Report on Historical Climate Baseline Statistics for East and West Hararghe, Ethiopia

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Editor: Bahati Musilu

1 TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

AMJ	April-May-June
ASALs	Arid and Semi-Arid Lands
ASON	August-September-October-November
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station
DJF	December-January-February
ENSO	El-Niño Southern Oscillation
FMAM	February-March–April–May
FAO	Food and Agriculture Organization of the United Nations
GHA	Greater Horn of Africa
GHG	Greenhouse Gases
GIS	Geographic Information System
HoA	Horn of Africa
ICPAC	IGAD Climate Prediction Applications Centre
IDDRSI	IGAD Drought Disaster Resilience and Sustainability Initiative
IGAD	Intergovernmental Authority on Development
IOD	Indian Ocean Dipole Mode
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
JJAS	June–July–August-September
JRC	Joint Research Centre
KMD	Kenya Meteorological Department
LGP	Length of Growing Period
LTM	Long-term Mean
OID	Ocean Dipole Mode
OND	October–November–December
PET	Potential Evapotranspiration
QED	Quality of Education
RFE	Rainfall Estimates
SON	September-October-November
SPI	Standardized Precipitation Index
SRA	Short Rains Assessment
SSA	Sub-Saharan Africa
SST	Sea Surface Temperature
SSTs	Sea Surface Temperatures

UN	United Nations
UNDP	United National Development Programme
WMO	World Meteorological Organization

1. INTRODUCTION

Extreme rainfall and temperature that include the recurrence of drought and floods have become common in the Greater Horn of Africa (Ogallo Linda et al. 2017; Omay et al., 2016; Sabiiti, et al., 2016; Awange, et al., 2007; Kinguyu, Ogallo L. A. & Anyamba 2000; Ogallo L. A., 1993; among many other authors). IPCC (2014a) reports that during the last 30 to 60 years, Eastern Africa has been experiencing frequent droughts and heavy rainfall events. IPCC (2014b) further reports that the changes in temperature and precipitation patterns seen in the Region have also been reported in many parts of the world. Globally, there are several scientific reports from various authors which indicate that climate variability and change including changes in temperature and precipitation patterns are also common over Ethiopia.

The risk of loss of rural livelihoods and income due to climatic hazards is particularly real in arid and semiarid regions, largely inhabited by communities engaged in pastoral and agro-pastoral livelihood systems (Befikadu et al., 2019; Weldegerima et al., 2018; Esayas et al., 2018; Degefu & Bewket, 2014; Viste, Korecha, & Sorteberg, 2013; Rossel & Holmer, 2007). These communities have limited access to information, technical support and financing for adaptation options hence responding to local climate variability and predictions is very limited. Therefore, enhancing the capacity of communities to cope and adapt to climate variability and change helps to build their resilience and improve their livelihoods.

About 50%, 84% and 30% of Ethiopia, Kenya and Uganda respectively, are classed as either arid or semiarid lands. Annual evapotranspiration in drylands in Arid and Semiarid Lands (ASALs) exceeds rainfall. Agricultural productivity is also limited by poor availability of moisture thus affecting the food and nutrition security of populations. Prolonged and widespread drought is a recurrent feature of the ASALs that is exacerbated by climate change phenomena, advancing desertification and ecological degradation. In its 2011 report, the International Federation of Red Cross (IFRC) states that most pastoral communities in the ASAL region are overwhelmed by weather and climate related hazards as they search for safe paths through the periods of recurring drought. Traditional pastoral routes, national park fences and farm enclosures limit access to grazing and water points, and pursuing what there is can lead to violence. Increase in regional conflict has left the arid lands awash with weapons, and neighbouring tribes are well armed.

Enhanced desertification in the Horn of Africa’s dry-lands is another key challenge in the Region. The harsh ecological circumstances of the ASALs contribute to severe hardships amongst the affected communities, including poverty, hunger, malnutrition, dislocation and conflicts over natural resources both within and across boundaries in the region. The vulnerability of the Horn of Africa’s Arid and Semiarid Lands has been especially evidenced over the last decades by the occurrence of drought induced famine in many parts of the region, notably in the early 1980s and most recently in 2011, when millions of people were affected by drought causing untold suffering and death of both livestock and human populations.

Most of the Countries within the Horn of Africa consist of fragile ecosystems that are highly vulnerable to climate change, and thus the livelihood strategies undertaken by dryland communities are equally fragile and vulnerable. The task of building resilience to climate change and supporting community adaptation to climate change is therefore linked closely to sustainable management of natural and productive resources.

The IGAD Drought Disaster Resilience and Sustainability Initiative (IDDRSI) strategy states that due to this interplay of factors, “efforts to increase the capacity of communities and households in the ASALs to cope with and adapt to greater prevalence of drought events requires a wholistic approach that addresses the need for information (including climate information and information on climate resilient practices), access to appropriate technology, capacity building, new livelihood opportunities and a supportive policy regime”.

Highly economically valued products such as gum Arabica, are largely found in the dryland areas of the Horn of Africa. According to the United Nations Development Program (UNDP), countries like Uganda and Ethiopia, that have a high percentage of drylands, are mostly dependent on the development, efficient and effective use (and also resilience) of these parts of the countries. Therefore, the drylands in the Horn of Africa can be said to be socially, economically and ecologically important areas where building of climate resilience can effectively contribute to poverty alleviation and economic retardation of the resident populations and their countries as a whole.

The Agricultural Climate Resilience Enhancement Initiative (ACREI) is a 3-year partnership program being effected in the GHA by the World Meteorological Organization (WMO), the Food and Agriculture Organization of the United Nations (FAO) and the IGAD Climate Prediction and Applications Center (ICPAC) with funding from the Adaptation Fund. The program targets Ethiopia, Kenya and Uganda and supports community adaption practice, climate proofing of extension systems and climate informed decision making. ACREI attempts to improve climate forecasts using a regional approach to build the capacity of communities to understand and appropriately use climate information and related agro-advisories in decision-making to climate-proof their livelihoods; and thus, enhance their water, food and nutrition security.

The main goal of the ACREI is to develop and implement adaptation strategies and measures that will strengthen the resilience of vulnerable smallholder farmers, agro-pastoralists and pastoralists in the Horn of Africa to climate variability and change in line with the IGAD Drought Disaster Resilience Sustainability Initiative (IDDRSI) programme, the National Adaptation Plans of Action (NAPAs) and Development Strategies/Visions of participating countries. The overall objective of the project is “Improved adaptive capacity and resilience to current climate variability and change among targeted farmers, agro-pastoralists and pastoralist communities.” The three components of the project include:

1. Community Adaptation practice through sustainably enhanced productivity, production, livelihood diversification and income levels among targeted communities;
2. Climate proofing of extension systems through enhanced technical capacity of development and extension actors (national, sub-national, private sector, NGOs, CBOs) to support community level climate adaptation strategies; and

3. Climate informed decision making through improved climate informed decision making in regional, national and sub-national institutions.

In close partnership with the National Meteorological and Hydrological Services (NMHSs), ICPAC leads component 3 of the project while FAO leads Components 1 and 2. The third component focuses on data Processing and Forecasting Systems (DPFS); appropriate information packaging; dissemination channels and policy gaps, which are major limitations to provision of effective climate services to farming communities by the National Meteorological and Hydrological Services (NMHSs) in the region. The infrastructure and facilities for data processing and forecasting systems have continued to deteriorate leading to great difficulties in providing weather and climate services in the region to meet national and regional needs. The human resource capacities in the NMHSs in the region are also insufficient to meet the evolving challenges. These shortcomings have continued to negatively impact on the availability, timeliness, efficiency, accuracy and quality of actionable climate service delivery.

In order to effectively implement the above three components, baseline data and information that is easily accessible to the users has been key activity for the project. The users must also be able to understand and appreciate the significance of these baseline data as well as basic weather and climate concepts such as normal, above normal, below normal, risk management, among other terms. Analysis of the baseline climate was therefore one of the first major activity of the project to support the project components. Baseline climate data analysis in the three countries were undertaken by organizing workshops for the focal points from each member states under support of climate scientists from ICPAC. The workshops also enabled integrated planning and outcome mapping roadmap of the project to be agreed upon by each participating Member States and specific are users in the project area.

This project report provides a summary of the Climate Baseline Statistics for East and West Hararghe (Ethiopia), as derived from the workshop on area specific analysis of climate data. Similar reports for Taita-Taveta, Kenya has been published in Volume1, while the report for Isingiro / Sembabule Districts (Uganda) will be presented in volume 3. The locations of the three study areas as shown in Figure 1.1-1.

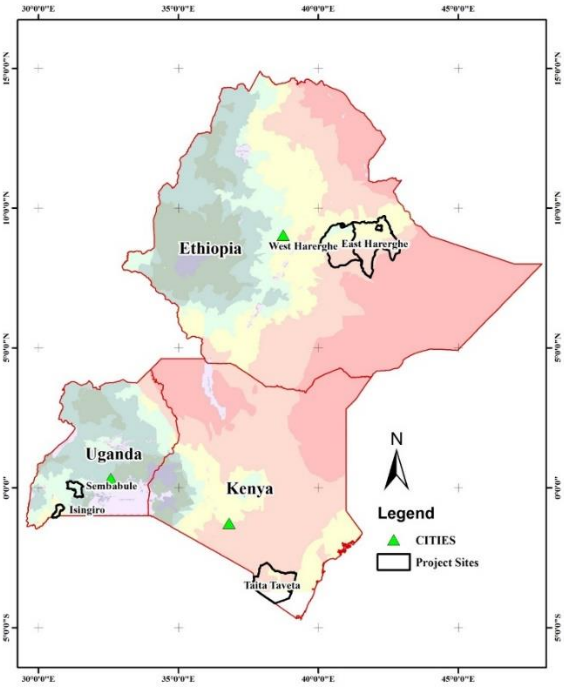


Figure 2.1-1 ACREI project Sites

The analysis generated and mapped location-specific basic climate statistics including mean, trends, maximum and minimum temperatures as well as other space-time climate characteristics that are required to provide local climate risk knowledge including those essential for climate change adaptation and mitigation.

The other products created during the workshops included rain-fed cropping start, progression and end of season, number of rain days, seasonal rainfall distribution in space and time, probability of damaging dry spells and or storms occurring including when, where and for how long, and percentile of precipitation, related seasonal water balance variables, seasonal peak, among others. These climate product will serve as a source of information for all components of the project as well as the partners and stakeholders.

2. ETHIOPIA AND TARGET SITE

Agriculture is the major socio-economic sector in Ethiopia and contributes to approximately 42% of the national Gross Domestic Product (GDP), while 80% of the country's population depends on the sector for their livelihoods. Chronic food and nutrition insecurity affects 10% of the population and even in average rainfall years these households cannot meet their food needs and must rely partly on food assistance. Malnutrition affects a large number of children as well as pregnant and lactating women in Ethiopia, with May-June 2016 figures indicating around 458,000 expected admissions for severe acute malnutrition (FSNWG, 2016). The farming systems in Ethiopia can be classified into five major categories – the highland mixed farming system, the lowland mixed agriculture, the pastoral system, shifting cultivation and commercial agriculture. Over 95% of the annual gross total agricultural output of the country is said to be generated from smallholder farmers with an average farm size ranging from 0.5 to 2 hectares. Overall, the agriculture sector is highly vulnerable to the impacts of climate change.

Ethiopia has the largest livestock population in Africa and the tenth largest in the world. Livestock is an integral part of the farming systems in the country. It is the source of many social and economic values such as food, draught power, fuel, cash income, security and investment in the highland, lowland and pastoral farming areas. As in the case of crops, the sector makes a significant contribution to GDP and is also a major source of foreign currency.

Droughts periodically reverse agricultural sector performance gains, with devastating effects on household food security and poverty levels. Vulnerability to droughts is greatest in the pastoral areas of the lowlands and the densely populated, food-insecure districts of the highlands. Drought-induced famines are further exacerbated by limited coping mechanisms and inadequate contingency planning for drought mitigation and the threat of climate change. Other causes of the vulnerability of Ethiopia (and in particular the drylands) to climate variability and change include under-development of water resources, low health service coverage, high population growth rate, low economic development level, low adaptive capacity, inadequate road infrastructure in drought prone areas, limited institutional capacity at the sub-national level, lack of community awareness, poor information dissemination/communication and inadequate early warning systems among others.

Ethiopia's drylands cover approximately 63% of the country's land area and are found mainly in the north, east and central areas of the rift valley, also south and south eastern parts of the country and include a very wide and diversified range of agricultural environments. These regions have an estimated human population of between 12 to 15 million people. Ethiopia's drylands provide important forage for livestock and constitute a main source of food and livelihoods for a large proportion of Ethiopia's population.

Crops grown in the drylands include sorghum, finger millet, field peas, chickpea, cowpea, perennial cotton, safflower, castor bean, sesame and other crops. However, livestock production is the predominant dryland farming system and is practiced either as nomadic pastoralism or agro-pastoralism. Livestock in the drylands serve as insurance against crop failure and as a source of food, usually for dairy rather than meat production. In all, pastoral lands in the country cover an area of over 625,000 km^2.

Ethiopia's dryland household livelihoods are considered to be highly vulnerable to climate variability and change largely due to widespread poverty, low adaptive capacity and high levels of dependence on natural resources. The major challenges threatening the dryland communities of Ethiopia relate to the degradation of the natural resource base, which leads to soil erosion and vegetation loss, soil fertility decline, water stress, as well as drying of water resources, lakes and rivers. This degradation is being exacerbated by increasing climate variability and change, with profound impacts on the livelihoods of the communities.

The next section provides general information on project site in Kenya namely East and West Hararghe.

2.1 East and West Hararghe

East and West Haraghe Zones are situated in the eastern part of Ethiopia, bordering Somali Region as well as the urban administrative regions of Dire Dawa and Harari. Both Zones can be classed into lowlands (30-40%), midlands (35-45%) and highlands (15-20%) areas. The two zones have two rainy seasons; *belg* (February to May) and *kiremt* (June to September). *Belg* rains are mainly used for land preparation and planting of long cycle crops such as maize and sorghum and seed bed preparation for short-cycle *meher* crops. The *meher* rains are used for planting of cereal crops like barley, teff, wheat and vegetable crops like onion, shallot and potatoes in the highlands and peanuts in the lowlands. Despite the agricultural system in the two zones being strongly subsistence based, East and West Hararghe also have some cash crop production, which includes coffee, Irish potatoes, onions and *chat* which are produced in the highland areas and to some extent groundnuts grown in the southern lowlands of East Hararghe Zone.

Recurring droughts have depleted the resilience of these zones with particular effect on food security of agro-pastoralists in the lowland areas of these zones. The severity of food insecurity is more critical in the lowlands than in the mid- and highlands, mainly due to moisture stress hampering agricultural production. The two zones also suffer from problems of population pressure, land shortage, soil erosion, droughts and chronic food and nutrition security particularly in the lowland areas where moisture stress hampers agricultural production. Crop pests, mainly Quelea birds, bollworm, stalk borer and armyworm outbreaks are additional production constraints, while weeds such as striga, a parasitic weed mainly attacking maize and sorghum, are causing in yield declines of staple crops.

East Hararge is bordered on the southwest by the Shebelle River which separates it from Bale, on the west by West Hararghe, on the north by Dire Dawa and on the north-east by the Somali Region. East Hararghe Zone is one of the drought and conflict prone areas of Ethiopia where malnutrition prevalence has been high for a long period. According to the Central Statistical Agency (2011), the zone has a total population of 3,244,379 inhabitants spread among 648,876 households. The Central Statistics Agency (2011, went on to indicate that of the zones population, 8.27% are urban inhabitants, 1.11% is pastoralist, 17% agro-pastoralists, and the rest are agriculturalists (74%).

In the past, Eastern and Western Haraghe have been highly affected by droughts. Whereas in some of the highland areas of these two zones, pockets of high vulnerability exist due to structural development problems, people living in mid- and lowland areas of these zones, especially those making a living from agro-pastoralism, are the most vulnerable to food insecurity.

Livestock production is the major or the sole livelihood of pastoral and agro-pastoral communities and it plays a significant role in diversifying the income of farming communities in both zones. Among the livestock types, cattle and goats which are the major marketable livestock commodities, are the most dominant in the farming system followed by camel population which is the highest particularly in Mieso Woreda in West Hararge zone. Crop residue, natural pasture and weeds are the major feed resource for cattle. However, the productivity of livestock has been decreasing substantially due to continuous drought, population pressure and shortage of grazing land due to conversion of grazing land into crop production. Shortage of feed is one of the limiting factors in livestock production. During drought periods, migrating with livestock to other areas is common. Livestock disease such as anthrax, blackleg, internal and external parasites is another major problem constraining livestock production and this is aggravated during aftermath of droughts due to poor body condition of livestock that contributes to the lack of resistance to many of the diseases. This results in very low productive performance (pregnancy and birth) due to weak livestock physical body condition. Consequently, livestock product especially milk is very low and livestock herd size is reduced in most of the lowland areas of the two zones.

