consultation with the National Meteorological Agency and were chosen because they represent the climatological diversity of the country. [Source: NMA, 2012]

In the north-western parts of the country, rainfall has been relatively constant between the 1960s and the present – after a decline in annual rainfall in the mid-1980s there has been a gradual recovery in recent years. The southwest of the country has experienced an overall decline in rainfall since the 1960s and steep decline since 1996. Of significant concern for food security are the declines in March-September rainfall in the northeast and the southeast. In the northeast, rains have declined since the mid-1990s with 2010-2012 having very low rainfall. Similarly, in the southeast and eastern parts of Ethiopia, rainfall has been steadily declining since the mid-1980s with the last few years having very low precipitation averages. The northeast and southeast of Ethiopia already have limited water availability, and therefore reduced precipitation patterns would significantly affect livestock production and potentially food security (Funk et al., 2011; NMA, 2012; Figure 7).

These climate trends are consistent with community perceptions of risk. According to research by the Africa Climate Change Resilience Alliance (ACCRA, Ludi et al., 2011; Figure 8), weather-related hazards are perceived by communities to be the main risks affecting their livelihoods and food security. In particular, erratic or decreasing rains are seen as the key risks at the community level.

	1960s	1970s	1980s	1990s	2000s
Ander Kello, Chifra					
Rainfall amount			Decreasing		
Rainfall distribution			Becomes more erratic in space and time		
Temperature			Increasing		
Pasture condition	Decreasing				
Livestock numbers				Decreasing	
Mobility				Decreasing	
Kase-hija, Gemechis					
Rainfall amount			Decreasing		
Rainfall distribution			Rainfall season shortening		
Temperature			Increasing		
Forest cover		Deforestation increased and species disappeared			
Farmland size			Decreasing		
Irrigation	Traditional	Modern with increasing demand			
Invasive species				Partinium invading the area	
Wokin, Dabat					
Rainfall amount				Feb-May rainfall becomes irregular	
Frost	Frost decreasing over time				
Temperature			Increasing since 1985		
Indigenous forest cover	Declined to <1% from 70% in 1940s				
Soil fertility		Declining			
Crop pests			Increasing since 1985		

Figure 8. Community perceptions of climate risk. [Source: Ludi et al., 2011]

Observed climatic changes have had negative impacts on both cropping and pastoral areas[5]. Recent trends in rainfall performance in crop growing areas suggest increasingly dry conditions across several regions. Between 1990 and 2011, *belg* rains in SNNPR, Oromia, and Amhara have experienced a 35-80 per cent increase in the frequency of below-normal rains compared to the 1960-1989 period. The *meher* rains have experienced similar increases in below-normal rains in southern Oromia, and parts of SNNPR, and Gambella, and have shown a northwestward retreat (Figure 9).

Belg rains (March-June) have decreased and have also shown a northwestward retreat, with negative impacts on the quantity and quality of available pasture (Figure b). This trend is associated with more intense and frequent droughts which affect the ability of livestock to recover from poor rainy seasons (USGS and USAID, 2012; LEAP, 2013).

[5] More detailed analysis of the relationships between climate and food security trends is undertaken in Sections II and III.

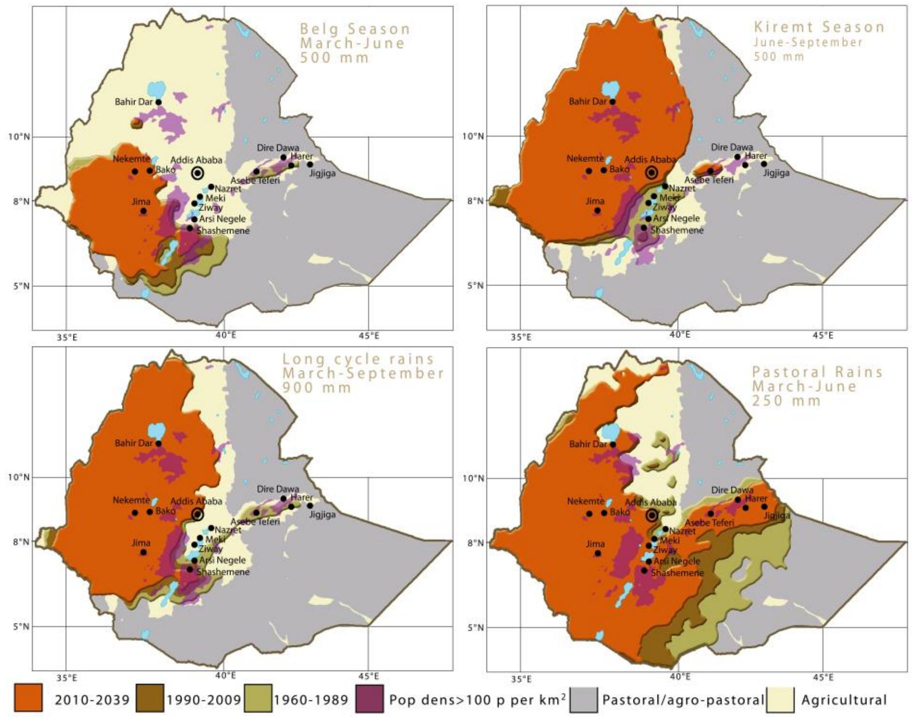

Figure 9a. Rainfall climatology over different seasons (*belg*, March-June, top left; *kiremt*, June-September, top right; *meher*, March-September, bottom left; and pastoral rains, March-June, bottom right) in Ethiopia in the periods 1960-1989 and 1990-2009, and predictions for 2010-2039. [Source: Funk et al., 2011]

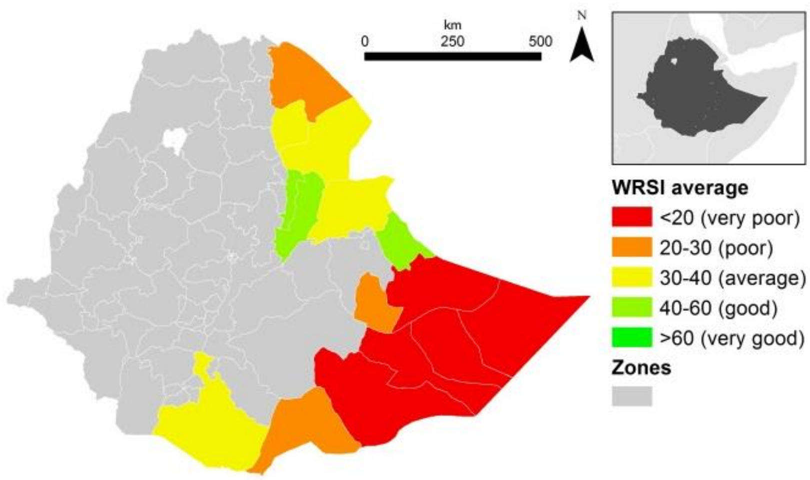

Figure 9b. Rangeland WRSI[6] average (1983-present) in pastoralist areas by zone. The majority of pastoralist zones have below-average WRSI values indicating low availability of pasture for livestock rearing. [Source: LEAP, 2013]

[6] The water requirement satisfaction index (WRSI) is an indicator of rangeland performance based on the availability of water to the rangeland vegetation during a growing season. WRSI can be related to rangeland vegetation using a linear yield-reduction function specific to the plant (Verdin and Klaver, 2002). This information can then be derived to identify areas where grazing may not be feasible due to low availability of pasture.

Part II: Climate variability and food security trends

Summary

- ► Production of the key cereal crops (*teff*, wheat, barley, and maize) has almost quadrupled between 1961 and 2010. Although this increase has been relatively consistent, there have been significant declines in production in 1973 and 1975, and again in 1984/1985 – a trend that is linked to major drought events.
- ► Climate trends affect crop production. There is a positive correlation between year-to-year variations in rainfall and cereal yields, suggesting that wetter years are linked to higher yields. Correlations are stronger in April-May compared to other periods, highlighting the importance of *belg* (early) rains in ensuring food security outcomes. For individual crops, correlations are strongest for *teff* and wheat, suggesting that some of the key crops in Ethiopia are particularly sensitive to variations in rainfall.
- ► There appears to be a link between climate trends and food prices, possibly because lower production is linked to higher prices. March-May rains have the strongest correlation with food prices, highlighting again the importance of early rains.

Crop production

Cereal production in Ethiopia (*teff*, wheat, barley, and maize) has almost quadrupled between 1961 and 2010. Overall in this period, cereal production has increased steadily with some declines between 1973 and 1975, and again in 1984/1985 – this trend is linked to the impact of major droughts in Ethiopia during these years. Yields have also increased steadily in this period with a relatively stable yield between 1975 and 1993, followed by a rapid increase thereafter. Finally, area under production decreased steadily between 1973 and 1993, again suggesting that the frequency and magnitude of droughts in this period might have affected the viability of agriculture in addition to population pressures on existing land (Figure 10).