The 2011 El Niño-induced drought in Ethiopia, was one of the strongest on record. It particularly affected smallholder farmers in the north-eastern and eastern parts of Amhara and Oromia Regions, including East Hararghe. The failed rains also affected long-cycle crops typically harvested in the *meher* season (e.g. maize and sorghum), resulting in reduced crop yields, as much as 50 to 90 percent crop losses were experienced. The erratic and delayed *kiremt* rains further hindered the planting and development of crops, resulting in reduced harvests. Two consecutive seasons of below normal rainfall in both zones severely affected regeneration of pasture and replenishment of water points for livestock consumption. Moreover, crop residues which are mostly used as animal feed in most crop dependent areas in the affected zones were scarce. As a result, availability of pasture was below normal with the shortage being even more severe in the lowland agro-pastoral areas where the project sites are located (**Figure 2.1-1)**.

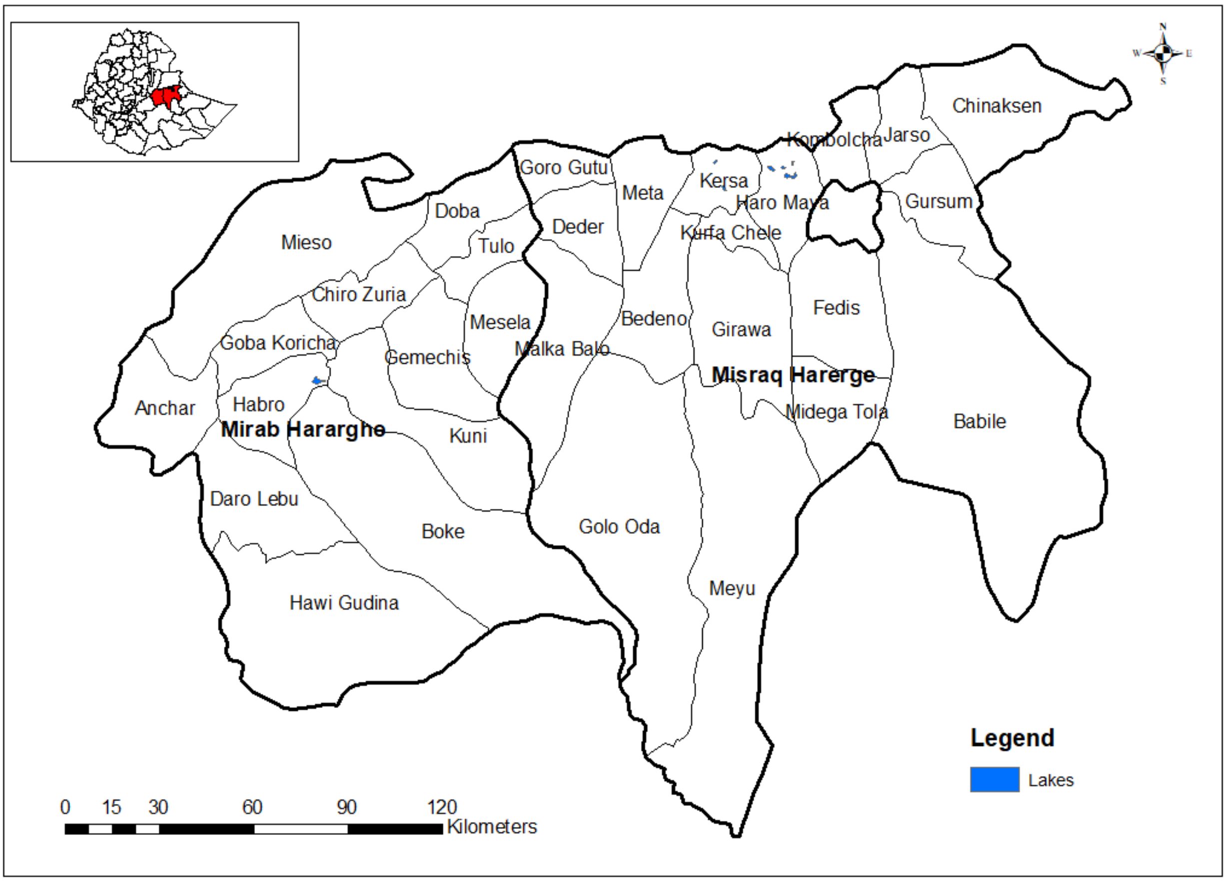


Figure 2.1-1 East and West Hararghe Districts and Divisions

3. CLIMATE BASELINES WORKSHOP

ICPAC and the National Meteorological and Hydrological Services from Ethiopia, Kenya and Uganda held a workshop in Naivasha, Kenya from April 15 to 19 to generate historical climate analysis for the ACREI project sites. The workshop programme also included capacity enhancement for the focal points on climate data analysis tools. The team used standard appropriate tools and procedures developed by ICPAC to analyse historical data and generate useful climatological baseline products.

The workshop was targeted to contribute to three out of the four outputs to be implemented by ICPAC including **Output 3.1:** *Downscaled, location-specific seasonal climate forecasts and future projections generated regularly*; **Output 3.3:** *Agro-climatic advisories appropriately packaged and timely disseminated*; and **Output 3.4:** *Evidence based climate information feeds into policy dialogues in the region.*

The activities achieved under this output are:

i. Conducting regional and national learning forums;
ii. Documentation and dissemination of good practices and lessons learned on the use of climate information in agricultural decision making and

iii. Improved regional food and nutrition security assessment coordination including capacity building on attribution of food insecurity to various climate related hazards.

The outcomes of the workshop included: -

i. Capacity building of NMHs on latest climate products and tools available for analysis of historical climate;
ii. Training for NMHs on the use of Climate Data Tools (CDT);
iii. Analysis of historical climate of project sites including monthly climatology, rainfall intensity, historical onsets, rainfall and temperature trends among others;
iv. Providing location, specific climate baseline results as a basis on which climate hazards are created;
v. Review of the ACREI project work plan based on the baseline results;

These outcomes are presented in the final conclusions section.

3.1 DATA

The ACREI project in Ethiopia targeted East and West Hararghe areas chosen based on a number of criteria, including their vulnerability to climate change, relevance in terms of resilience building, and fragility of the natural resource base, level of land degradation including ongoing efforts or past efforts towards mitigating climate change. Some level of extension capacity and past experience with group extension methodologies was however desired. Since the project is learning and innovative in nature, access was considered to allow frequent support and backstopping, thus road infrastructure, security and peace were among the selection criteria.

Country station data together with satellite rainfall data was used in the study from the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) dataset (CHG, 2016). [1]

4. BASELINE STATISTICS FOR EAST AND WEST HARARGHE

Several baseline climate products including maps were generated at the capacity building workshop. Examples of the products presented in this report include:-

a) Mean Annual Rainfall;
b) Monthly and Seasonal Rainfall Distribution;
c) Inter-annual Variability/ Anomalies;
d) Rainfall Trends;
e) Rainfall Intensity;
f) Onset, Cessation dates and Length of Growing Period; among many other basic statistics.

[1] CHIRPS is a global dataset (50° S-50° N, 180° E-180° W), with a resolution of 0.05°, ranging from 1981 to near-present gridded precipitation time series. CHIRPS data are produced by scientists at the University of California, Santa Barbara (UCSB) Climate Hazard Group (CHG) and the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center. The data was developed to support the United States Agency for International Development Famine Early Warning Systems Network (FEWS NET).

4.1 Mean Annual Rainfall

Mean annual rainfall represents the expected total amount of rainfall at the specific location. Since most of socio-economic activities in the area are rain dependent, information regarding the mean annual rainfall baseline statistics together with the expected minimum and maximum annual rainfall (**Figure 4.1-1, 4.1-2, 4.1-3**) are extremely important climate variables for the development of effective climate resilient strategies for any location.

East and West Hararghe generally receives over 500 mm of rainfall per year. West Hararghe generally receives more rainfall than East Hararghe. Meta, Deder and Tuko are generally the wettest towns in West Hararghe receiving rainfall amounts of between 950 and 1100mm. Babile division in West Hararghe generally receives the lowest amount of rainfall in the district with parts of the division receiving between 350-450 mm of rainfall.

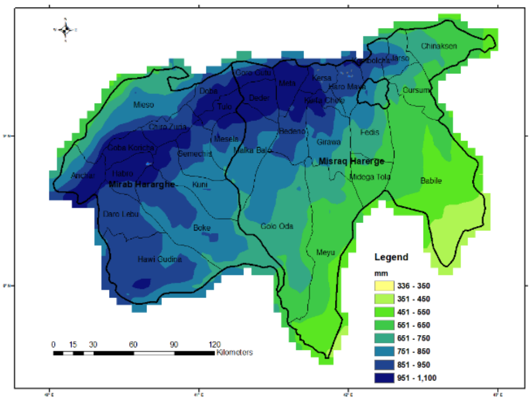


Figure 4.1-1 Annual Rainfall distribution (1981-2010)

The distribution of the driest and wettest scenarios in East and West Hararghe are summarized in **Figure 4.1-2 & 4.1-3**. The figures show great similarities between the wettest and the driest years in East and West Hararghe. It was observed that some parts of the district that receive over 700mm of rainfall annually, sometimes receives between 900 to1000mm of rainfall annually, and less than 500mm of rainfall in a year in some of the worst drought years. It is however noted that some areas in the districts receive less than 500mm of rainfall in their wettest years.

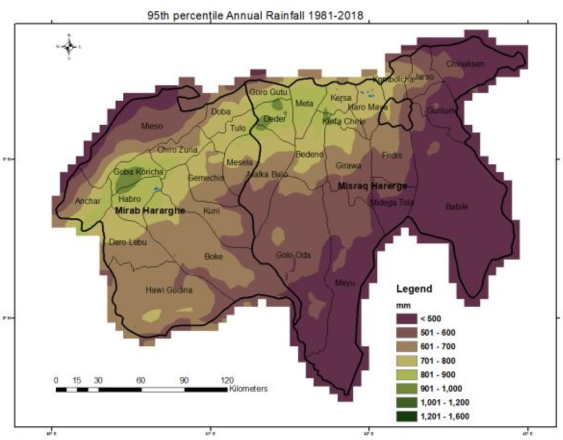


Figure 4.1-2 Annual maximum rainfall extremes 1981-2010

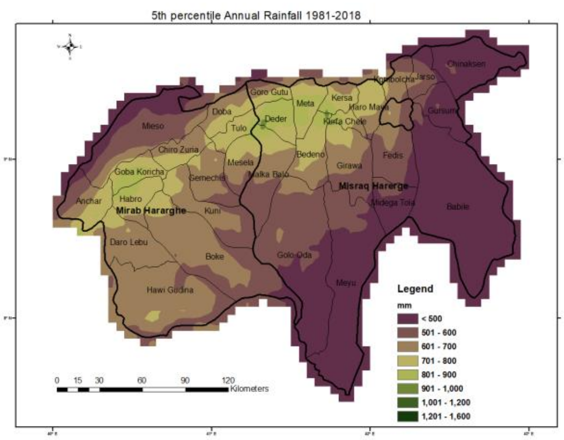


Figure 4.1-3 Annual minimum rainfall extremes 1981-2010

4.2 Monthly and Seasonal Rainfall Distribution

Figure 4.2-1 presents the mean monthly rainfall for East and West Hararghe. March to October seems to exhibit the largest amounts of rainfall. The Government of Ethiopia names three seasons in Ethiopia, namely *Bega* (dry season) which extends from October-January, *Belg* (short rain season) which extends from (February-May), and *Kiremt* (long rain season) which extends from June-September (NAPA, 2007). **Figure 4.2-1** shows significant rainfall amounts received in October therefore the October to January (*bega*) season also receives some rainfall even though most of the months in the season are generally dry.

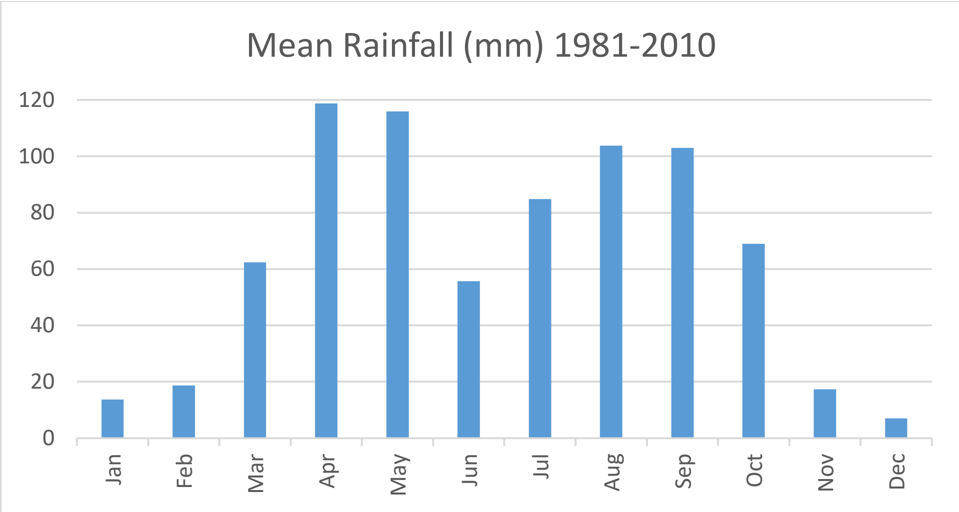


Figure 4.2-1 Mean Monthly rainfall (1981-2010)

The spatial distribution of the individual months from January to December as well as for February to May (*Belg*) and June to September (*Kiremt*) seasons are shown on **Figure 4.2-2** to **4.2-4**, while the percentages of the specific season contribution to annual rainfall is shown in **Figure 4.2-5** and **4.2-6**. The figures also highlight significant spatial rainfall differences even within the individual seasons that must be considered while developing climate resilient policies for the county.

West Hararghe generally seems to receive more rainfall in both *Belg* and *Kiremt* seasons. In East Hararghe, Goro Gutu, Meta Dobu and Tulo division and in West Hararghe Goba Koricha, Harbo and Anchar divisions displayed the highest amounts of rainfall in the *Kiremt* season, all recording over 500mm of rainfall during the season (**Figure 4.2-3)**. Babile division generally seems to receive the lowest amount of rainfall particularly in the *Kiremt* season where parts of the division receive as low as 50 to100mm of rainfall. (**Figure 4.2-3**). The southern parts of Meyu division also receives less than 100 mm of rainfall in the *Kiremt* season.

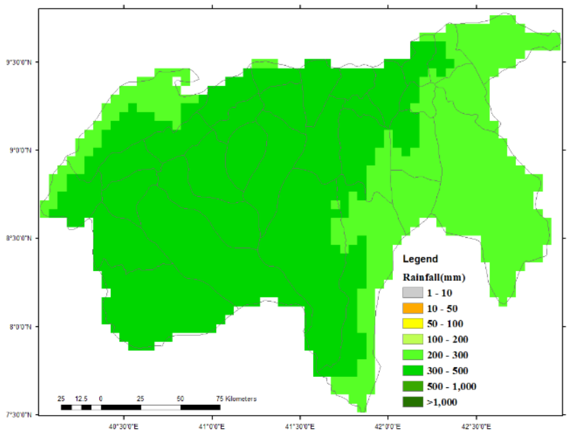


Figure 4.2-2 February – May (Bega) seasonal rainfall (1981-2010)

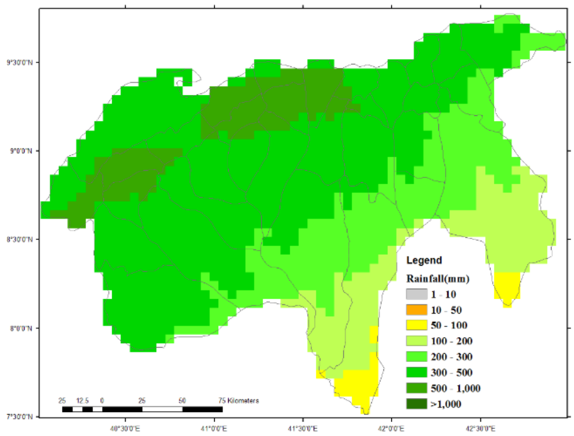


Figure 4.2-3 June – September (Kiremt) seasonal rainfall (1981-2010)

Figure 4.2-4 shows the rainfall distribution from January to December.