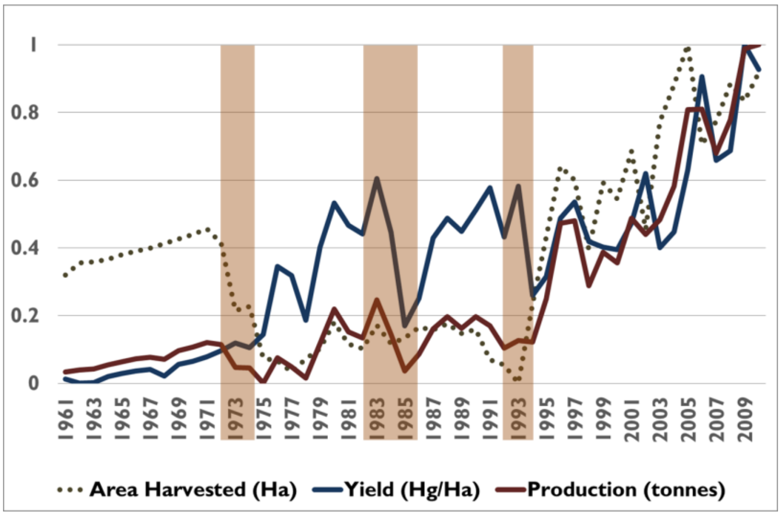

Figure 10. Cereal crop production trends and key drought events, 1961-2010. [Source: FAOSTAT, 2012]

The links between rainfall trends and crop production during different seasons is further illustrated by missed planting opportunities since 2000 (LEAP, 2013; Figure 11). Lower rainfall (both *belg* and *kiremt*) is linked to reduced planting opportunities. For instance, as shown in Figure 11, lower rainfall in 2000-2002, 2008, 2009, and 2011 were associated with less land being cultivated (higher missed planting opportunities). In addition, crops could perform more poorly as a result of erratic distribution of rainfall and dry spell length. The graphs also indicate that less areas missed planting during the *meher* rains – this is related to better rainfall situations (both amounts and distribution) in *meher* compared to *belg*.

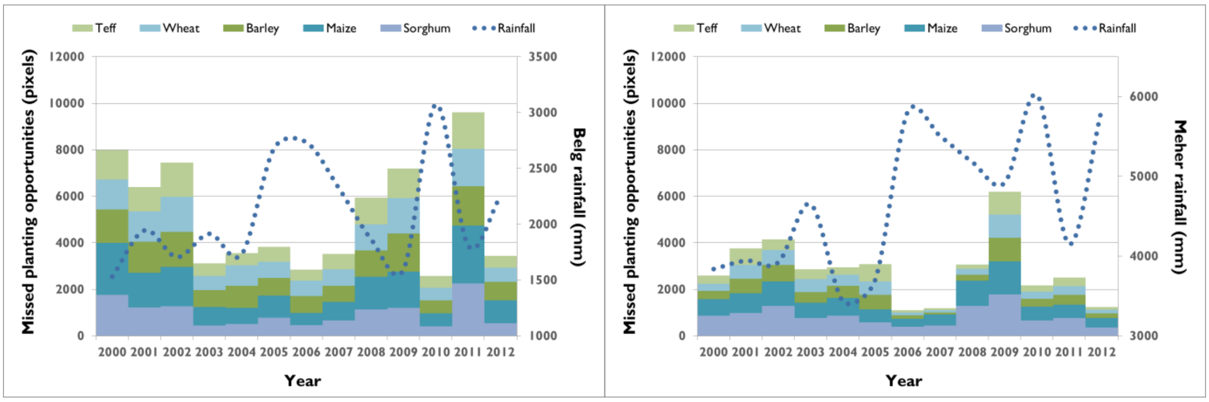

Figure 11. Missed planting opportunities for *teff*, wheat, barley, maize, and sorghum, and rainfall trends during the belg (left) and kiremt (right) seasons. Missed planting is measured in terms of the number of pixels (area) that could be cultivated with a specific crop but were not planted in a particular season or year[7]. [Source: LEAP, 2013; NMA, 2012]

This relationship between climate risk and agricultural production is consistent with community perceptions. According to a study in the Abay and Baro-Akobo River Basins of Western Ethiopia, farmers perceived recent climate change as a decrease in rainfall (Bewket and Alemu, 2011). In terms of impacts, about 77% respondents reported a reduction in crop production while 60% reported a reduction in length of crop growing period, linked to a failure of *belg* rains. The study found out that local people associated the following events with climatic variability: increased incidence of insects (79%), increased plant diseases (62%), increased weeds (44%), and shifts of suitable areas for major crops (59%). This highlights that climate variability can have different impacts on crops.

Climate-yield correlations[8]

Quantifying the relationship between crop yields and climate is challenging. Given the importance of non-climatic variables including, among others, sub-national differences in farm inputs such as choice of fertilisers, irrigation techniques and seeds, as well as economic changes influencing agricultural

[7] A higher number indicates that less land was cultivated. Here, it is important to note that area planted may not be directly linked to climate factors; for instance, between 2000 and 2002, there was a significant reduction in area planted due to the crash of maize prizes and the resulting losses people suffered. This resulted in a much lower area planted in 2002, which combined with a drought in 2002/2003 led to the 2003 food security crisis.

[8] In addition to production and prices, analyses to identify the relationship between climate and nutrition outcomes were carried out. There are two important challenges in quantifying the relationship between climate risk and nutrition. On the one hand, long-term nutrition data are not available as time series, given that nutrition surveys occur periodically. On the other hand, potential impacts of climate are only noticeable in the long-run (through stunting rates, for example). Therefore, due to lack of long-term data, no results are reported here. However, despite these challenges, some analyses have tried to link disaster risk to nutrition outcomes. According to Fuentes and Seck (2007), children born during a drought in Ethiopia are up to 35.5 per cent likelier to be malnourished and 41% likelier to be stunted. These results are similar to research in Zambia and Kenya (ibid.) and Bangladesh (Del Ninno et al., 2003).

management techniques are also very important. For this analysis, focus is given to national-level trends.

Differences in precipitation have a higher explanatory power than temperature in describing changes in crop yields: correlation between precipitation and yields is R=0.269 whereas correlation between temperature and yields is R=0.128. This suggests that wetter years are associated with higher crop production. While higher precipitation could be generally associated with higher yields, it is important to note that extreme rainfall could lead to flood events and consequently to lower crop production.

Using first-differences time series for climate and crop production (i.e. the difference in values from one year to the next), it is possible to evaluate the relationship between climate and crop production, assuming that production trends are attributable to technological advances (cf. Lobell et al., 2005; Lobell and Field, 2007).The results of the analysis show that yields are particularly sensitive to precipitation (Figure 12).

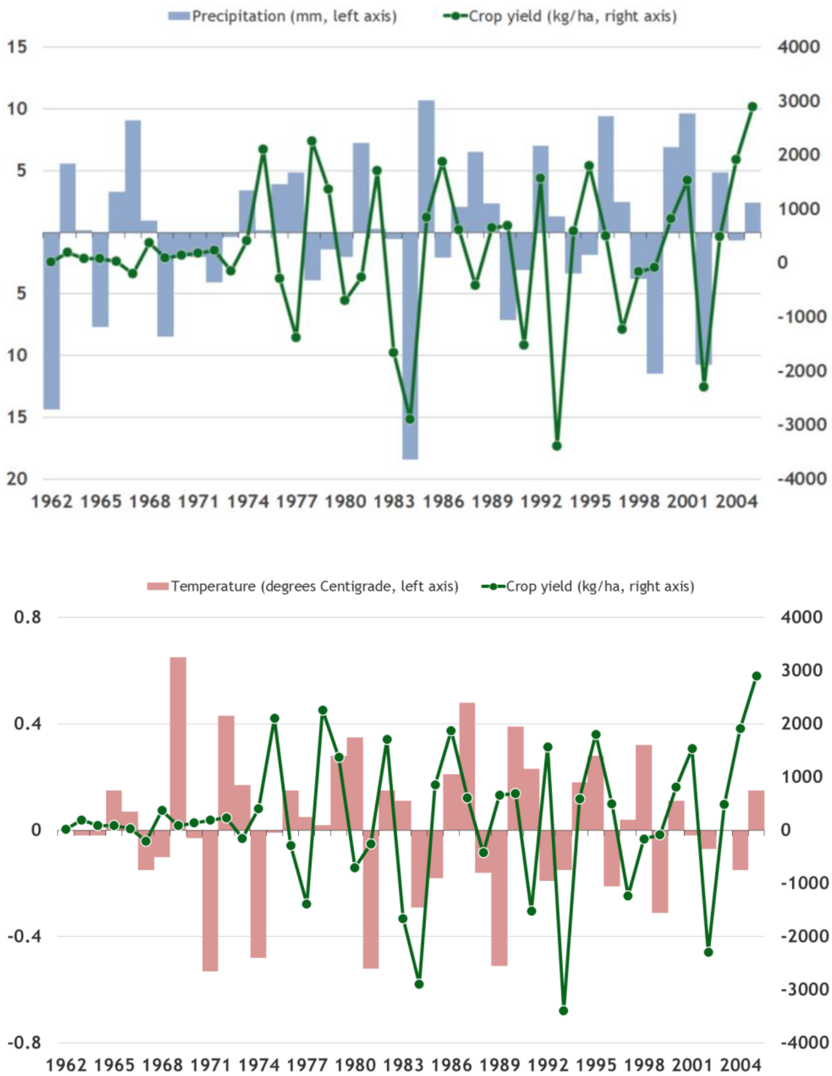

Figure 12. Relationship between precipitation (top) and temperature (bottom) with crop yield first differences. [Sources: CSA, 2012 and NMA, 2012]

The correlation between annual precipitation and crop production in the period 2000-2009 is 0.386 (p=0.11) – this suggests that the relationship between rainfall and crop production has been larger in the last decade compared to the long-term mean. The positive correlation suggests that higher precipitation is linked to higher crop production. These results are similar to previous assessments at the global level (e.g. Lobell and Field, 2007). Therefore, in the absence of adaptation measures, climate change could have a significant adverse impact on food production in the country.

The correlation is stronger in April-May (R=0.463, p=0.06) compared to June-August (0.380, p=0.08), September-November (0.329, p=0.09) and December-February (R=0.319, p=0.15).This highlights the importance of *belg* (early) rains in ensuring food security outcomes.

Correlations between annual rainfall and production are particularly strong for *teff* (R=0.496), wheat (R=0.401), with weaker correlations for barley (R=0.316), pulses (R=0.305), maize (R=0.163) and sorghum (R=0.156). These results suggest that *teff* and wheat are particularly sensitive to variations in rainfall. The weaker correlations between rainfall, and maize and sorghum could be explained by the fact that these crops are more drought-tolerant (Rajabi and Ober, 2012).

Climate-price correlations

Establishing a correlation between food prices and climate is difficult in the context of Ethiopia given that food prices are dependent on a number of factors, and might be affected by commodity prices in other countries.

Total crop production and consumer price index (CPI; from CSA, 2010) values in the year after harvest are correlated at -0.638, highlighting that crop production might be a critical factor affecting food prices. Therefore, years with below average precipitation might result in lower crop production and higher food prices.

Total annual rainfall and consumer price index values have a very low correlation – R=-0.029, p<0.05 – highlighting the complexity of attributing food prices to climate variability alone (Figure 13). Seasonally, however, March-May and June-September rains appear to have stronger correlations with food prices (R=-0.448 and R=-0.332 respectively), again reiterating that reliable *belg* rains are important for food security in Ethiopia. Changes in the timing or intensity of *belg* rains can therefore affect both production and, potentially, food prices exacerbating food and livelihood insecurity.

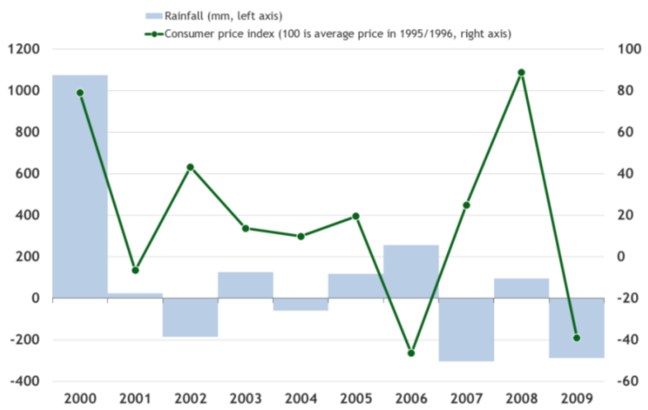

Figure 13. Correlation between rainfall and consumer price index, 2000-2009. [Source: CSA, 2012 and NMA, 2012].

Part III: Climate impacts on livelihoods

Summary

- Food insecurity patterns are seasonal, and are linked to rainfall patterns: hunger trends decline after the rainy seasons.
- All of the rural livelihood systems of Ethiopia – crop cultivation, pastoralism, and agro-pastoralism – are highly sensitive to climate and are vulnerable to hazards in multiple ways.
- Income is a key determinant of vulnerability to climate. Most income in rural livelihoods is derived from crop and livestock sales, both of which are highly sensitive to climate. Lack of (or erratic) rainfall has a negative effect on households' incomes and forces households to rely on external assistance.
- Food sources are highly variable across livelihood zones and across wealth groups. Generally, the wealthiest households are able to obtain all their calories from own production while the poorest households are highly dependent on markets and are not always able to meet their food requirements even if they procure food. These food sources are all highly sensitive to climate. Production of crops for own consumption could decrease due to lack of (or erratic rainfall), while climate trends may also affect food prices, and therefore the ability of poor households to purchase food.

Livelihoods in Ethiopia are highly complex due to the varied differences in topography, rainfall patterns, and population density. Despite the complexity of livelihood systems in Ethiopia, it is possible to understand risks and vulnerabilities by focusing on three main livelihood zone types: cropping (mostly located in the northern and western parts of the country), pastoral (mostly located in the eastern and southeastern parts of the country), and agropastoral[9] (mostly located at the margin between the two) (Figure 14).

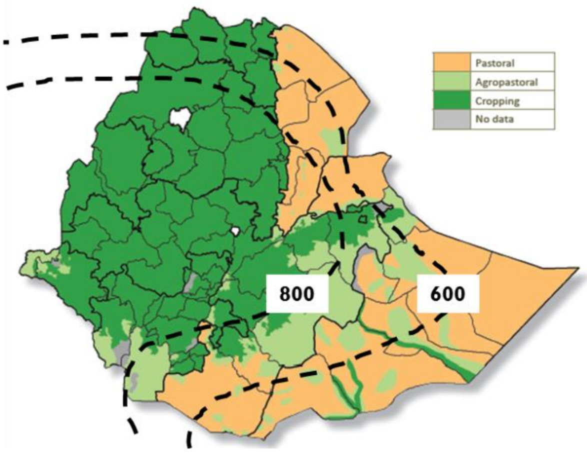

Figure 14. Distribution of key livelihood systems in Ethiopia (agriculture, agro-pastoralism, and pastoralism) overlaid with rainfall climatology, 1981-present. [Source: USAID and DRMFSS, 2010, and NMA/IRI, 2012]

[9] A combination of cropping and pastoral economies.

In rural Ethiopia, pastoralists account for 6 per cent of the total population, agropastoralists account for 5 per cent, and cultivators account for over 89 per cent. In both Afar and Somali, the majority of people are pastoralists. In Gambella, agropastoralism and livestock raising account for approximately half of households' livelihood activities. Research in northeastern Ethiopia shows that some pastoralists have shifted to agro-pastoralism – this trend can be explained by the impact of climate-related shocks (drought resulting in lack of stock feeding), economic factors (increase in poverty rates) and demographic pressures (rapid population growth) (Tolossa, 2008). In all other regions, the majority of households engage in crop cultivation (Figure 15).

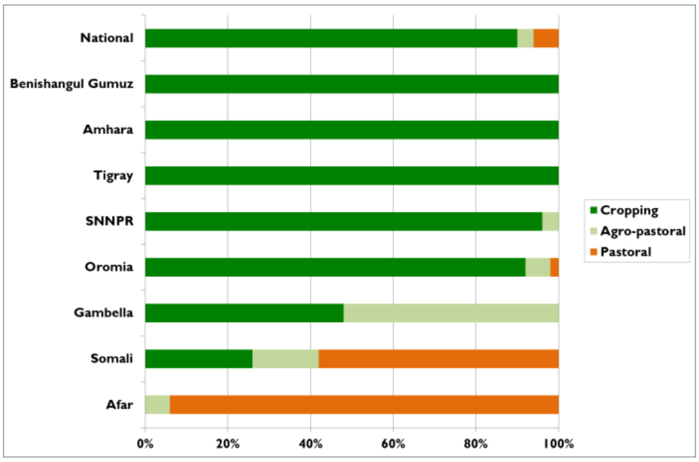

Figure 15. Proportion of crop cultivation, agro-pastoral, and pastoral populations by region. [Source: CSA, 2012]

All of the rural livelihood systems of Ethiopia – crop cultivation, pastoralism, and agro-pastoralism – are highly sensitive to climate and are vulnerable to hazards in multiple ways. Table 2 summarises the sensitivities of the major livelihood systems, as well as the major climate-related hazards.

Table 2. Climate sensitivities of key livelihood systems.