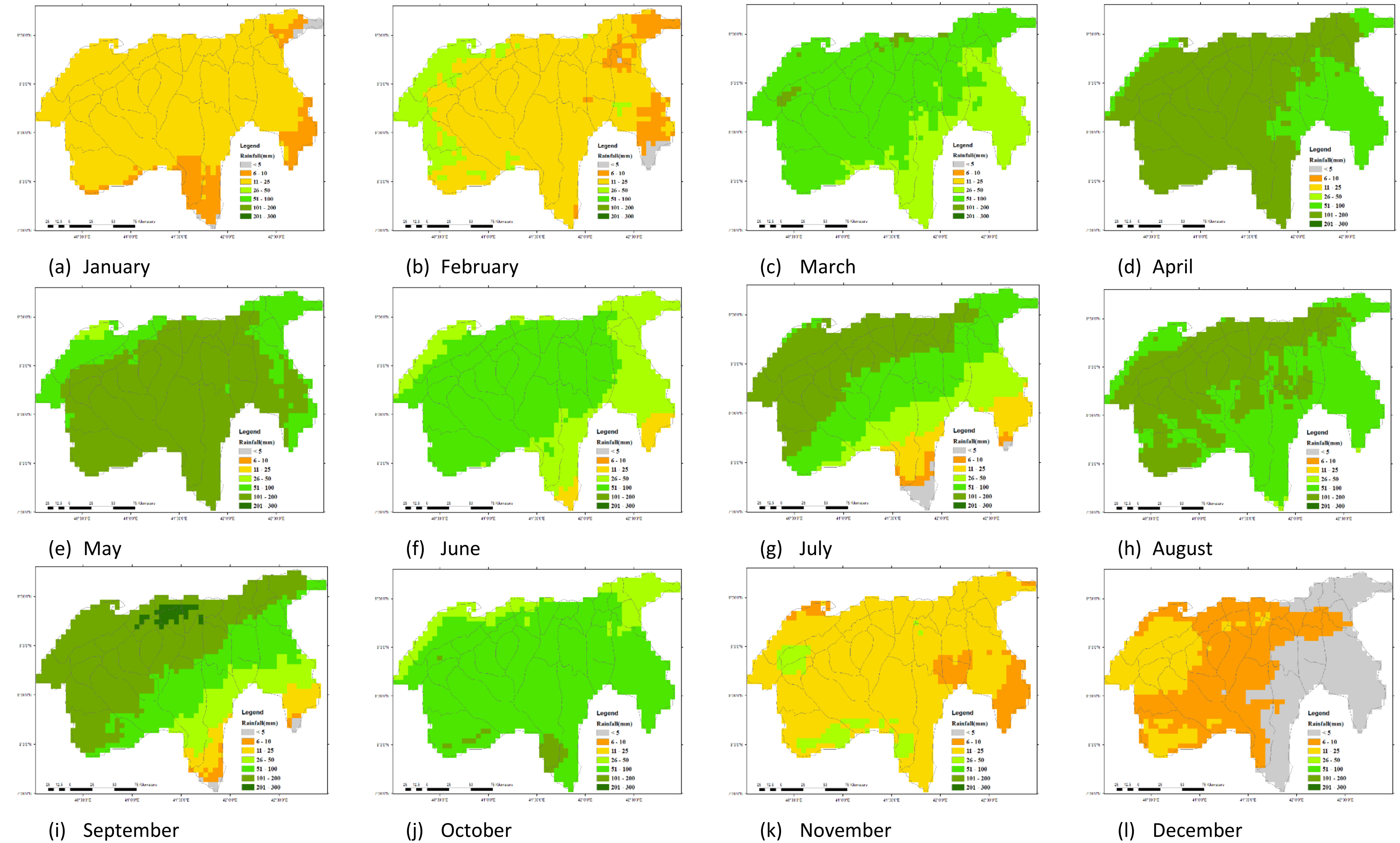


Figure 4.2-4 Monthly rainfall climatology (1981-2010)

While *Belg* (February to May) is generally considered the short rain season and *Kiremt* (June to September) the long rain season nationally, East and West Hararghe seems to experience more rain in *Belg* than it does in *Kiremt* as seen in **Figures 4.2-1 and 4.2-4**.

The rainfall variability from season to season and location in the district is shown in **Figures 4.2-1 and 4.2-4**. *Belg* contributes between 60 to 70% of the annual total in some parts of Meyu division and 50-60 % in parts of Babile division. On the other hand, the division in the northern parts of East and West Hararghe seemingly contribute 60 to 70% of the annual total in *Kiremt* season **Figure 4.2-6**. In some parts of the district, both seasons contribute in the range of 40 to 50% in both seasons.

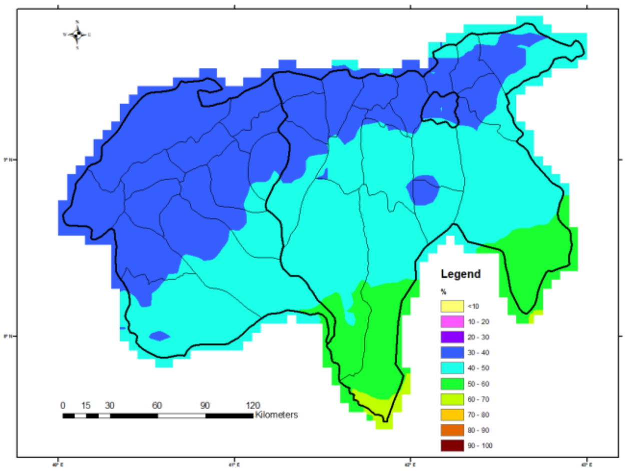


Figure 4.2-5 Seasonal Contribution of Belg (February – May)

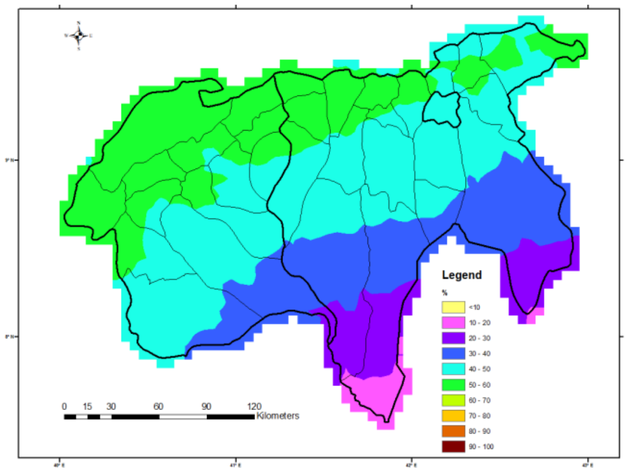


Figure 4.2-6 Seasonal Contribution of Kiremt (June - September)

4.3 Interannual Variability

Figure 4.3-1 and 4.3-2 give examples of the interannual rainfall patterns in East and West Hararghe between 1981 -2010 for *Belg* (FMAM) and *Kiremt* (JJAS) seasons. The figures indicate year to year variability of rainfall at all locations within the County. The recurrences of high and low rainfall amounts are reflective of repetitions of excessive and deficit rainfall often associated with floods and droughts.

Some of these extremely wet and dry years occurred during El Niño / La Niña (ENSO) and negative / positive Indian Dipole years (Gedefaw, et al., 2018; Eshetu, Johansson, & Garedew, 2016; Hagos , Tesfaye, & Duncan, 2014). The standard El Niño / La Niña is represented by Oceanic Niño Index (ONI) quantified from mean Sea Surface Temperatures (SST) anomalies in the Niño 3.4 region (**5ºN-5ºS, 120º-170ºW**).

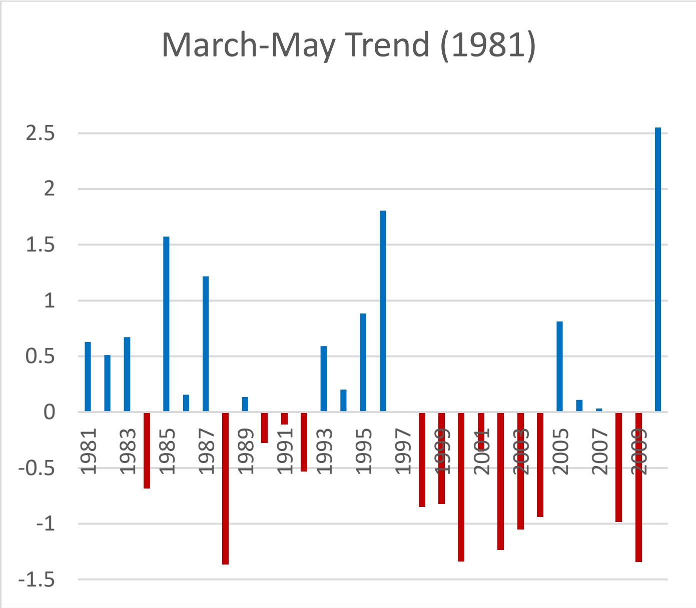


Figure 4.3-1 Rainfall anomaly in March to May (1981–2010) for the East and West Hararghe region (Source: observed data blended with CHIRPS)

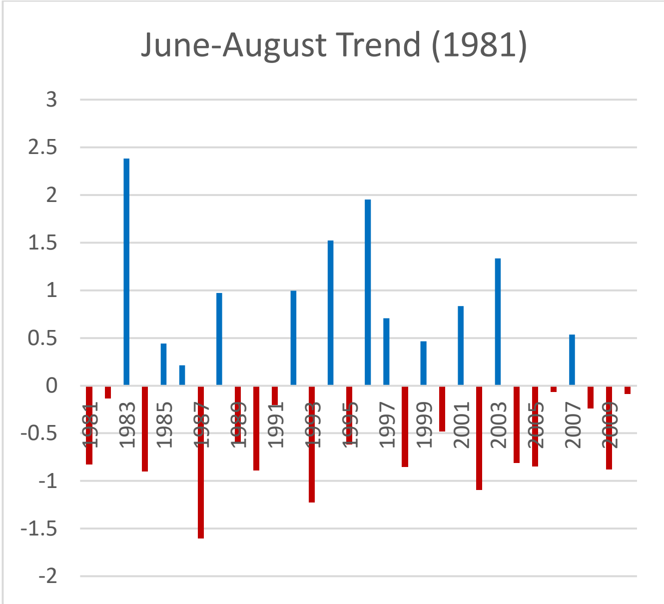


Figure 4.3-2 Rainfall anomaly in June to August (1981–2010) for the East and West Hararghe region (Source: observed data blended with CHIRPS)

Mean Month to month spatial patterns of rainfall for El Niño / La Niña years is shown in **Figure 4.3-4 and 4.3-5.** The maps show significant rainfall persisting over many months during some El Niño years, while the opposite is true for La Niña years. In general both ENSO and IOD had significant impacts on the county rainfall more evident impacts in OND season. This calls for more research to enhance ENSO/IOD and County rainfall anomalies teleconnection knowledge. In Ethiopia most studies have indicated below/ above normal rainfall associated with El Nino / La Nina (Befikadu et al., 2019; Weldegerima et al., 2018; Esayas et al., 2018; Degefu & Bewket, 2014; Hagos , Tesfaye, & Duncan, 2014; Viste, Korecha, & Sorteberg, 2013; Rossel & Holmer, 2007)

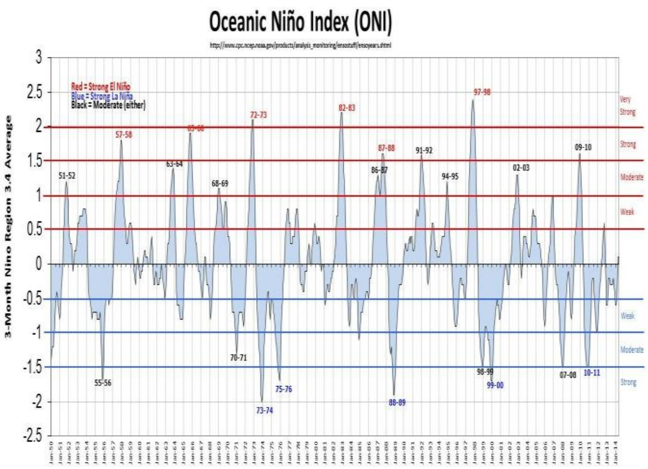


Figure 4.3-3 El Nino/ La Nina index quantified by Nino 4.3 ONI index (NOAA)

Table 1: Major +IOD Years, 1960 - 2016

1961	1963	1972	1982	1983	1994
1997	2006	2012	2015		

Table 2: Major -IOD Years, 1960-2016 *(NOAA)*

1960	1964	1974	1981	1989	1992
1996	1998	2010	2014	2016	

4.4 Rainfall Trends

Trends define the long term pattern of the rainfall time series at the specific location within the district. Negative/positive trends indicate decreasing/increasing mean rainfall tendency. Results show that East and

West Hararge is generally experiencing a negative trend during both the FMAM and JJAS season **Figure 4.4-1 & 4.4-2.**

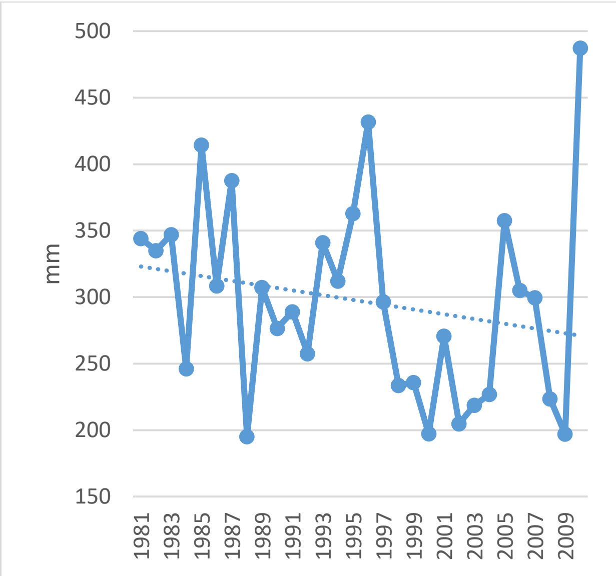


Figure 4.4-1 Rainfall Trend over East and West Hararghe in March to May Season (1981-2010)

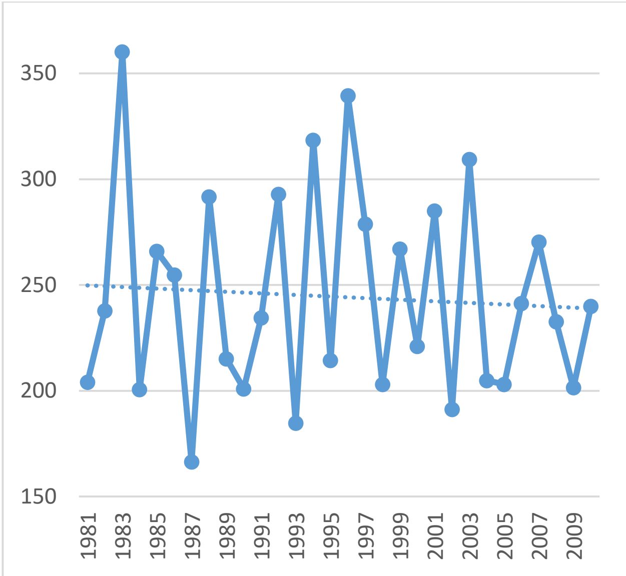


Figure 4.4-2 Rainfall Trend over East and West Hararghe in June to August Season (1981-2010)

Both **Figure 4.4-3 & 4.4-4** show spatial variability in the observed trend with a generally negative trend in the *Belg* rainfall, with some parts of districts receiving a neutral trend. Decreasing rainfall in the *Belg* and *Kiremt* season is consistent with reported trends for the country (FEWSNET, 2012; Abebe, 2017; Birara, Pandey, & Mishra, 2018). During the *Kiremt* season, the trend is generally positive throughout East Hararge rainfall and generally negative in most parts of West Hararghe **Figure 4.4-4.**

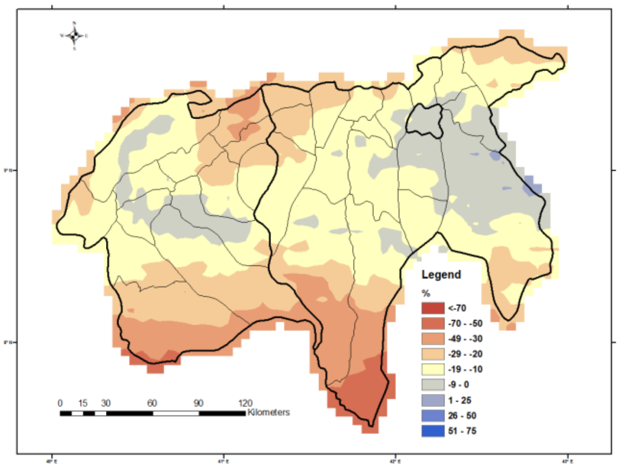


Figure 4.4-3 % Rainfall Trend over East and West Hararghe in Belg (February – May) Season (1981-2010)

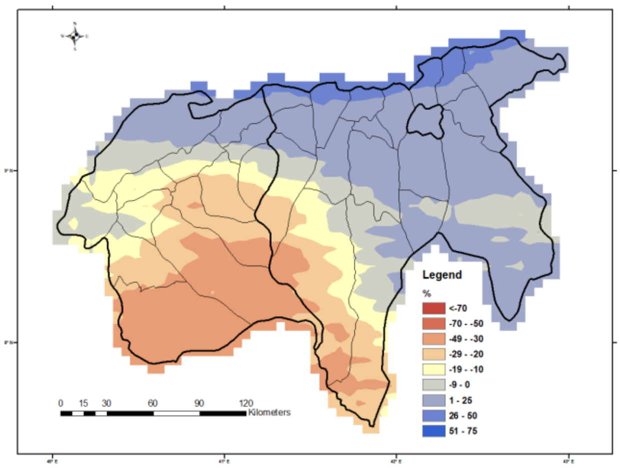


Figure 4.4-4 % Rainfall Trend over East and West Hararghe in Kiremt (June - September) Season (1981-2010)

Figure 4.4-5 shows the rainfall trend experienced in Hawi Gudina division in West Hararghe during *Kiremt* (JJAS) season which as shown in **Figure 4.4-4** is generally experiencing negative rainfall trend. **Figure 4.4-6** however shows the trend in the parts of Goro Gutu in East Hararghe which seem to be experiencing a positive rainfall trend.

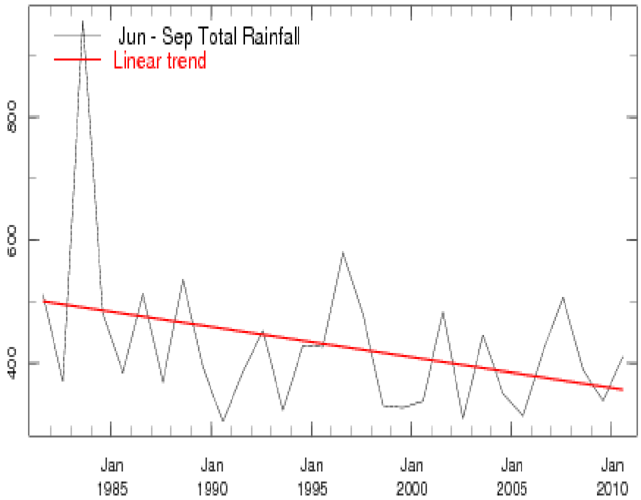


Figure 4.4-5 Rainfall Trend over Hawi Gudina division during Kiremt Season (1981-2010)

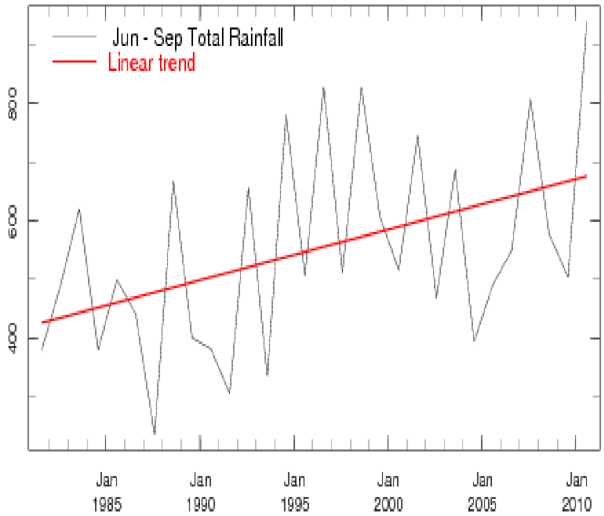


Figure 4.4-6 Rainfall Trend over Goro Gutu division during Kiremt Season (1981-2010)

The study has not examined the relationship between the observed rainfall over the country with climate change signals due to the relatively short period of the available time series data. The significant spatial differences in the observed rainfall trends calls for tailor made adaptation intervention strategies in the county vary spatially.

Apart from the baseline rainfall characteristics that have been discussed in the previous sections, there are many other important rainfall baseline statistics that are required by specific user sectors for drought and flood risk management among many other applications. These include: rainfall intensity and associated variance; probability of exceedance of specific rainfall thresholds and associated variance; mean characteristics of wet/dry days and associated variance; probability of occurrence of specific wet/dry spells; Onset, cessation and length of growing seasons. Part of the following report will be devoted to address these special baseline rainfall statistics.

4.5 Mean Rainfall intensity

Rainfall intensity represents the amount of rainfall received per specific unit time. The parameter may reflect surface runoff, rain water erosion potentials, etc. Mean rainfall intensity presented in this section were derived from the amount of rainfall in mm per day. **Figure 4.5-1 & 4.5-2** show significant differences in the spatial patterns of rainfall intensity particularly in the *Kiremt* season. Parts of Deder division for example receive high rainfall intensity when compared to the rest of the district while parts of Meyu and Babile receive lower intensity of rainfall during the *Kiremt* season (**Figure 4.5-2**). The next section provides some highlight on the variance characteristics of rainfall in East and West Hararghe.

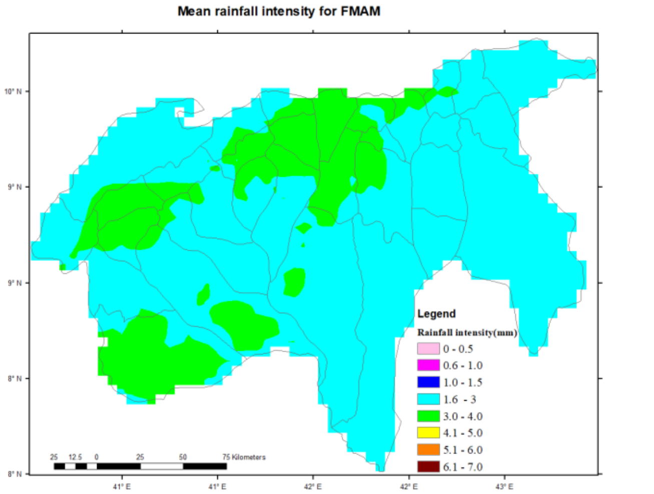


Figure 4.5-1 Seasonal Rainfall Intensity for Belg (FMAM) in East and West Hararghe (1981-2010)

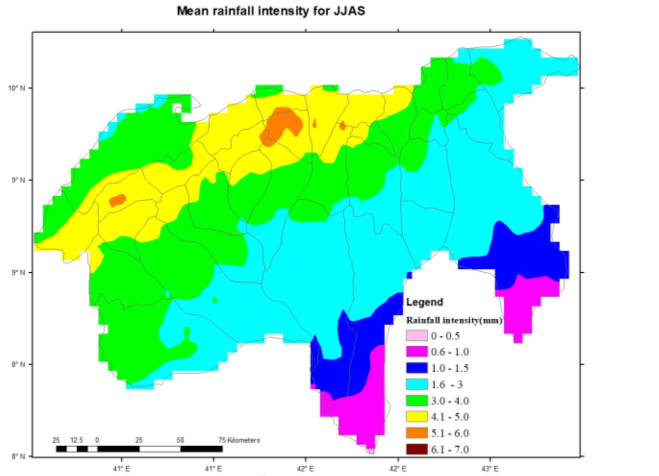


Figure 4.5-2 Seasonal Rainfall Intensity for Kiremt (JJAS) in East and West Hararghe (1981-2010)

4.5.1. Observed Variance in Rainfall intensity

This section presents the degree of variability of rainfall intensity within the county using coefficient of rainfall variability index (standard deviation divided by the mean). **Figures 4.5-3 & 4.5-4** show that the rainfall intensity is generally less variable during *Kiremt* season than during *Belg* season. Such knowledge is very critical for climate risk management planning purposes for the district.

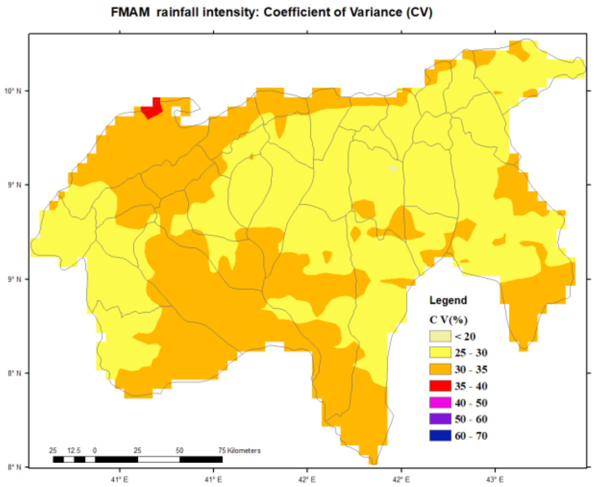


Figure 4.5-3 Belg (FMAM) Rainfall Intensity: Coefficient of Variance (1981-2010)

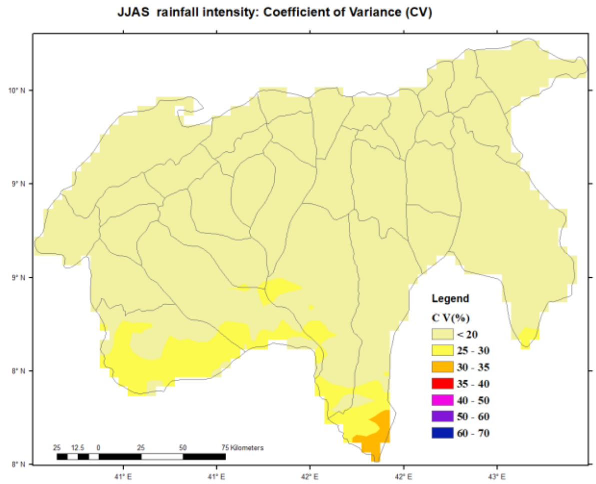


Figure 4.5-4 Kiremt (JJAS) Rainfall Intensity: Coefficient of Variance (1981-2010)

4.5.2. Probability of Exceeding Specific Rainfall Thresholds

Many activities that use water have critical thresh hold rainfall needs outside which some degree of stress thresholds for the specific water use. This section presents the probability of receiving rainfall intensity exceeding 5mm per day in East and West Hararghe Districts (**Figure 4.5-5 & 4.5-6**). The figures show that the probabilities were generally low in the entire county in both FMAM and JJAS. Some parts of Deder division has the highest probability of 55-70% during JJAS season to exceed 5mm intensity of rainfall per day (**Figure 4.5-6**).

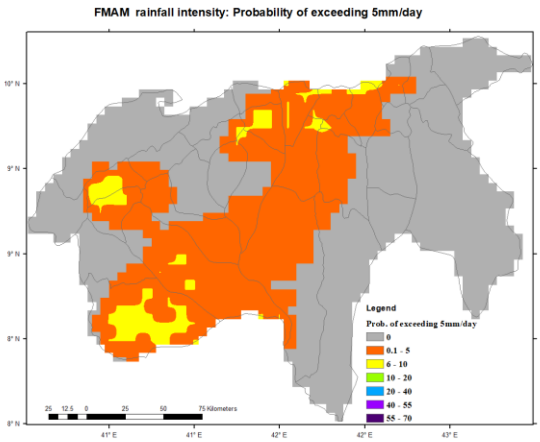


Figure 4.5-5 Probability of Rainfall intensity exceeding 5 mm Belg (FMAM) Seasons (1981-2010)

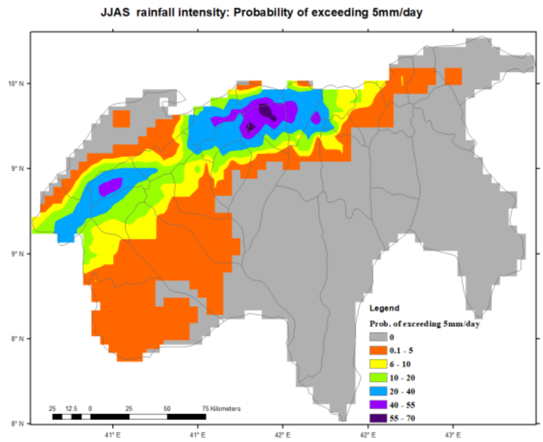


Figure 4.5-6 Probability of Rainfall intensity exceeding 5 mm Kiremt (JJAS) (1981-2010)

4.6 Mean Wet Days

A threshold for a wet day was set as a day receiving 1mm or more rainfall per day, while any day receiving less than 1mm per day is set as a dry day. The characteristics of wet/ dry days are very important for many farming activities including application of fertilizer, spraying, movement of heavy farm machines, construction, etc. This section presents the characteristics of wet days at the county for MAM and OND Months. The results as seen in **Figures 4.6-1 & 4.6-2** shows that both districts receive between 21 to 30 wet days during *Belg* season but varies from 10 to 40 wet days in *Kiremt.* The number of wet days shows more variability in JJAS than in FMAM. The coefficient of variation of the computed wet days are presented in the next section.

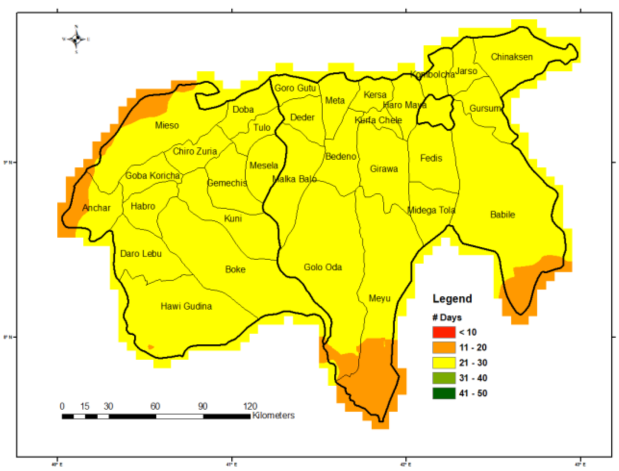


Figure 4.6-1 Average Number of Wet days in the Belg (FMAM) Season (1981-2010)

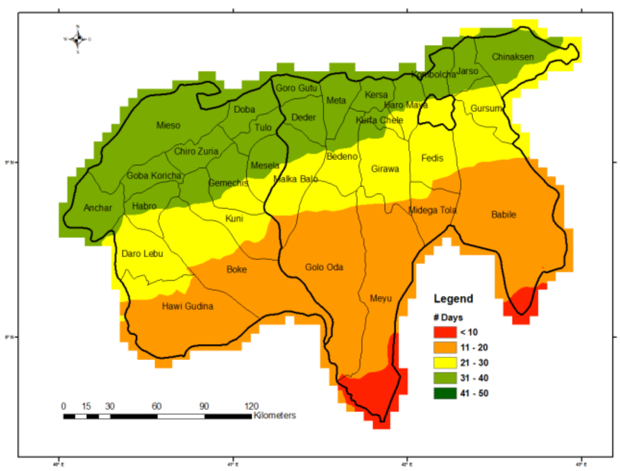


Figure 4.6-2 Average Number of Wet days in the Kiremt (JJAS) Season (1981-2010)

4.6.1. Observed Variance in Wet Days

The coefficients of variation of the computed wet days are shown in **Figures 4.6-3 & 4.6-4** for *Belg* and *Kiremt* seasons. The figures show that variability in the number of wet days differs significantly spatially in both the *Belg* and *Kiremt* season (**Figures 4.6-3 & 4.6-4**), with the least variability being seen largely around Mieso and Chinaksen divisions during *Kiremt* season.

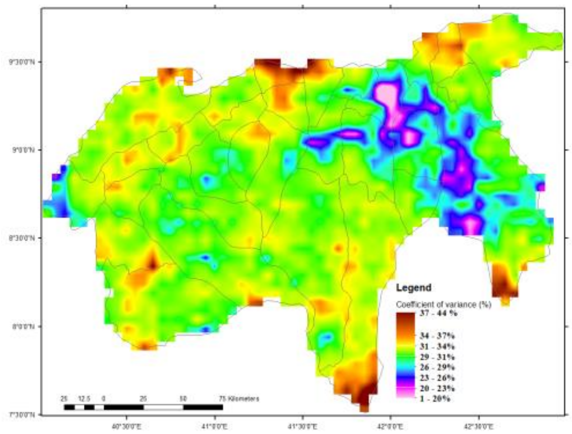


Figure 4.6-3 Wet Days: Coefficient of Variance during Belg (FMAM) Season (1981-2010)

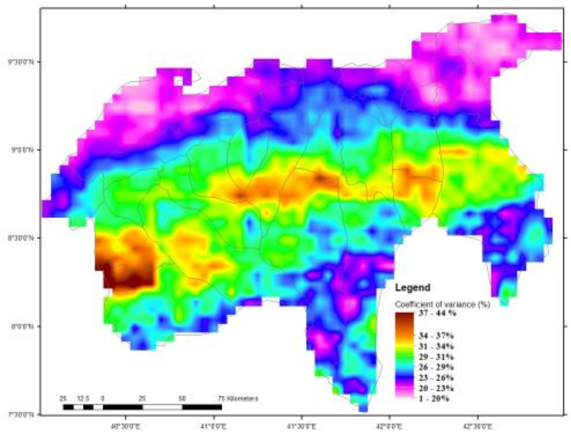


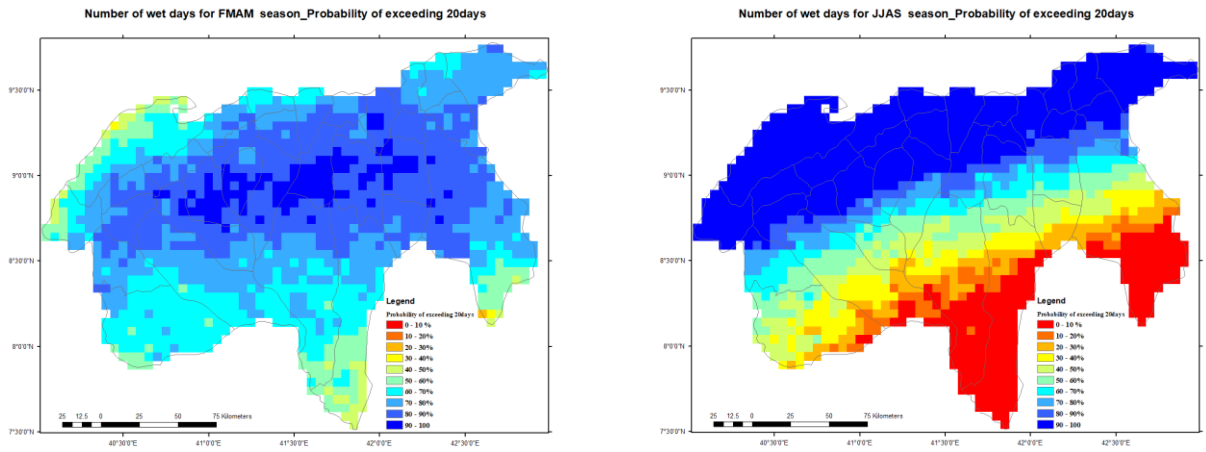
Figure 4.6-4 Wet Days: Coefficient of Variance during Kiremt (JJAS) Season (1981-2010)

4.6.2. Probability of Number Wet Days

This section presents baseline statistics for the Probability of the number of Wet Days in East and West Hararghe Districts. The figures show that the probability of the number of wet days exceeding 20 during FMAM season is generally high with most areas exceeding 70% (**Figure 4.6-5**). However, during JJAS the probability of the district having over 20 wet days varies significantly with some areas having over 100% probability while other areas hiving less than 10%. The probability of exceeding 30 days generally is low during both seasons, however there are exceptions towards the north with greater than 70% probability during the *Kiremt* season.