Livelihood systems and sensitivities to climate-related shocks	Major climate-induced hazards and impacts on livelihoods systems	
Crop Cultivation Rainfall determines crop output and availability of animal feed. Scarcity, variability, and excess rainfall all affect agriculture. Erratic rainfall patterns could reduce the length of the growing season as well as yields, with negative impacts on incomes and food security.	Rainfall	Changes in rainfall patterns affect the quantity and quality of water available for cultivation. Erratic rainfall patterns could reduce the length of the growing season as well as yields, with negative impacts on incomes and food security.
	Temperature	Extremely low temperatures in the highlands result in frost damage. Frost affects crops and reduces yields. Extremely high temperatures in the lowlands affect agricultural productivity.
	Flooding and water logging	Unseasonal heavy rainfall in some parts of the country damages crops. Flooding also results in animal losses, which can adversely affect livelihood assets.
Pastoralism Rainfall affects the availability of animal feed and water for livestock rearing. Changes in rainfall patterns will likely affect the quantity and quality of water available for livestock consumption. This would affect livestock	Rainfall	Changes in rainfall patterns will likely affect the quantity and quality of water available for livestock consumption. This would affect livestock health, with potential impacts on the quality of meat and milk. Erratic weather patterns could also render livestock more vulnerable to diseases.
	High Temperature	Extremely high temperature in pastoral parts of the country is a critical challenge to livestock productivity.

health, with potential impacts on the quality of meat and milk. Erratic weather patterns could also render livestock more vulnerable to diseases.	Livestock diseases	Erratic weather conditions render livestock more vulnerable to diseases. Livestock diseases such as trypanosomiasis, African Horse Sickness and epizootic lymphangitis are endemic to the pastoral areas in Ethiopia, and can be highly fatal. Animal losses often have negative impacts on livelihoods.
Agro-pastoralism Both cultivation and pastoralism are affected by rainfall variability, as highlighted above. Changes in rainfall patterns could affect crop output, as well as the availability of water and food for livestock.	Climate variability	Agro-pastoralists are vulnerable to the same risks as agricultural and pastoralist households. Rainfall variability (both spatial and temporal), flooding, extreme temperatures, and livestock diseases severely affect agro-pastoral livelihoods

Seasonality

Livelihoods are closely linked to seasonal cycles of rainfall: the beginning, peak, and end of the rains each affecting the economic activities practiced by households, and they also affect the extent to which households depend on different sources of food and income. Rainfall is the key determinant of livelihood and food security: for example, in the pastoralist areas (Somali, Afar, and southern Oromia), rainfall is both scarce and highly variable, and this affects their livelihoods resulting in chronic and acute food insecurity.

Almost all agricultural areas receive more rain in the *meher* season, while pastoral and agropastoral areas are more dependent on *belg* rains (with its variants as discussed earlier). As shown in Part II, the amount of rainfall during both the *belg* and *meher* seasons has decreased by around 15-20 per cent, especially in the south-central and southeastern parts of the country, thereby significantly reducing the amount of area that is viable for agriculture.

Belg rains are highly important as they form the main rains in some parts of the country and given their unpredictable nature are considered the major determinant of hunger periods. A large percentage of total crop production is harvested in areas where more rain falls in *belg* than in *meher*. In areas where more rain falls in *meher*, higher yielding long-cycle crops such as maize and sorghum are planted during the *belg* season and harvested during the *meher*. In areas with a single rainy season, crops are planted earlier in the south than in the north following to the south-north rain movement (rains start later in the north).

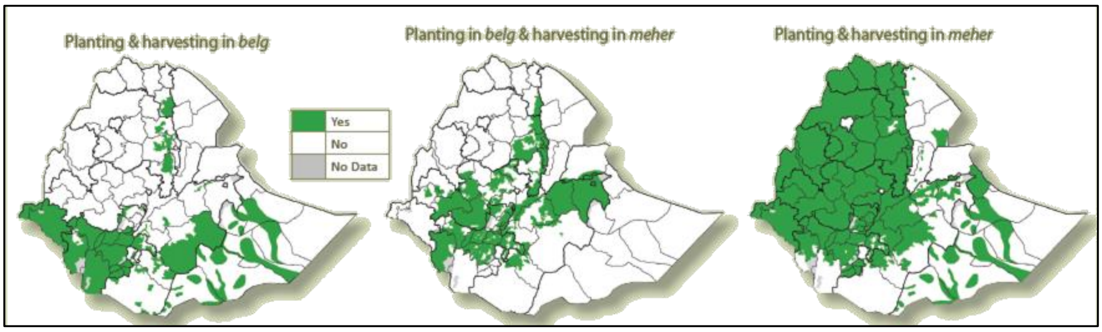

Figure 16. Dependence on *belg* and *meher* rains for planting and harvesting. [Source: USAID and DRMFSS, 2010]

Seasonal patterns of crop production are also dependent on the rainfall regimes and can be classified into three categories: (i) planted and harvested in *meher*, (ii) planted and harvested in *belg*, and (iii) planted in *belg* and harvested in *meher* (Figure 16). Within a single livelihood zone, farmers may grow crops from one or more of these categories. The greatest seasonal complexity is in the south and southeastern parts of the country – a condition that is linked to the diversity in rainfall patterns in these areas. This also highlights some of the ways in which populations that are vulnerable to rainfall variability have adapted their livelihood activities to manage risks.

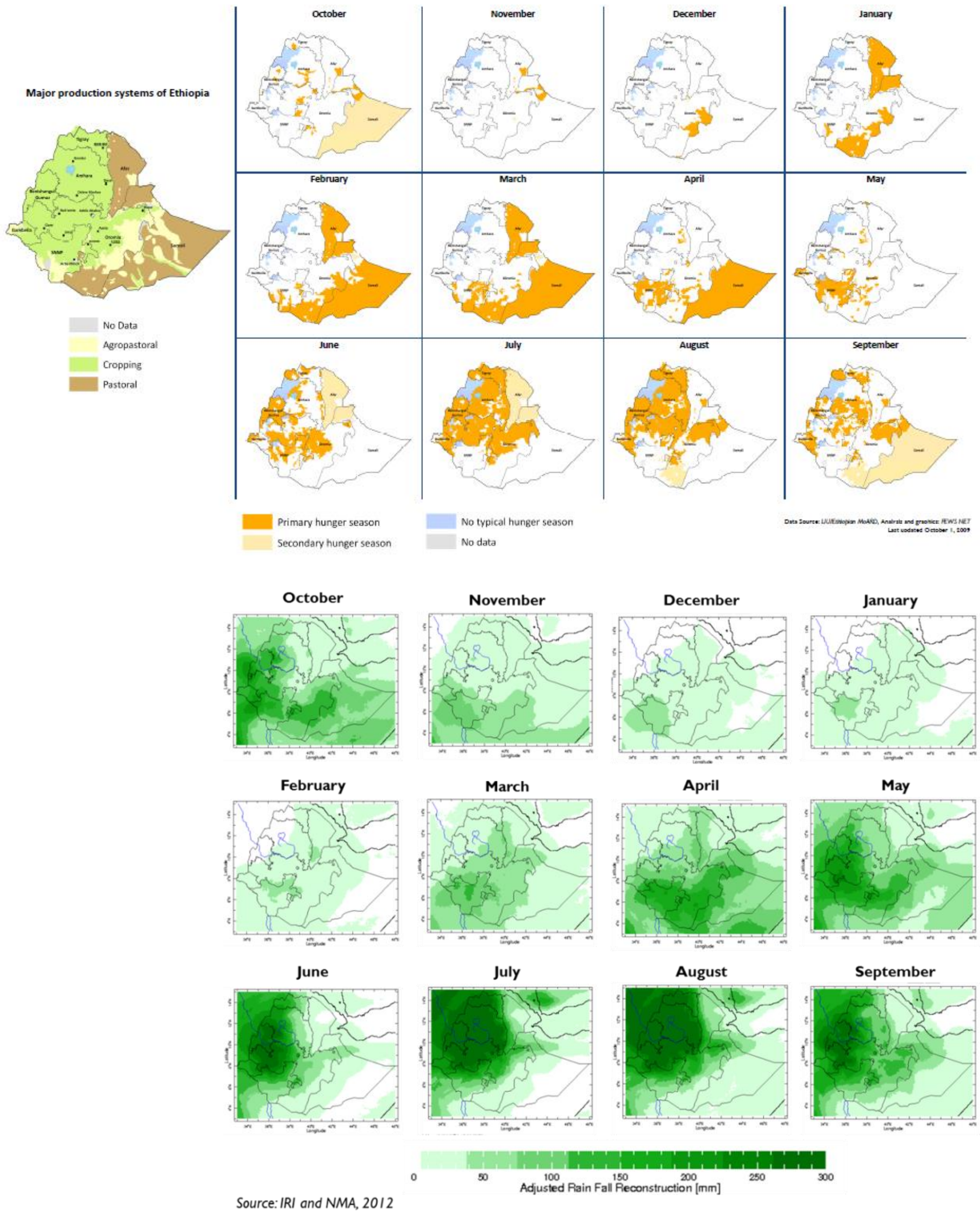

Figure 17. Overview of seasonal hunger (top) and monthly rainfall patterns (bottom, average from 1983-2010). [Source: seasonal hunger maps from FEWS NET, 2012a; rainfall maps from NMA/IRI, 2012 based on weather station observations and remote sensing proxies]

The seasonality of rainfall also affects the hunger periods. Generally, for agricultural areas, hunger occurs during the pre-harvest months: in *meher*-dependent areas (northern, central and eastern Ethiopia), the hunger season is typically from June to October whereas in *belg*-dependent areas (especially in the south) the main hunger season occurs between February and June. For pastoral areas the main hunger season occurs before the belg rains, from December to March. This is because livestock give birth twice a year in pastoral areas, at the beginning of the meher and the belg rains, leading to increases in milk production and improving conditions (and prices) of livestock (Figure 17; for comparative purposes, both the monthly food security patterns and the monthly rainfall average between 1983 and 2010 are shown).