February – May (FMAM) Season *June – September (JJAS) Season*

Probability of the number of wet days in the season exceeding 20



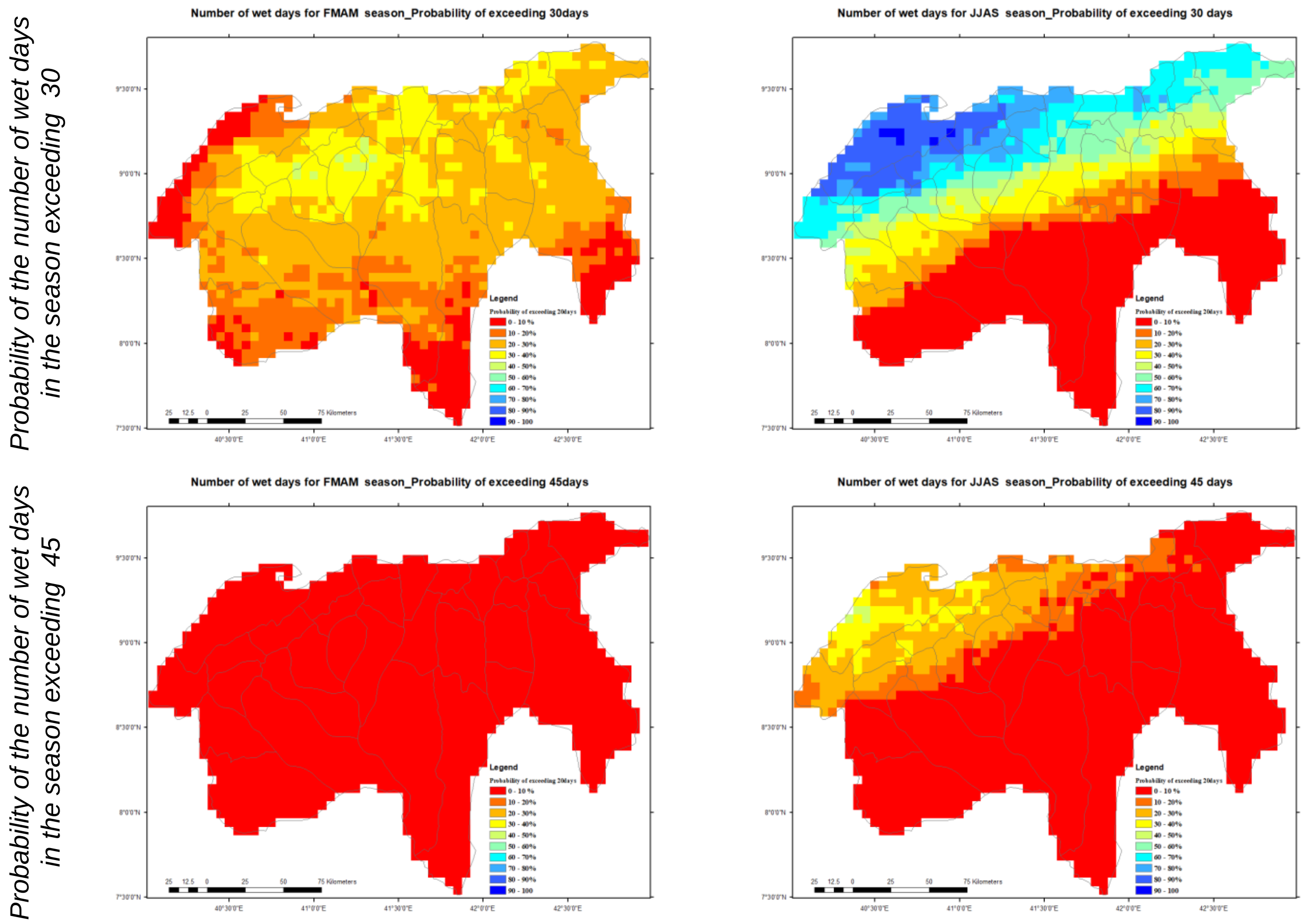


Figure 4.6-5 Probability of the number of wet days in the FMAM, JJAS and OND season exceeding 20 , 30 and 45 days (1981-2018)

4.7 Mean Wet Spells

A wet spell of *n* days, for example 3 days, is taken to represent a case where at least 1mm daily rainfall threshold was received for *n* (3) continuous wet days. The figures below show parts of the districts that received at least one wet spell more in FMAM season than in JJAS season (**Figures 4.7-1 & 4.7-2)**.

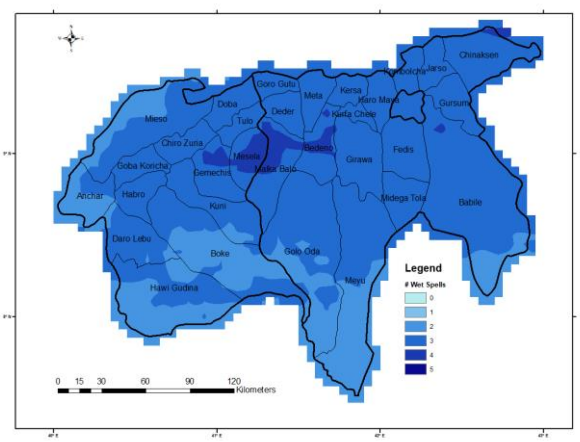


Figure 4.7-1 Average Number of Wet Spells in the FMAM Season (1981-2010)

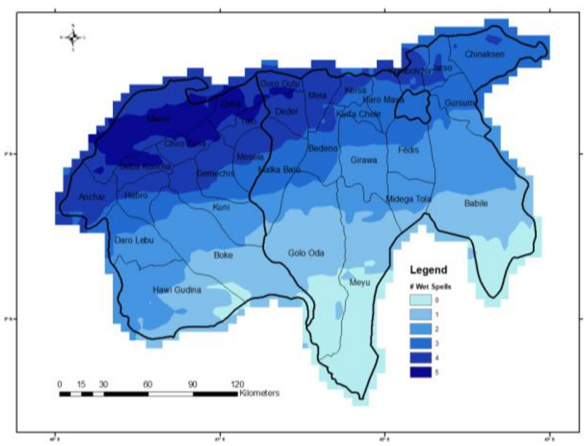


Figure 4.7-2 Average Number of Wet Spells in the JJAS Season (1981-2018)

It was noted that occurrences of longer wet spells were more in JJAS than in FMAM. There was also notable variability from location to location during JJAS (**Figure 4.7-2**) where some parts of the districts received up to 5 wet spells while other parts received none. The next section provides some probabilities for occurrences of some specific wet spells.

4.7.1 Probability: Wet Spells

The previous section presented baseline statistics for wets days. It noted that there are occurrences of longer wet spells in JJAS season than in FMAM. This section presents examples of the probabilities for occurrences of some specific wet spells, using the 3 days wet spells. The probability of number of wet spells in East and West Hararghe districts exceeding 3 in both *Belg* seasons varies from place to place with some areas having less than 10% while other areas having over 70%, however the probability of exceeding 5 spells in the *Belg* season is generally less than 10% as shown in **Figure 4.7-3.** The probability of exceeding 3 wet spells in the *Kiremt* season varies as well with the southern region having lower than 10% and the northern region having areas with greater than 80% probability. Probability of receiving over 5 wet spells is generally less than 30%.

February – May (FMAM) Belg Season *June – September (JJAS) Season*

Probability of the number of wet spells exceeding 3 spells

Probability of the number of wet spells exceeding 5 spells

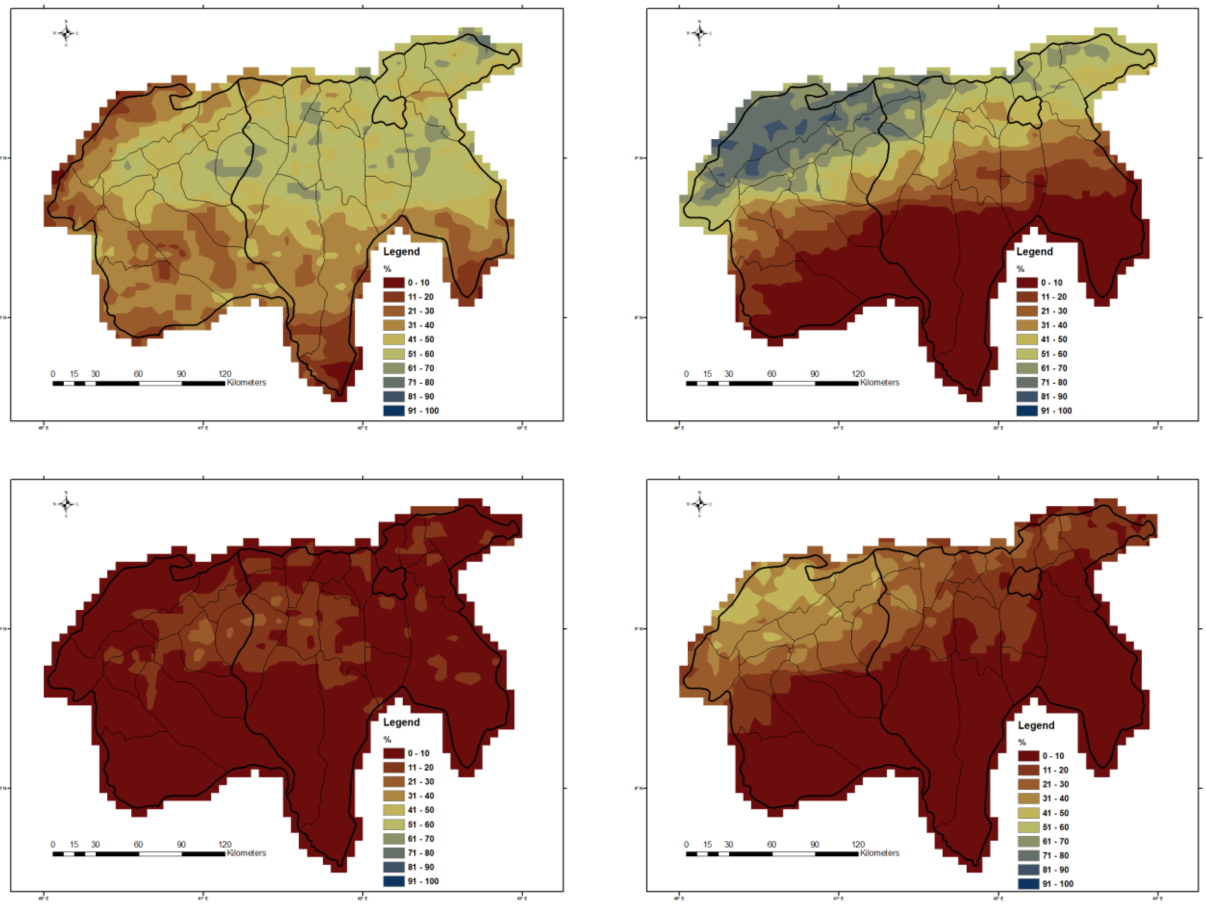


Figure 4.7-3 Probability of the number of wet spells in MAM & OND Season exceeding 3 Spells

4.8 Mean Dry Days

The number and distribution of the dry days can be used to highlight drought potentials of a given location as highlighted in the following sections. **Figures 4.8-1& 4.8-2** present mean number of dry days observed in East and West Hararghe districts. The figures indicate that the number of dry days in the district generally ranges between 90 and 110 days in both FMAM and JJAS. However, there seems to be generally more dry days throughout the county during the JJAS season than FMAM season.

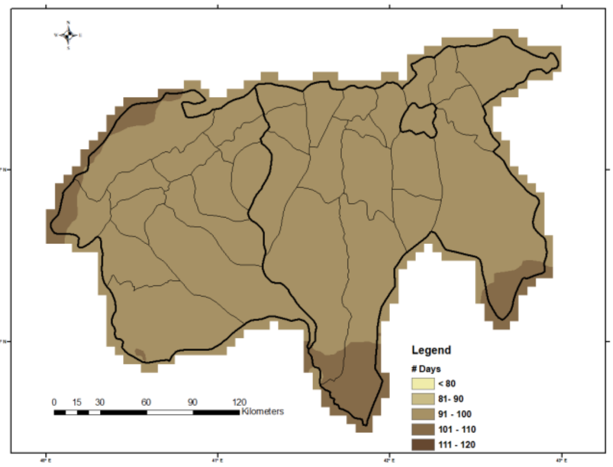


Figure 4.8-1 Average Number of Dry days in the Belg Season (1981-2018)

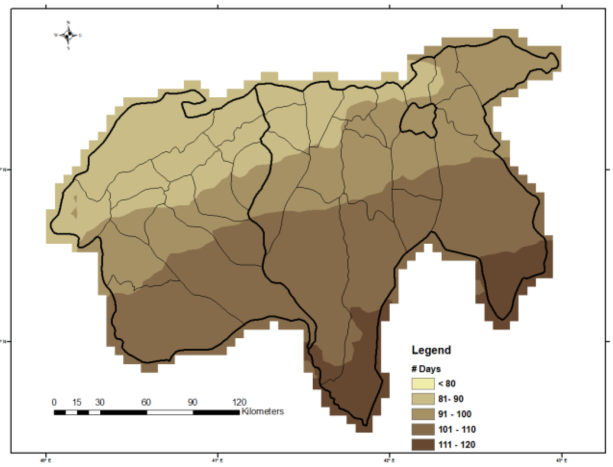


Figure 4.8-2 Average Number of Dry days in the Kiremt Season (1981-2018)

Section 4.8-3 shows spatial patterns of the observed variance of the dry days while their corresponding probability of occurrence is given in Section 4.8-4.

4.8.1. Coefficient of variation: Dry Days

The spatial patterns of the variance of the dry days in East and West Hararghe districts is given in **Figures 4.8-1& 4.8-2.** The figures indicate that the variability in the number of dry days is low with the coefficient of variation in both FMAM and JJAS generally being less than 10%.

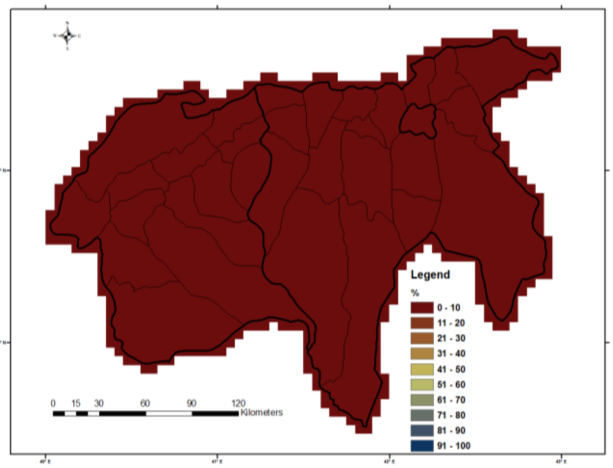


Figure 4.8-3 Dry Days: Coefficient of Variance during the MAM (1981-2018)

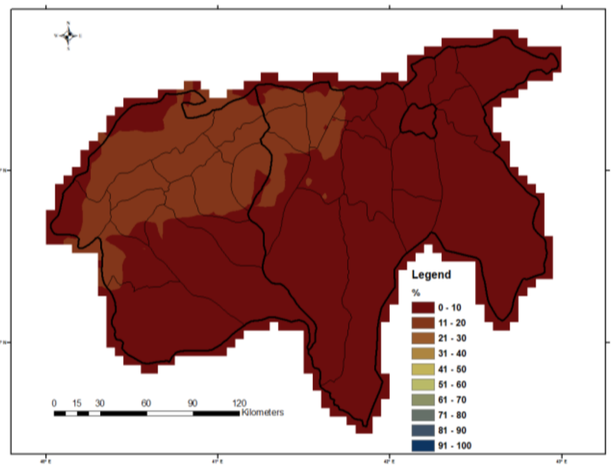


Figure 4.8-4 Dry Days: Coefficient of Variance during the OND (1981-2018)

4.9 Mean Dry Spells

Like in the case of wet spells, a dry spell of *n* (e.g. 7) days represent a case of *n* (7) days without receiving any wet day (at least 1 mm rainfall). Results show that the number of dry spells in both FMAM and JJAS rainfall seasons. **Figures 4.9-1 & 4.9-2**. There is more variability observed during FMAM than JJAS season, with FMAM generally having 4 wet spells while JJAS ranging from 4 to 6 dry spells. Longer spells were evident in some years where no wet day was reported during the whole month in a rainfall month. The variance of these dry spells are presented in the next section.

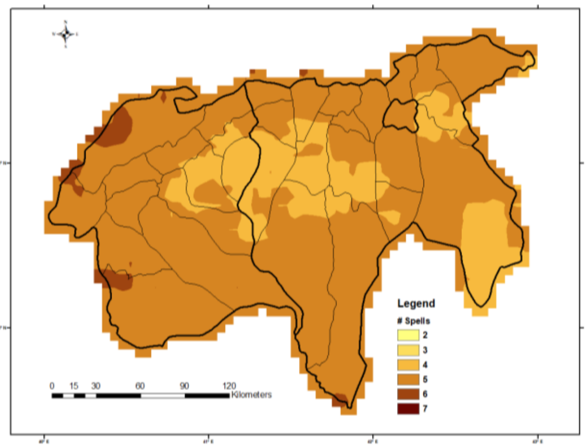


Figure 4.9-1 Average Number of Dry Spells in the Belg Season (1981-2018)

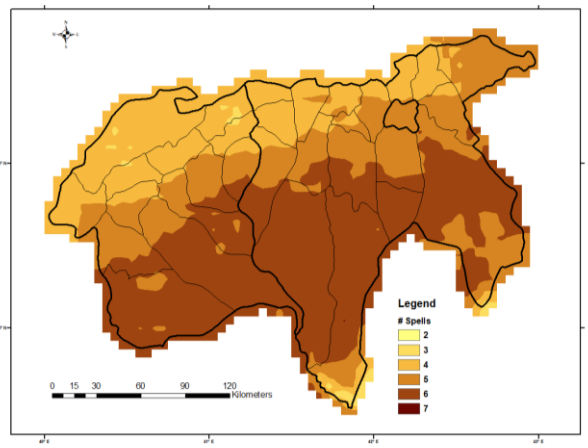


Figure 4.9-2 Average Number of Dry Spells in the Kiremt Season (1981-2018)

4.9.1. Coefficient of variation: Dry Spells

The coefficient of variation in both FMAM and JJAS is generally less than 30% as seen in **Figures 4.9-3 & 4.9-4.** This shows that the variability from the long term mean in the number of dry spells is generally low, signifying the degree of persistence of the dry spells. The probability of these dry spells are presented in the next section.

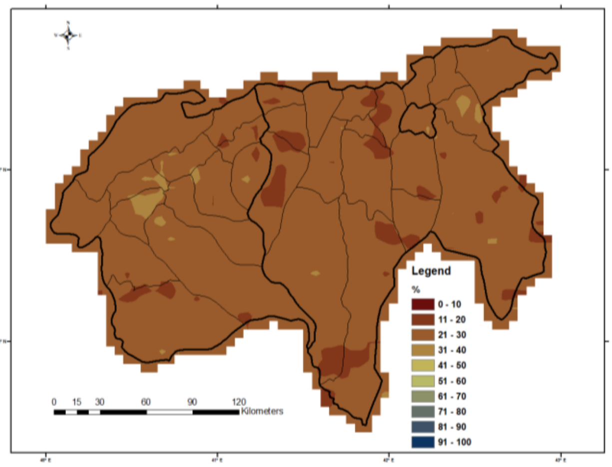


Figure 4.9-3 Dry Spell: Coefficient of Variance in the MAM Season (1981-2018)

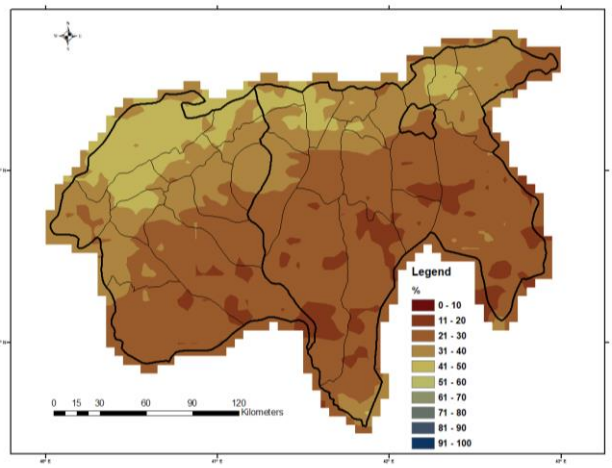


Figure 4.9-4 Dry Spell: Coefficient of Variance in the OND Season (1981-2018)

4.9.2. Probability: Dry Spells

The probability of the dry spells exceeding 3 in both FMAM and JJAS seasons is generally high as shown in **Figure 4.9-5.8** The probability of exceeding 5 dry spells in both East and West Hararghe generally exceeds 50% in both FMAM and JJAS seasons with some areas as high as 90% during JJAS. It reduces to less than 10 percent probability for dry spells exceeding 7 dry spells in both seasons.

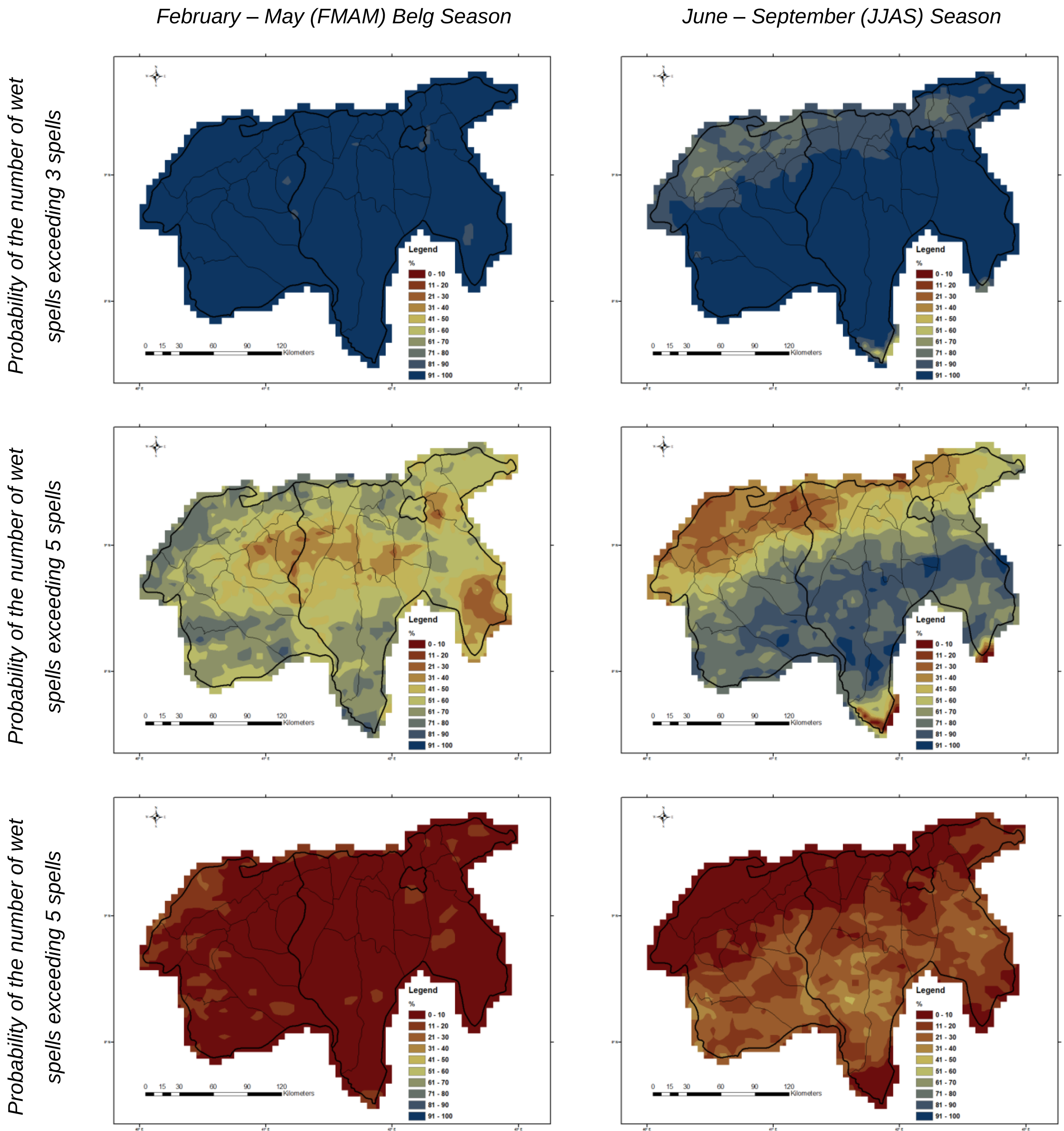


Figure 4.9-5 Probability of the number of dry spells in the FMAM & JJAS season exceeding 3, 5 and 7 dry spells

4.10 Climatological Baselines for Onset, Cessation dates and Length of Growing Period

The onset marks the beginning of the rains while cessation marks the end. The length of time between the onset and cessation dates gives the length of the growing season assuming that the water requirement for specific crop is met throughout the period. The climatological baselines for Onset, Cessation dates and Length of Growing Period are discussed in the following sections.

4.10.1. Onset

The onset was calculated with a threshold 1mm of rainfall per day, having a rainfall total of 5 mm in five days with at least two rainy days with a dry spell not exceeding seven days. **Figure 4.10-1** shows the mean onset of the February to May season is generally in the first dekad of February. There however cases of early onsets occurring as early as early January, with some late onsets occurring in April.

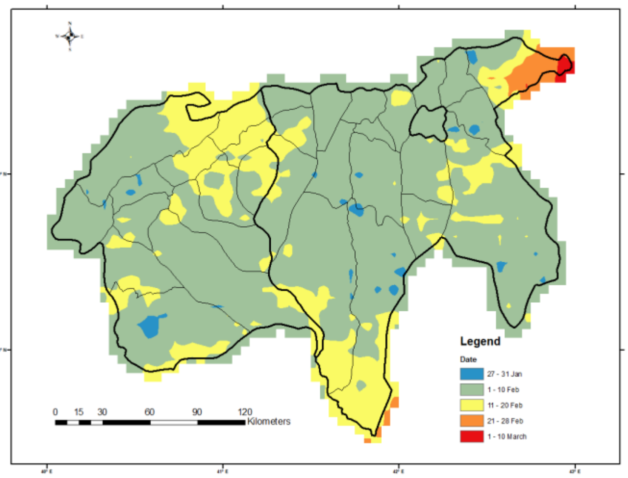


Figure 4.10-1 Historical onset in the Belg Season (1981-2019)

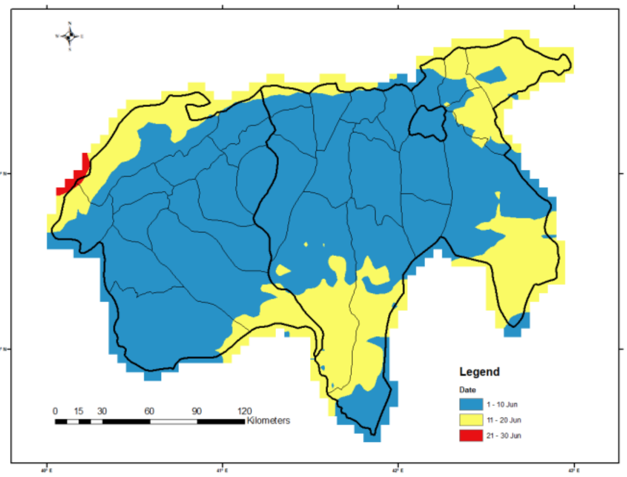


Figure 4.10-2 Historical onset in the Kiremt Season (1981-2018)

The onset of the JJAS season can be said to generally fall in the first decade of June (**Figure 4.10-2**) but is really an extension of the FMAM season. Very unique patterns were evident in some years associated with strong positive and negative ENSO and IOD events when early and late onset dates are observed (**Figure 4.10-3 to 4.10-4)**.

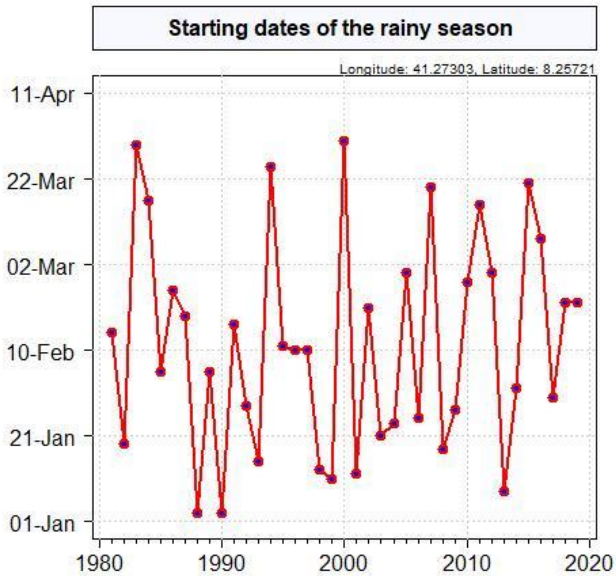


Figure 4.10-3 Time Series of Onset for a point in East and West Hararghe districts during the Belg Season (1981-2018)

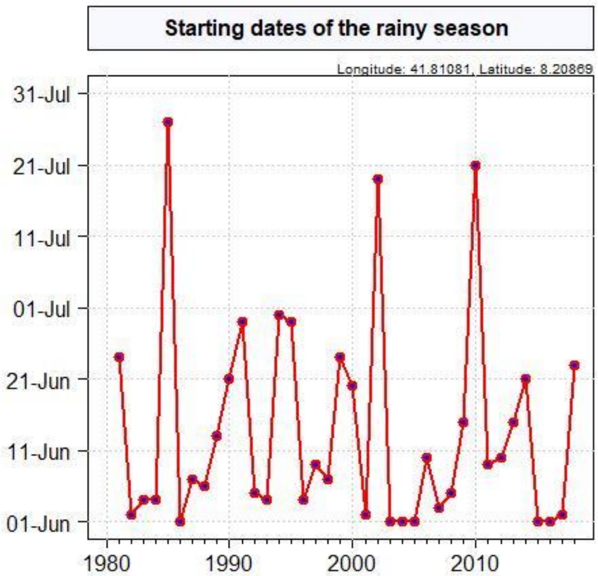


Figure 4.10-4 Time Series of Onset for a point in East and West Hararghe districts during the Kiremt Season (1981-2018)

4.10.2. Cessation

Cessation of the season was calculated with the threshold of a drop in water balance below 5 mm for a period of three days. The results show that the mean cessation of the FMAM rainfall season in the East and West Hararghe districts generally occurs in the first dekad of May **Figure 4.10-5.** Generally the mean cessation date for JJAS rainfall is during the first dekad of September, though there some areas where it falls on the second dekad of September (**Figure 4.10-6**).

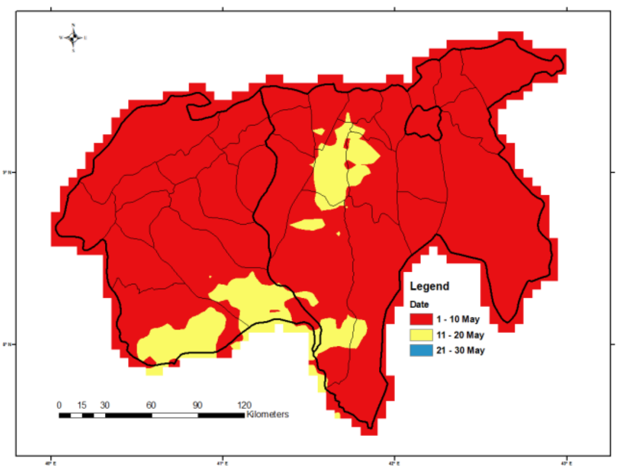


Figure 4.10-5 Historical cessation in the Belg Season (1981-2018)

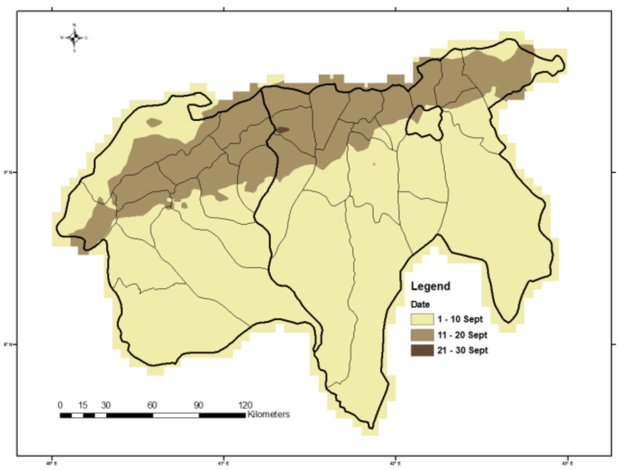


Figure 4.10-6 Historical cessation in the Kiremt Season (1981-2018)

Apart from the above climatological statistics for the rainfall onset and cessation dates, very unique patterns were evident in some years associated with strong positive and negative ENSO and IOD events when early and late cessation dates are observed (**Figure 4.10-5 to 4.10-6)**.