Variability in rainfall not only affects the hunger season but also labour availability. During the hunger season, the poorest households depend on two main types of labour that might be affected by climate variability: migrant labour (mostly in the easternmost and westernmost parts of the agricultural areas) and local labour (in other agricultural areas). Rain failure can result in reduction in area cultivated, and therefore a lower demand for agricultural labourers (both local and migrants) to cultivate land. The lower income, combined with higher food prices, could exacerbate seasonal hunger even before the harvest has failed.

Income sources and wealth

Income sources and wealth are important determinants of vulnerability to climate: the ability of a household to manage climate-related risks depends on its asset base. Over 29 per cent of the country's population is considered to be poor. In agricultural areas, poverty is closely linked to small landholdings. High population density, low soil fertility and erratic rainfall patterns further exacerbate poverty such as in Gambella, northern Amhara, northeastern Tigray, and parts of SNNPR. In the pastoral areas, the main factor contributing to poverty is the lack of availability of water and pasture.

The main income sources across all wealth groups throughout the country are crop and livestock sales – both of which are highly sensitive to climatic variability. However, there are considerable differences in cash sources between and within regions. The majority of households in agropastoralist areas depend on crop sales for their cash. One exception is the north-eastern highlands where insufficient rainfall does not allow for sufficient crops to be grown for own consumption *and* sales. Conversely, households in pastoral areas mostly obtain cash by selling livestock and livestock products. The wealthiest pastoralists only raise livestock and obtain sufficient cash in this way. Given the high climate sensitivities of income, unfavourable changes in precipitation patterns could result in significant losses of income, and force the poorest households to resort to negative coping strategies that could degrade their assets. Erratic or no rains usually render the poorest agropastoralists and pastoralists dependent on food assistance or remittances/gifts. As shown in Part II, rainfall has been declining steadily since 1980 in pastoralist areas (particularly in the southern and southeastern parts of the country), suggesting that pastoralist households are becoming increasingly dependent on external assistance to meet their food requirements.

Generally, poorer households depend on labour, including agricultural (particularly in the westernmost parts of the country) and casual labour (particularly in northern Afar) for their income. The availability of work is linked to the wet and dry seasons. During the former, labour consists of land clearing and preparing fields, weeding and harvesting crops. Its peak period occurs during and after the rains. During the dry season, labour consists of non-agricultural activities such as brick-making and construction. Therefore, any significant changes in the onset of the rainy season could affect labour availability for the poorest households with adverse impacts on their livelihoods and food security.

Food sources

The diets of rural households are generally quite limited in variety. Cereals (both home-grown and purchased) contribute to more than 80 per cent of household calories across most of the country. The main exceptions are pastoral areas, where households consume more milk and sugar. Pulses are the most common addition to cereals in household diets. Enset and root crops are an important source of food in SNNPR and Oromia. Vegetables also contribute to household diets across most of the agricultural areas of Ethiopia but their consumption is infrequent. Food preferences are closely linked to food types grown and access to markets.

Teff is the preferred cereal across most of the country, especially in the mid-highlands where it is mostly produced. However, it is rarely the main staple in households in other parts of the country because it is a very expensive cereal. Producers tend to sell *teff* to the urban markets to purchase cheaper cereals. The wealthier farmers sell other crops to buy *teff* for consumption. Given that *teff* is highly sensitive to rainfall variability (see Part II), significant rainfall changes in the *teff*-producing areas of the northwestern highlands could result in adverse livelihood impacts.

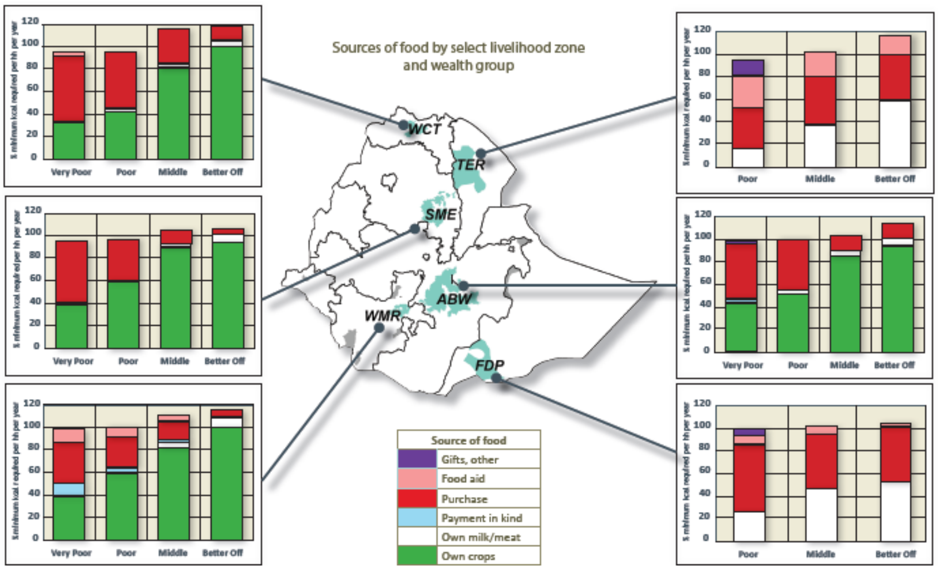

Figure 18. Sources of food by wealth group in selected livelihood zones. [Source: USAID and DRMFSS, 2010]

Milk and butter consumption is especially high among pastoral and agropastoral communities. In some agricultural areas where cattle ownership is high, too, there is relatively high consumption of dairy products. Production of milk and dairy products is dependent on the availability of pasture. As discussed in Part II, pastoralist areas have experienced a decline in annual rainfall, with erratic *belg* rains, over the past 30 years. However, the impact of climate trends on pastoralist communities is more complex. For example, pastoralist communities in south-central Ethiopia are dependent on water from rivers (especially the Shebelle River). The availability of water for these communities is more dependent on rainfall in the highlands than on rainfall in southern Ethiopia. In contrast, in Eastern Somali, pastoralists are more dependent on local rainfall. In the absence of adaptation efforts, therefore, pastoralists in these areas would be more negatively affected by increasingly seasonal rainfall.

Household food sources are highly variable across the country and also across wealth groups. Figure 18 illustrates the range of food sources across wealth groups in selected livelihood zones. The graphs illustrate that in cropping and agropastoral zones, consumption from own production is critical. The wealthiest households are able to obtain all their calories from own production. In comparison, the poorest households are highly dependent on markets and are not always able to meet their food requirements even if they procure food.

In contrast, in pastoral zones, households across all wealth groups are highly dependent on markets. The main difference between wealth groups is the amount of calories obtained from own milk/meat – the wealthier household obtain up to 50 per cent of their food from their own milk or meat.

The main food sources in the country are therefore highly sensitive to climate risks as highlighted in Table 3.

Table 3. Climate sensitivities of food sources.

Food source	Climate sensitivity
Own production	Erratic rainfall patterns could affect crop production, and therefore the availability of food. While is it wealthier households that obtain more food from their own production, the very poor and poor households in the central and southern parts of the country also obtain a significant proportion of their food from their own production. If production of poorer households decreases, they are likely to depend increasingly on markets.
Purchase	Across the country, the poor are highly market-dependent and purchase most of their food. Changes in production due to climate-related phenomena are likely to increase food prices, thereby reducing the ability of households to buy food.
Milk and livestock products	Milk is mostly consumed in the pastoralist zones of Ethiopia, and is a key component of nutrition among pastoralists. Changes in seasonal patterns are likely to affect the quality and availability of water and food for livestock, thereby affecting livestock reproductive cycles and reducing the quality of milk and meat.

Market dependence

Access to markets is important for food security across the country. Even in the most productive areas, the poorer farmers depend on markets to meet their food requirements. They depend on markets to purchase food and also to sell their products and assets to obtain additional cash. Pastoralists, especially, are highly dependent on markets. In the best of cases, some pastoralists obtain up to 50 per cent of their food requirements from milk, but depend on the exchange of livestock for grains and other products for the majority of their food.