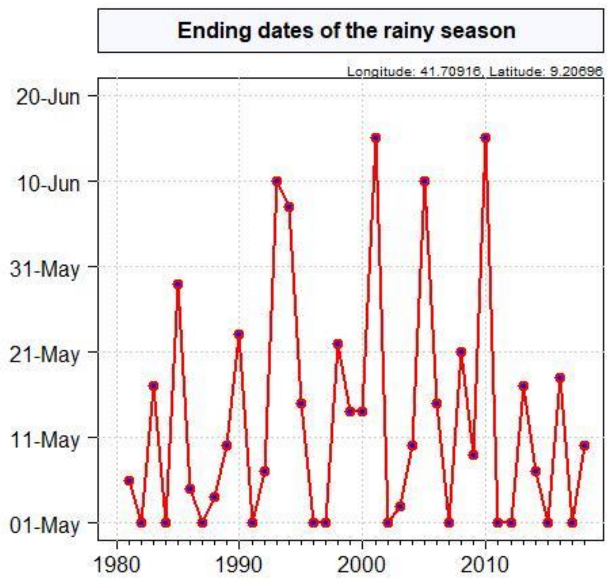


Figure 4.10-7 Time Series of Cessation for a point in East and West Hararghe districts during the Belg Season (1981-2018)

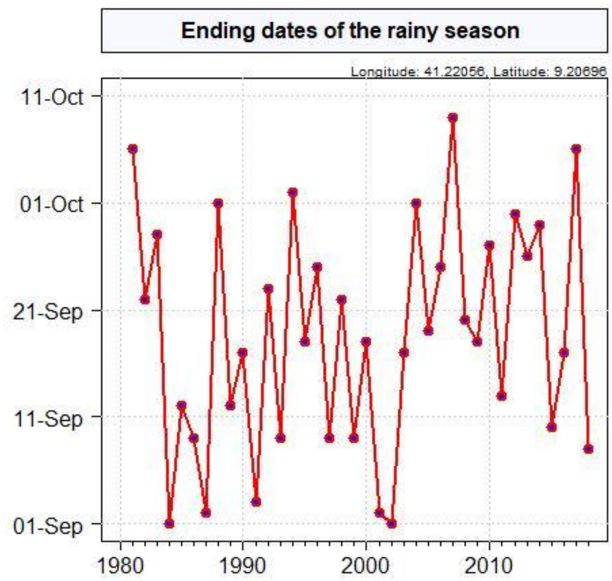


Figure 4.10-8 Time Series of Cessation for a point in East and West Hararghe districts during the Belg Season (1981-2018)

4.10.3. Length of Season

The mean length of the February to May rainfall season generally is approximately 81 to 100 days as seen in **Figure 4.10-9**. The June to September season on the other hand generally ranges from 71 to 100 days **Figure 4.10-10**.

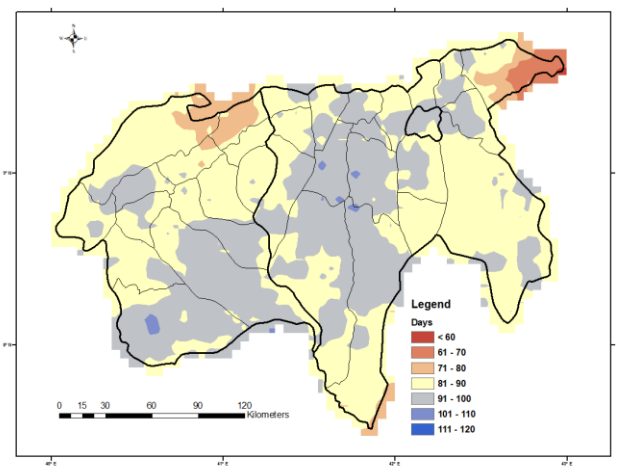


Figure 4.10-9 Historical Length of Season in the Belg Season (1981-2018)

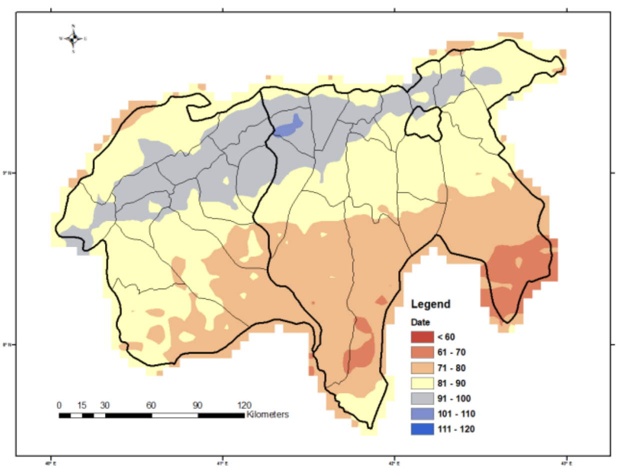


Figure 4.10-10 Historical Length of Season in the Kiremt Season (1981-2018)

Since length of the seasons is determined by the rainfall onset and cessation dates, very unique patterns were also evident in some years with strong positive and negative ENSO and IOD events, when shorter or longer than normal growing season length are observed. In some of these cases the short growing season lead to total crop failures, food deficits, hunger and some deaths. In some cases the wet days extend beyond the standard FMAM and JJAS rainfall seasons giving long growing periods.

4.11 Temperature

A part from rainfall parameters, the other climate parameter that is of great significance in the ASALs areas is Temperature. Temperature stress has physiological impacts on all ecosystems among many other effects. The Government of Ethiopia (2007) reports that Ethiopia has experienced increasing warming temperature trends in many parts of the country. Warmer temperatures are reported to be reducing plant and vegetation productivity in semi-arid environments. Temperature increase can affect people directly through increase in heat-related illness, whereas indirect health impacts can also result from changes to natural and social systems. The following sections present the observed temperature characteristics in East and West Hararghe.

4.11.1. Annual Mean Temperature

The annual mean temperature was obtained from average monthly temperature for the twelve months within the period 1981-2010. Mean climatology for annual mean, maximum and minimum temperatures are shown in **Figure 4.11-1** to **4.11-3**.The mean temperatures varies from location to location with relatively higher/ lower temperatures observed around Meyu and Kurfa Chele respectively where the mean highest/ lowest temperatures were about 25⁰C, and 20⁰C respectively **Figure 4.11-1**.

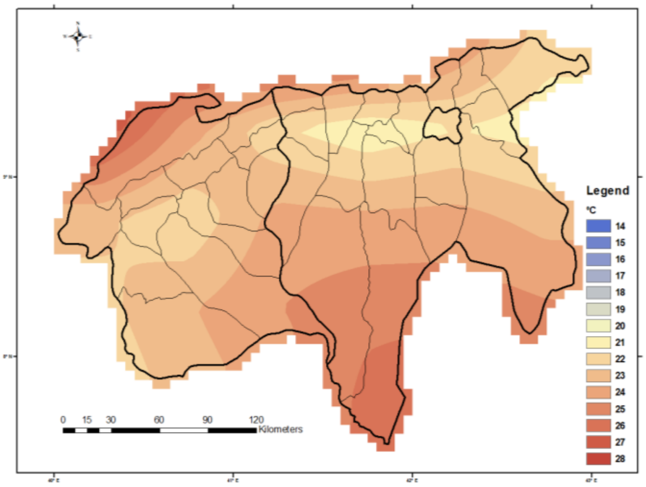


Figure 4.11-1 Mean annual surface temperature climatology (1981–2010) for GHA region

The pattern observed in the annual temperature is also seen in the Minimum and Maximum Temperature shown in **Figure 4.11-2** and **Figure 4.11-3** respectively.

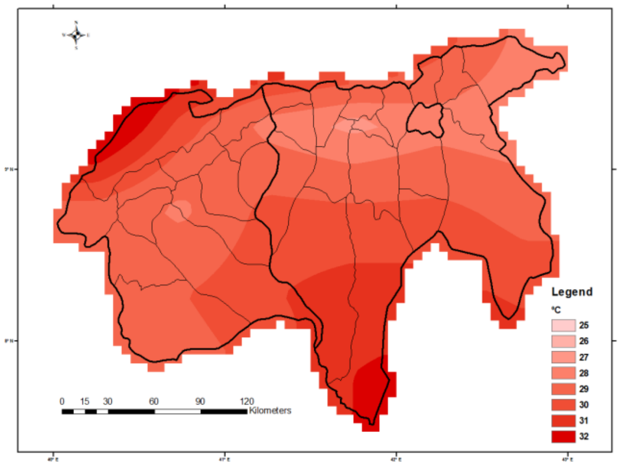


Figure 4.11-2 Mean annual minimum surface temperature climatology (1981–2010) for the GHA region

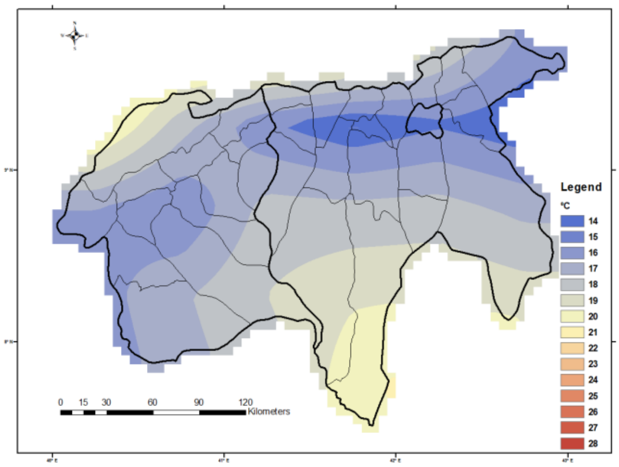
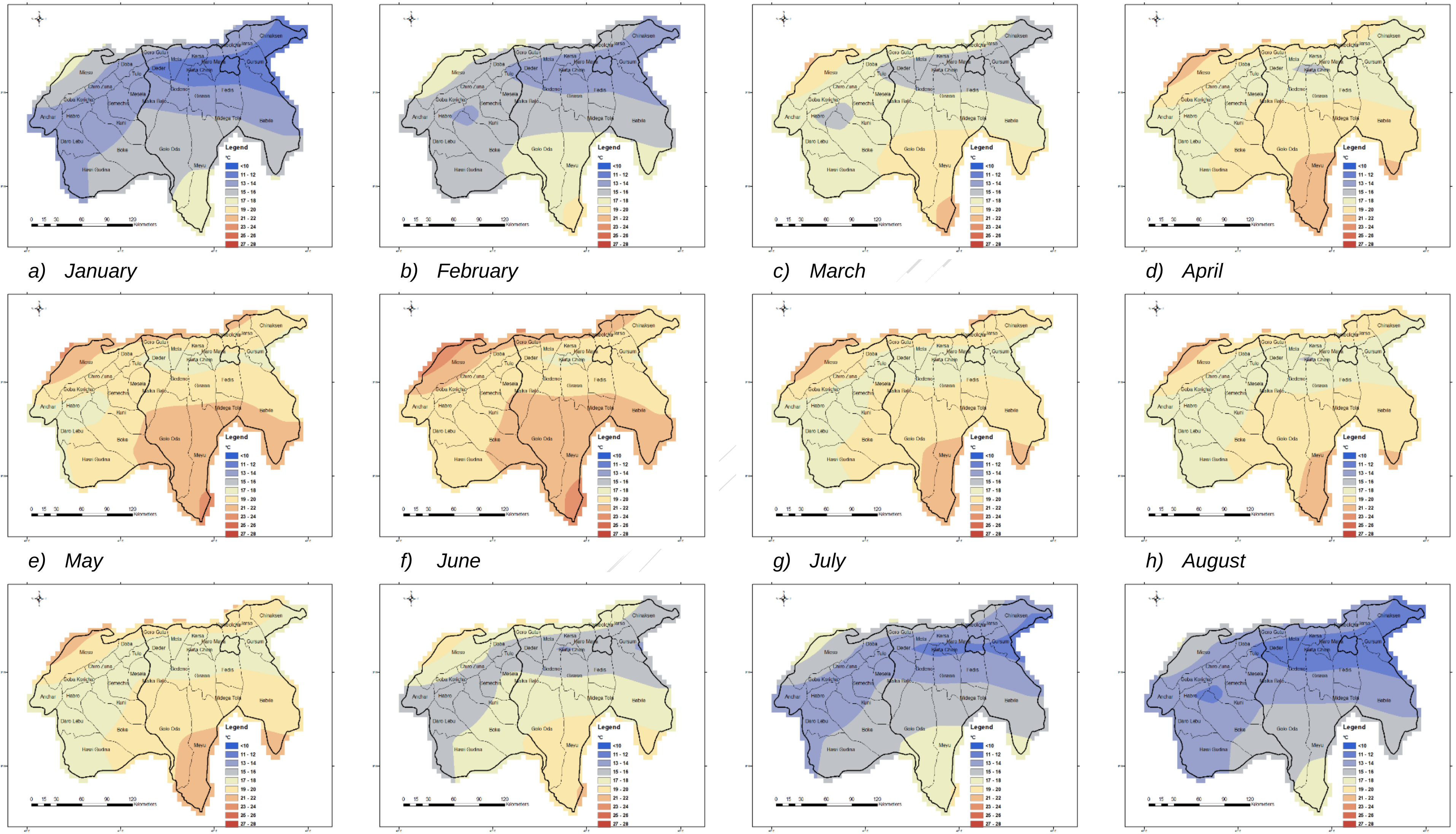


Figure 4.11-3 Mean annual maximum surface temperature climatology (1981–2010) for the GHA region

The lowest minimum mean temperature in East and West Hararghe is experienced around Kurfa Chele division between November and February, with temperatures ranging between 11⁰C -16 ⁰C as seen in **Figure 4.11-4**. The maximum mean temperature in East and West Hararghe is highest around Meyo and Mieso division ranging between 23⁰C - 36⁰C in May and June **(Figure 4.11-5)**. The temperature characteristics that were common with the monthly records are still evident from the respective seasonal temperature climatology.

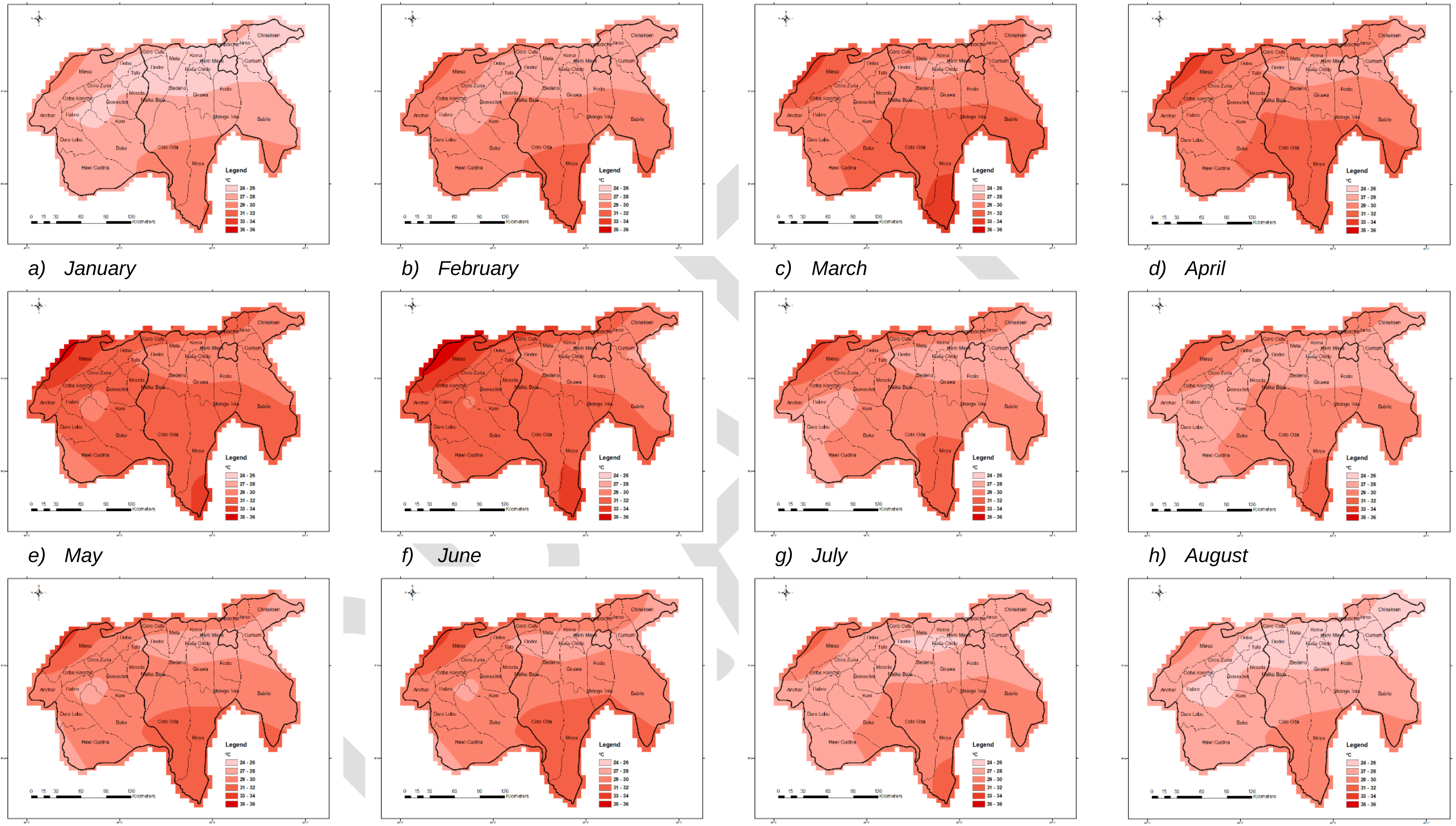


a) *January* b) *February* c) *March* d) *April*

e) *May* f) *June* g) *July* h) *August*

i) *September* j) *October* k) *November* l) *December*

Figure 4.11-4 Average Monthly Minimum Temperature over East and West Hararghe (1981-2010)



a) January b) February c) March d) April

e) May f) June g) July h) August

i) September j) October k) November l) December

Figure 4.11-5 Average Monthly Maximum Temperature over East and West Hararghe (1981-2010)

The highest mean temperature in the East and West Hararghe seems to occur in May and June while the lowest mean temperatures are experienced in December and January **Figure 4.11-6**.