Across all livelihood zones, households purchase at least some of their staple foods (Figure 19). The highest dependence on markets is where agriculture is not practiced (especially in the Somali and Afar regions) or where it is a secondary activity. In the north-east, east, and central highlands, dependence on markets is high due to a combination of limited land and erratic rainfall patterns. Recent trends suggest a decrease in rainfall trends in these areas, suggesting that households in these communities have become even more reliant on markets.

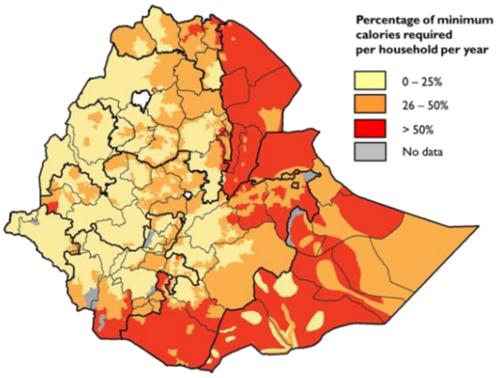

Figure 19. Percentage of calorie needs purchased from markets. [Source: USAID and DRMFSS, 2010]

The poorest households in the pastoralist areas depend on markets for more than 50 per cent of their food. In contrast, the poorest farmers in the western parts of the country depend almost exclusively on their own production to meet their household food requirements. The western regions of the country have relatively stable rainfall patterns although the historical trend suggests high inter-annual variability in rainfall – specifically, in the 1980s there was a noticeable decrease in rainfall in the western areas of Ethiopia which negatively affected food security. A return to those conditions could have detrimental impacts on food available from own consumption, and higher reliance on (more expensive) foods.

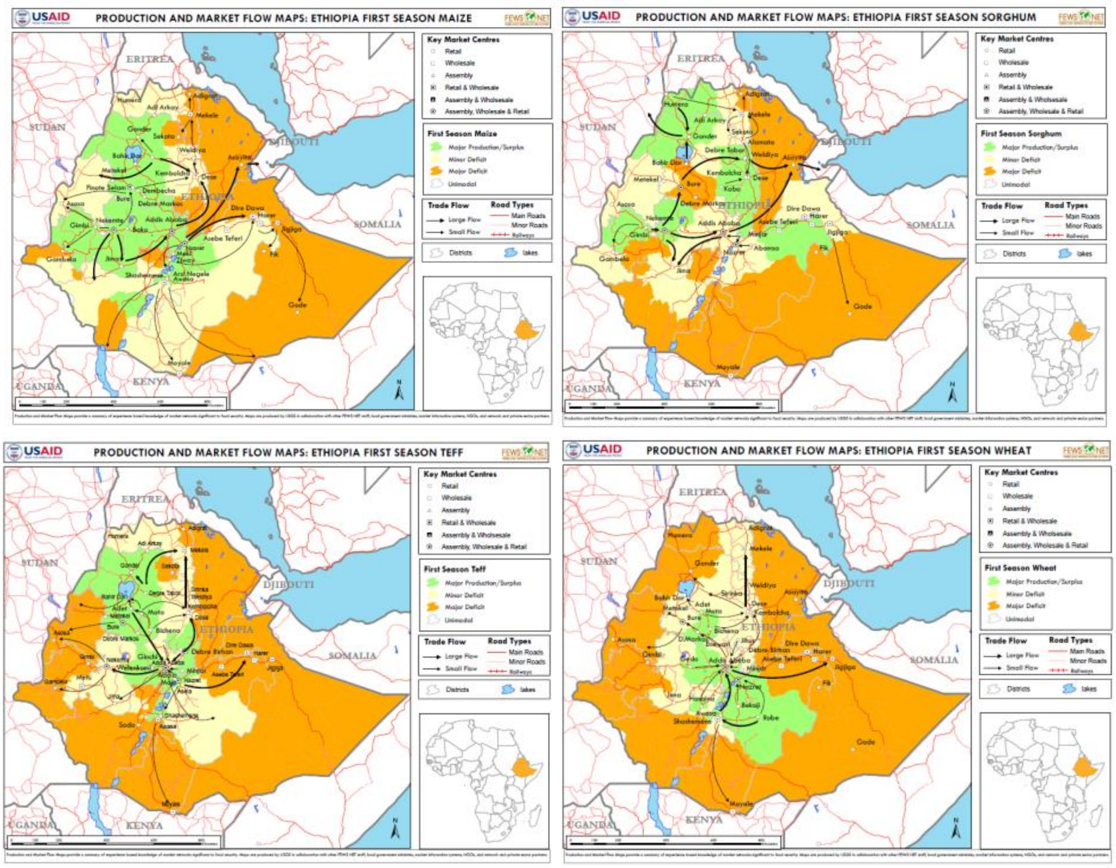

Figure 20. Market flow trades of maize (top left), sorghum (top right), *teff* (bottom left), and wheat (bottom right). [Source: FEWS NET, 2012b]

Given the high reliance on markets, vulnerability to climate risk also depends highly on how food markets and flows are affected by climate variability. As shown in Part II, there is a strong correlation between precipitation and yields, and yields and food prices following the harvest – suggesting that changes in rainfall could increase food price volatility. In particular, *teff* and wheat are very closely correlated with rainfall, and are therefore the most likely to experience food price increases. Therefore, net buyers of *teff* and wheat, who are mostly located in the lowlands and in western Ethiopia, are particularly vulnerable by climate-induced food price increases.

A market flow analysis illustrates the trade flows for key cereals: maize, sorghum, *teff* and wheat (Figure 20). Most cereal surpluses occur in the central and/or western parts of the country. Surpluses are exported internally, mostly to the pastoralist areas of the country as well as parts of SNNPR and southern Oromia. Due to the high dependence on purchased cereals in SNNPR and Oromia, especially among poorer households, any significant changes in production linked to rainfall variability could affect food price and food security more generally across these regions.

Part IV: Risk perceptions and coping mechanisms

Summary

- Climate is one of the main factors affecting vulnerability; households across most of Ethiopia consider lack of (or erratic) rainfall to be the main risk they face. This is especially the case in the southeastern, south-central, and eastern parts of the country, where rainfall is both decreasing and becoming more erratic.
- Households adopt a variety of coping strategies to manage these risks: livestock sales, local labour, migration, extra firewood sales, and self-employment.

According to an analysis by USAID and DRMFSS (2010), lack of rain (or erratic rainfall patterns) is by far the most common risk identified by communities across all livelihood systems in Ethiopia (Figure 21). The areas where limited rainfall has been identified as the most important risk are also the areas where rainfall has been declining – a trend that will likely continue under future climate change.

Drought and unpredictable rainfall are considered to be a primary risk in the eastern and southern parts of the country, and a secondary risk in some of the central and western parts of the country. That the lack of, or erratic, rainfall is considered to be such a critical hazard shows that livelihoods across the whole country are highly sensitive to rainfall patterns.

Box 4.1: Unique features of coping with flood among Afambo communities in Afar region

Flood risk management strategies in Afambo include exchange information about the occurrence of drought through traditional information exchange system called *daggu*, a local early warning system that indicates when relocation of families and assets is advised. Based on information provided by this early warning system, families can relocate, together with their assets, to high elevation during a flood. Households can also build flood protection infrastructure using local materials (such as soil and stone).

Similarly, there is a tradition that the better-off households and those who are not affected help the most affected by replacing lost animals and property through gifts. However, this culture is decreasing because of increasing economic stresses and disasters.

Source: WDRP/DRMFSS (2012)

In the pastoral rangelands, the main risk is related to erratic rainfall (anomalies in rainfall – which is quite limited in these regions – are associated with livestock diseases and significant decreases in livestock production). In the Somali region, rainfall is quite low and therefore anomalies such as the late arrival of pasture-reviving rains after long, hot dry seasons can have significant and rapid impacts on livelihoods. Moreover, when pastoralists lose livestock it takes several years to regenerate the herds, especially cattle, and therefore the impacts of climate variability are long-lasting.

The east-west divide is also quite clear in the agricultural areas, with rainfall generally higher and markedly more reliable in the west than in the east in comparable altitude bands. There are two notable exceptions. In Tigray, the West Central Teff Livelihood Zone is an upper middle-highland area where the most feared rainfall irregularities are **excessive showers** which waterlog fields (the other main risk is the local plague of the striga weed). The Arsi-Bale Highlands of south-east Oromia obtain sufficient **rainfall which frequently misses the surrounding lowlands**.

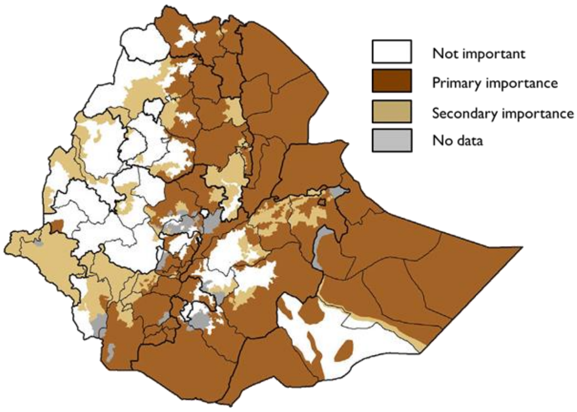

Figure 21. Areas where lack of/erratic rain is considered to be a key factor contributing to vulnerability. [Source: USAID and DRMFSS, 2010]

Box 4.2: How do the Raya Azebo communities in Tigray cope with drought?

During drought, households in Raya Azebo employ a variety of coping mechanisms, including outmigration, destocking, collecting wild foods, collecting and selling charcoal and firewood and borrowing money and grain. Reducing the amount and frequency of meals eaten per day are also among the coping mechanisms used in the area.

In the aftermath of droughts, there are social interactions and cooperation which help the most vulnerable households cope with climate-related risks. The relatively better-off households help the poor and those severely hit by drought by sharing food, labour, free use of oxen for farming, and by giving loans. In recent years, however, local social transfers have been declining due to deteriorating economic conditions.

Source: WDRP/DRMFSS (2012)

Communities use a variety of coping mechanisms to deal with erratic rainfall and drought (Figure 22). The most widespread coping mechanism is **livestock sales**. Both poor and rich households depend on livestock sales during shocks. However, for poorer households, livestock sales do not provide a large buffer due to limited number of livestock. Further, sale of breeding stock has a wider negative impact on restocking even after the end of distress season - this is particularly the case in the north-east highlands. Interestingly, livestock is the only asset sold during a bad year; farming equipment, jewellery and other assets are only sold in food security crisis years.

Increasing **local agricultural labour** employment is important mostly in lowland communities. A key exception is the Rayya plain which joins southern Tigray and northeastern Amhara, and which is a major employer of labour on the *teff* fields.

Migrant labour is a key coping strategy for several areas of the country. There is limited capacity of host areas to offer employment during normal years. When migrating communities and host areas both experience a bad year, food insecurity increases significantly.

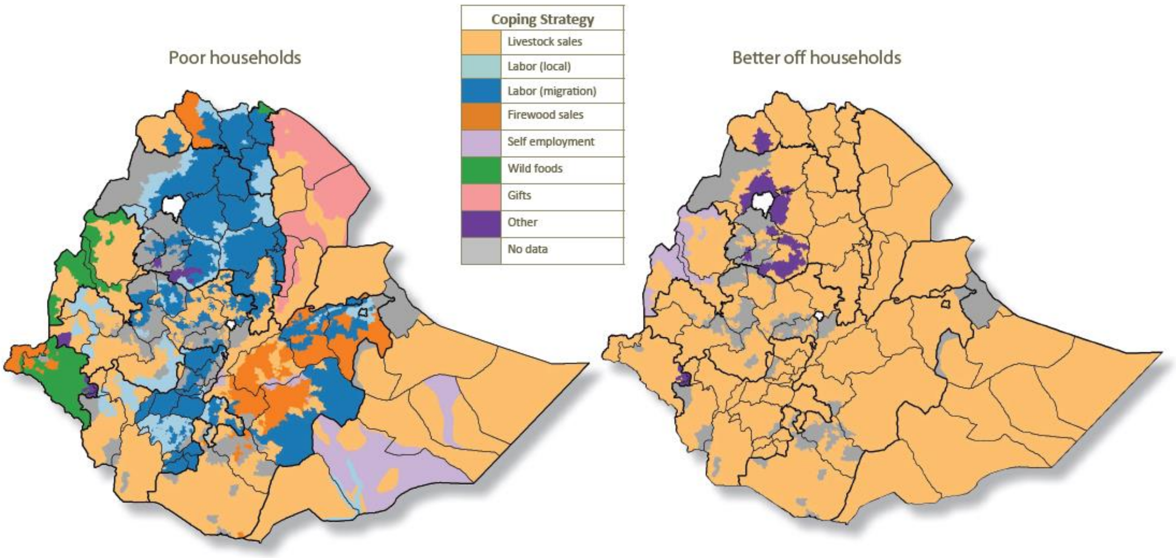

Figure 22. Key coping strategies by wealth group. [Source: USAID and DRMFSS, 2010]

Box 4.3: Ways of dealing with climate variability in the coffee growing area: The case of Wansho Wereda

The traditional agro-forestry system of the area plays a significant role in improving microclimates and in providing goods and services. Enset, avocado and other fruit-producing plants are resistant to short-lived climate stresses and provide food if cereal crops fail. Trees and shrubs can be used to generate income, which can be used to buy food and animal feed during drought. The agro-forestry system makes a significant contribution to local communities' resilience. People in Wansho remarked that gender roles tend to change during hardships, such as droughts. When drought occurs, men tend to migrate looking for work in construction, factories, and hotels. Male migration puts more responsibilities on women. Also during times of drought, women look for off-farm activities. For instance, women sell a local drink called keneto, engage in petty trade, and work for relatively better-off people or for people living in urban areas. The payment is often in kind (e.g., food for the family).

Source: Senait, Givery and Castillo (2010)

Finally, **extra firewood sales** and **self-employment** are common coping strategies in lowlands. Foothill areas adjacent to the highlands have an advantage in selling firewood, while in remote rangeland areas, communities sell gums, resins, and bush products.

Farmers adapt their farming strategies to better cope with erratic rainfall and drought risk. For instance, some farmers have planted improved varieties of crops adapted to moisture-deficit conditions and have diversified into high-value crops like spices and cosmetic plants. These cash crops are sold for higher prices at markets. In addition to planting new crops, some farmers are using water pumps to expand irrigated farming. Apart from farming, some agropastoral communities also raise small ruminants and chickens to compensate for dwindling livestock population owing to climate risks. The negative effects of lack of and erratic precipitation might have been countered by adaptation measures taken by vulnerable populations, such as shifting away from their traditional livelihoods. Some communities have gradually changed their choice of crops or planting dates, while others have migrated from vulnerable areas. There is also a shift in animal husbandry in different parts of the country. Some farmers, for instance, shifted their form of animal husbandry from open grazing system to tethered feeding with collected and conserved crop residues as a response to the diminishing grazing resource due to both climate extremes and man-made environmental degradation. In some kebeles, non-governmental organisations have been helping farmers to restock livestock lost due to droughts by using a "revolving fund" approach. First, a vulnerable household buys sheep on credit. Then, when those sheep reproduce, the farmers give the first offspring to another household to pay for the incurred debt. These households then continue the cycle. In this way, farmers in a specific community build up their livestock quickly.

Box 4.4: Summary of strategies to cope with climate risks in Yabello Wereda, Borena Zone

This Box summarises the strategies used by pastoralist communities in Yabello to cope with drought.

Migrating: The most commonly reported response mechanism to drought was migration. Temporary migration was an effective response due to the lack of local employment opportunities.

Conserving water and feed: During rainy seasons, households dig shallow ponds to collect rainwater; during drier seasons, they keep deep wells to overcome water shortages. Pastoralists continue a traditional practice of delineating, fencing, and scheduling pasture land into wet and dry season grazing areas. This is a way to overcome dry season feed shortage. A growing number of households make hay and pile and store it at home to feed animals during the dry months. Those who can afford it purchase feed from other places and preserve it to overcome dry season shortages.

Modifying farming techniques: Farmers are using early maturing and drought-tolerant crops.

Undertaking forest conservation/management practices: In the past 5 to 10 years, NGOs and government agencies have worked with communities to conserve forests and to introduce tree species adapted to arid and semi-arid conditions. Residents are participating in forest conservation. Some poorer households with few options are collecting and selling fragrant woods to generate income.

Modifying pastoralist practices: Some households have changed herd composition from cattle to camels and goats. However, poorer households cannot afford to replace cattle with camels, as the latter are more expensive than the former. Making the switch to camels also requires access to markets where cattle can be sold. That said, during times of drought, cattle fetch very low prices due to their weak body condition. The Government's Pastoral and Rural Development Office is doing trials of new grass species like Lucenia, Saspania, Elephant and Rhodes grass. Pastoralists are also being trained to use crop residues as animal feed; as a result, they have started harvesting and preserving crop residues for dry season feeding. Apart from training, the Pastoral and Rural Development Office has provided livestock feed during times of drought, helping to save thousands of livestock during the 2007/2008 drought. Finally, when raising livestock fails, some pastoralists are turning to farming.

Source: Senait et al. (2010)

Gradual adaptation measures occur at small spatial scales and cannot be captured by the models used in this analysis, which used de-trended data. In this context, the reported impacts of climate on food security should be interpreted as the expected impact in the absence of adaptation measures (cf. Lobell and Field, 2007). The scale of adaptation therefore adds a level of complexity in estimating climate impacts on food security.

Part V: Managing climate risk

Summary

- Three policy priorities have been identified to better address the challenges that climate change poses:
  - *Mainstreaming climate risk management into development and food security strategies*
  - *Focusing on the most vulnerable populations*
  - *Managing uncertainties associated with climate change*

Despite significant food assistance efforts over the last decades, high levels of food insecurity persist in Ethiopia. Climate risk, particularly droughts and floods, affects livelihoods and exacerbates environmental degradation, poverty, and food insecurity. Policies to tackle risks at different spatial scales are required to manage the negative impacts of climate on livelihoods and food security.

Based on this analysis, a number of policy strategies to address climate risk impacts on food security can be highlighted:

Mainstreaming climate risk management into development and food security strategies

One of the key messages of this analysis is that climate variability is a hunger risk multiplier, exacerbating current vulnerability trends. As such, it is difficult to isolate climate impacts on food and nutrition. Therefore, managing climate risk should not take place in isolation but should be integrated into broader disaster risk reduction strategies, development plans, food security and poverty reduction strategies, and national adaptation plans (NAPs). *Integrating climate risk management* structures into broader development pathways offers a cost-effective manner of addressing multiple development challenges, while accounting for the emerging risks posed by climate variability and change.

Disaster risk reduction strategies, social protection and safety nets offer critical platforms and vehicles for investing in risk management for the most vulnerable and should become a policy priority. In Ethiopia, the LEAP (Livelihoods, Early Assessment and Protection) tool is a platform to integrate risk transfer mechanisms into a broader safety net system.

Integrated climate risk management: the LEAP

LEAP (Livelihoods, Early Assessment and Protection) is a food security early warning tool that integrates risk transfer mechanisms, such as weather index insurance, into the Productive Safety Net Programme. The combination of these approaches improves the effectiveness of safety net programmes and reduces the negative impact of climate disasters on the most vulnerable people. The capacity of governments to prepare for disasters is also strengthened through effective integration of contingency planning and early warning systems with contingent finance and risk transfer tools that ensure resources are available when needed. These strategies represent a shift from traditional disaster *response* to more cost-effective disaster risk *management* approaches.

Scaling up risk management is critical in view of a changing risk environment characterised by increasing risks as well as larger numbers of people exposed to these risks. Successful scaling up should be implemented at the community level, as well as at the national, regional and global levels by adapting successful experiences and best practices in resilience building.

Focus on the most vulnerable

This analysis highlights that all rural livelihood systems in Ethiopia are highly sensitive to climate given the dependence of cropping, pastoral and agropastoral communities on rainfall. *Belg*-dependent areas are particularly vulnerable, especially given the increasing variability in *belg* rainfall over the last few years.

Recent climate trends show that rainfall is decreasing in the south-central, southeastern, and northern parts of the country, while the western parts of the country have been receiving more rainfall – and climate projections are consistent with these trends. This in turn suggests that the magnitude of droughts and floods may increase under climate change.

In this context, strategies for *livelihood and income diversification* are critical to ensuring resilience against more intense climate-related risks. For example, migration (both seasonal and permanent) has become an important source of household income for at-risk populations. Increasing voluntary labour mobility is a low-cost, low-regret approach that contributes to the adaptive capacity of communities through networks that are used to exchange goods, services and information while also giving at-risk populations the opportunity to adapt based on their needs. Support to additional income sources, such as wage labour, skilled non-farm activities and forest management can lead to improved livelihoods.

Landscape transformation through land rehabilitation can offer a long-term solution to climate risks. For instance, The MERET project (Managing Environmental Resources to Enable Transitions to more sustainable livelihoods) – a joint initiative of the Ministry of Agriculture, the Environmental Protection Authority, and WFP – promotes community-based and people-centred integrated watershed management and livelihood improvement aimed at improving the food security and livelihoods of chronically food insecure and drought-prone communities. In the past 5 years alone, MERET has reached 1.7 million at-risk people in over 500 communities. The project has contributed to the rehabilitation of over 400,000 hectares of degraded lands. A cost-benefit analysis made in 2005 showed that economic and financial rates of return exceeded 12% from the assets created and soil fertility restored, with evident impacts in food production, rural income generation and livelihoods. Food insecurity in the targeted areas was reduced by 40%, while 80% of interviewees reported being better able to cope with shocks and stress. Increased resilience will gradually allow communities to phase out from food assistance.

Landscape management could also contribute to effective flood risk management through the expansion and refurbishment of irrigation and water storage infrastructure, capacity building for water-efficient cropping practices, and adoption of flood-resilient crop varieties.

Manage uncertainties associated with climate change

One of the key characteristics in terms of climate risk in Ethiopia is that both droughts and floods can occur in the same growing season, with potentially devastating impacts on crop and livestock production. Strategies to address climate risk should focus on developing capacities to better analyse and anticipate risks. For instance, the introduction of early warning systems and contingency plans can support climate risk management and food security strategies. Investments should also be made in strengthening analytical tools such as early warning systems, and risk assessment and monitoring systems to enhance detailed and up-to-date risk information.

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Annex I: Data and methods

The analytical method carried out for this study consisted of two components:

1. A descriptive analysis to establish a baseline against which vulnerability to future risks can be assessed.
2. A dynamic analysis to evaluate the relationship between historic and current climatic variability and food security indicators.

These components provide complementary information to determine the relationship between climate variability, food security and vulnerability across Ethiopia.

Data Analysis

Descriptive analysis

The aim of descriptive component of this analysis was to identify the potential vulnerabilities of food security to climate variability in Ethiopia through maps and other visual outputs.

For the descriptive assessment, relevant variables that are climate sensitive were identified and major livelihood profiles across the country were examined. The relevant parameters from the secondary data and other sources were selected, and their specific vulnerabilities to climate variables were described.

The majority of these data were obtained from an extensive literature review, combining information from the Wereda Disaster Risk Profiles (WDRP; DRMFSS, 2012), the Atlas of Ethiopian Livelihoods (USAID and DRMFSS, 2010), and outputs from ACCRA (Ludi et al., 2011).

Dynamic Analysis

The aim of the long-term dynamic analysis was to evaluate the temporal relationship between historic and current climate and food security, and to evaluate the correlations between climate and food security trends at national and sub-national scale. Most assessments of climate impacts on food security focus on production—the aim of this analysis was to analyse potential impacts on other food security indicators.

Unprocessed long-term climate data (rainfall and temperature) from meteorological stations were obtained from National Meteorological Agency of Ethiopia (NMA). These were used to analyse temperature conditions and the trend and variability of rainfall. The analysis of climatic conditions involved the use of various mathematical procedures and techniques. Some of the analyses were used to identify long-term monthly, seasonal and annual mean values, and coefficient of rainfall variability.

Food security data were collected in consultation with the Central Statistical Agency. These included crop production statistics, area harvested and yields, food prices (measured under the consumer price index), and nutrition data (collected under the Demographic and Health Surveys).

The data were managed and visualized using SPSS and Microsoft Excel for statistical analysis and ArcGIS for geostatistical analysis. Additional maps and analyses were conducted using outputs from the LEAP (Livelihoods Enhancement, Assessment and Protection) platform maintained by the Disaster Risk Management and Food Security Sector of the Ministry of Agriculture.

To complement this process, a multiple regression model was developed to verify whether there is a statistically significant long-term trend in climate risks and major crop output in Ethiopia. The data have been tested for linearity, normality, homoscedasticity, autocorrelations and multicollinearity problems before running the model. Linearity analysis determines whether or not the relationships between the predictors and the outcome variable are linear. The assumption of normality was assessed by the Kolmogorov-Smirnov and Shapiro-Wilk tests. The basic logic behind the normality test is that the errors are identically and independently distributed. The results of the analysis indicate that the assumption of normality is satisfied. Another statistical test performed for the data was homoscedasticity (homogeneity of variance). The assumptions of homoscedasticity are that error variance should be constant and the variance of the residuals is homogeneous across the levels of the predicted values.

Dependent variable	Explanatory variables
Change in major crop output first-differences (difference from one year to the next)	Change in total June-September rainfall Change in total *belg* rainfall Change in mean minimum annual average temperature Change in mean maximum annual average temperature

Data Sources

The data for this analysis were obtained from five main sources: the National Meteorological Service Agency of Ethiopia (NMA), the Central Statistical Agency (CSA), the Wereda Disaster Risk Profiles (DRMFSS, 2012), the LEAP platform, and the Livelihoods Atlas of Ethiopia (USAID and DRMFSS, 2010).

Long-term climate (over 30 years for most sites) and crop production data were used for analytical purposes in this paper. The climate data (monthly rainfall and maximum/minimum temperature) of about 30 meteorological stations which are representative of the differences in the country's climate were considered. These stations were selected in consultation with the National Meteorological Agency, and were chosen to adequately represent the country spatially. The data obtained from the NMA and CSA were used to examine the dynamic relationship between historic and current climatic variability and food security indicators as well as livelihood systems and coping strategies across Ethiopia.

Additional information was obtained through a desk review of literature on climate change and food security with a particular focus on the Ethiopian context (keywords on SCOPUS and Google Scholar: Ethiopia AND "food security" AND climate).