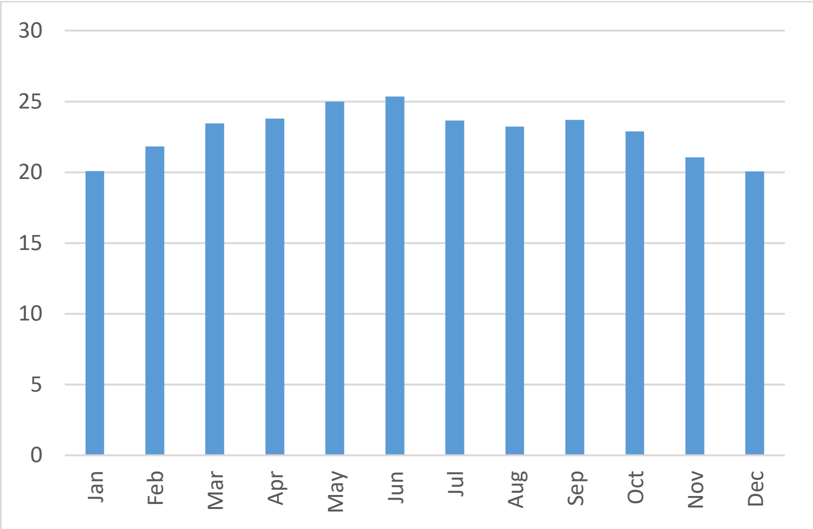
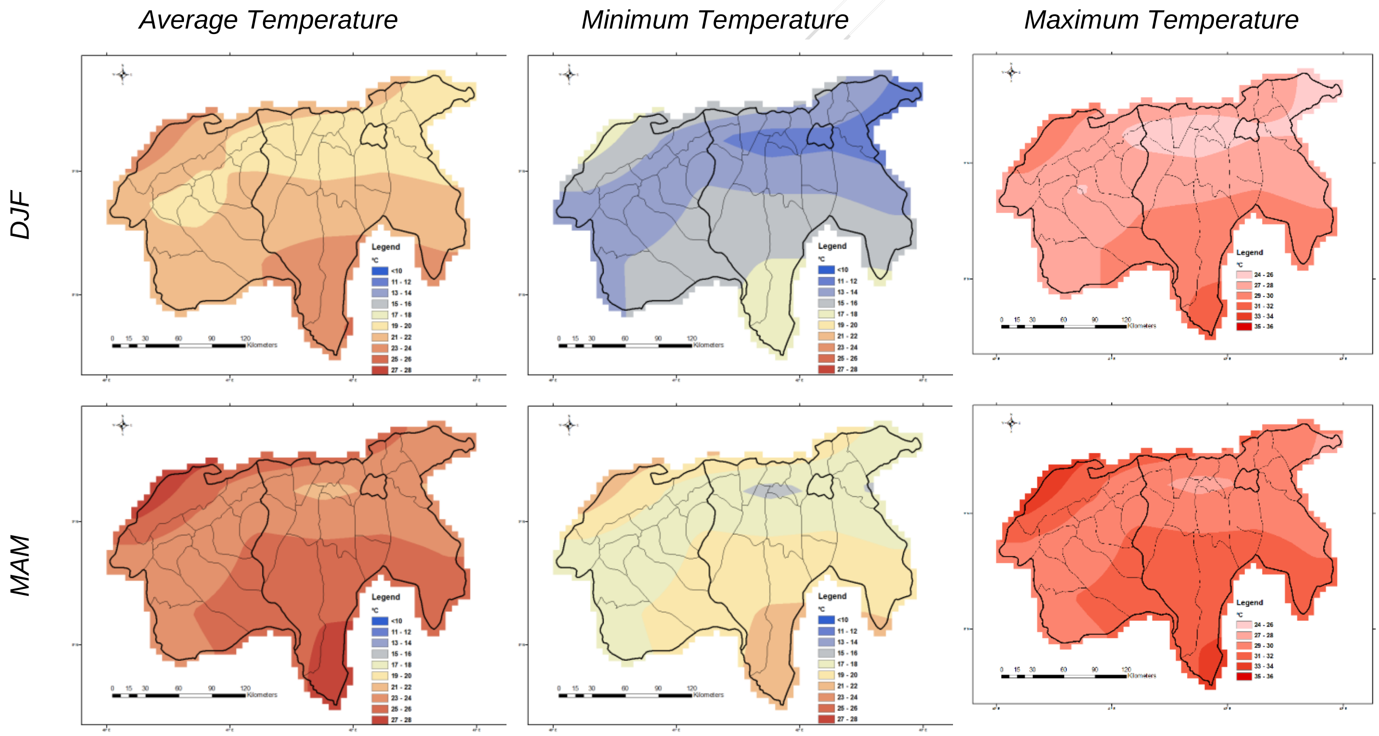


Figure 4.11-6 Average Monthly Temperature over East and West Hararghe (1981-2010)

4.11.2. Seasonal Temperature Climatology



JJA

OND

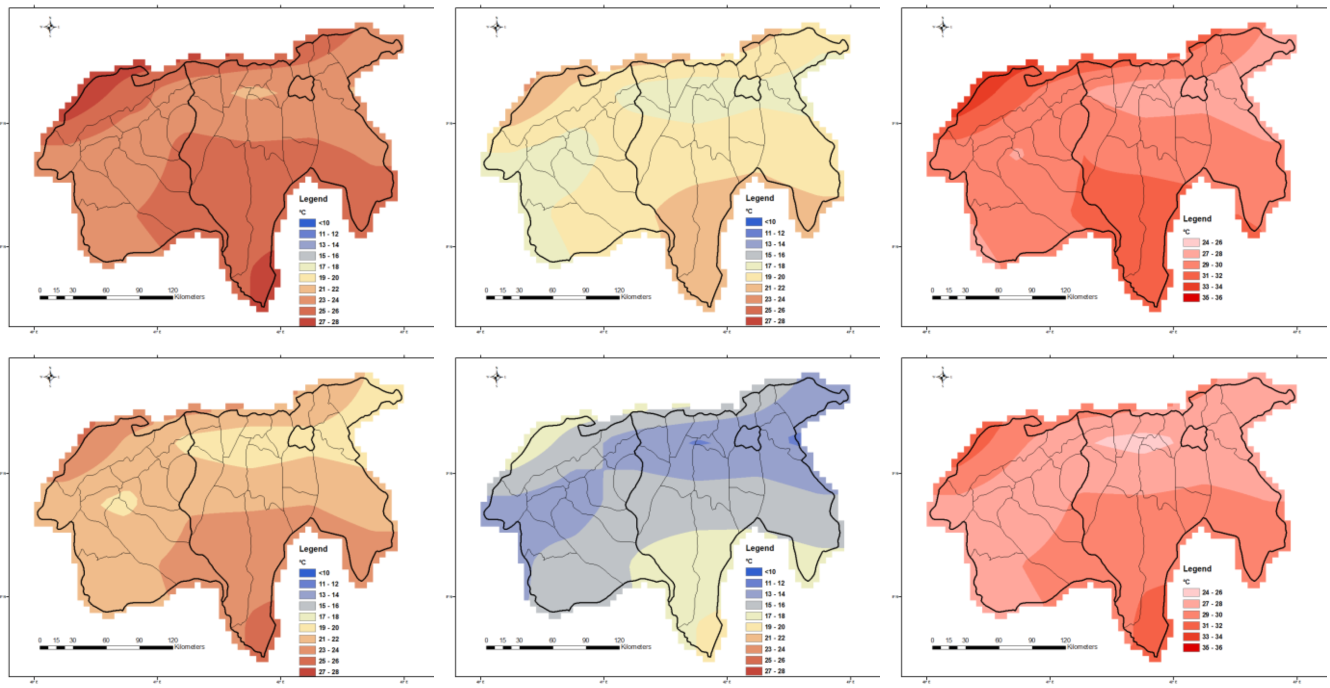


Figure 4.11-7 Average Seasonal Temperature over East and West Hararghe (1981-2010)

The temperature characteristics that were common with the monthly records are still evident from the respective seasonal temperature climatology. **Figure 4.11-7** shows that December – February (DJF) season and October–December (OND) are generally relatively cooler in comparison to the March-May(MAM) and June –July (JJA) seasons.

4.11.3. Temperature Trends

Spatial and temporal patterns of the mean, maximum and minimum temperature trends for East and West Hararghe are shown in **Figures 4.11-8** to **4.11-10**. Although some variations were observed in space and time characteristics of temperature, the space-time variabilities were relatively consistent when compared to rainfall. The minimum temperature is generally increasing but some parts of East and West Hararghe are experiencing a slight decrease as shown in **Figures 4.11-10**. This is consistent with a decreasing trend in the minimum temperature observed in parts of the Oromia region of Ethiopia (Tekalign, 2016) even though all the temperature trends calculated were not statistically significant. The overall trend observed in East and West Hararghe however, generally ranges between 0 to 1ºC per decade **Figures 4.11-8.** Mean surface temperature globally is reported to have increased by 1ºC (ICPAC, 2018; IPCC, 2014).

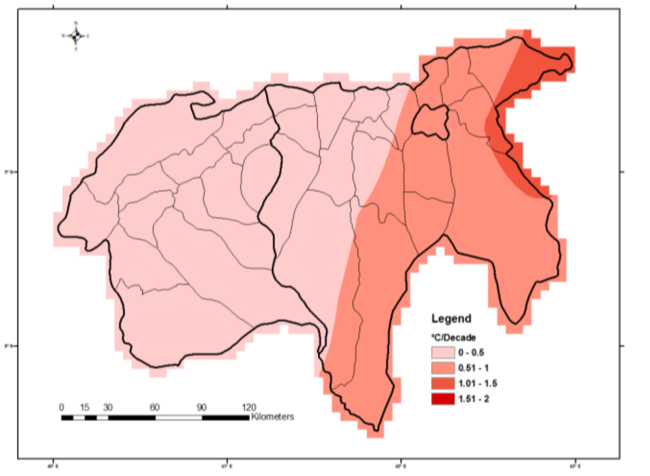


Figure 4.11-8 Mean Annual Temperature Trend (1981-2010)

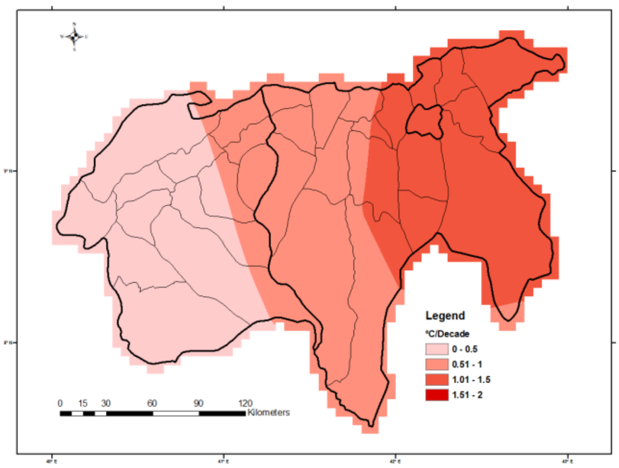


Figure 4.11-9 Trends in Mean surface temperature for FMAM season (1981-2010)

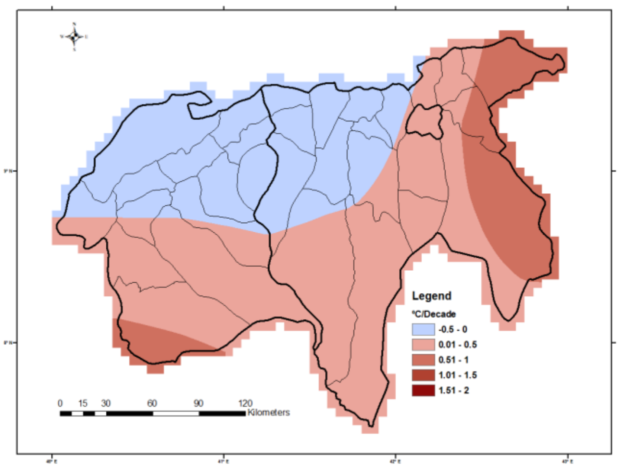


Figure 4.11-10 Trends in Mean surface temperature for JJAS season

Temperature time series are shown in **Figures 4.11-11** to **4.11-13**. An overall increasing trend in minimum, maximum and average temperature is observed at in East and West Hararghe districts. The observed positive trends were significant at 95% confidence. Although observed increasing trends in the mean, minimum and maximum temperatures are consistent with global warming trends that are being observed worldwide, the short duration of data used could not enable us associate the observed warming trends to climate change and global warming signals.

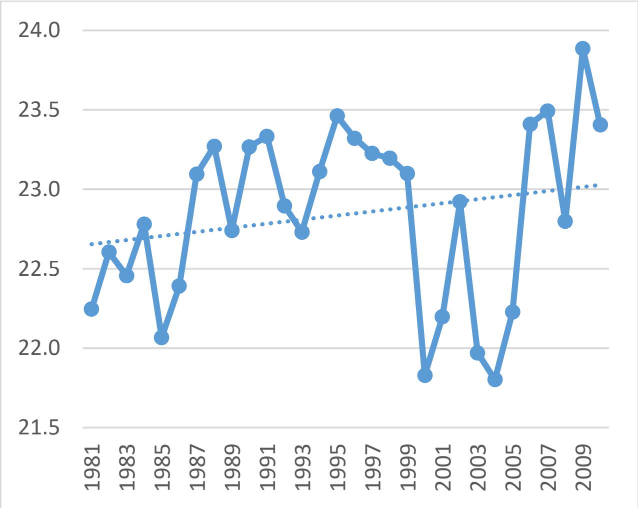


Figure 4.11-11 Time series for mean surface temperature (T_{av}) for East and West Hararghe

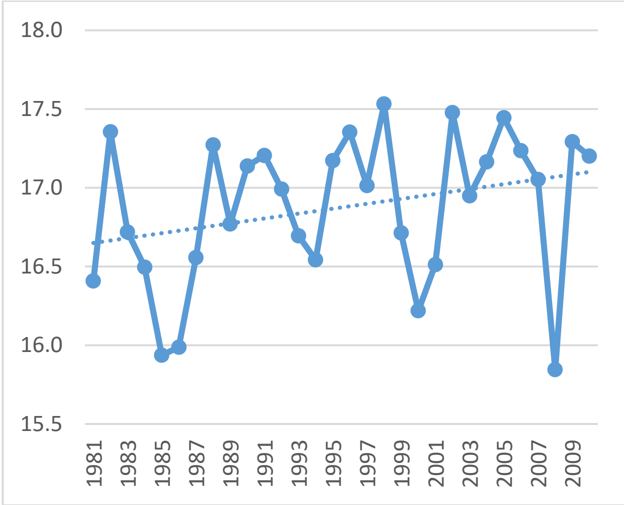


Figure 4.11-12 Time series for mean minimum temperature (T_{min}) for East and West Hararghe

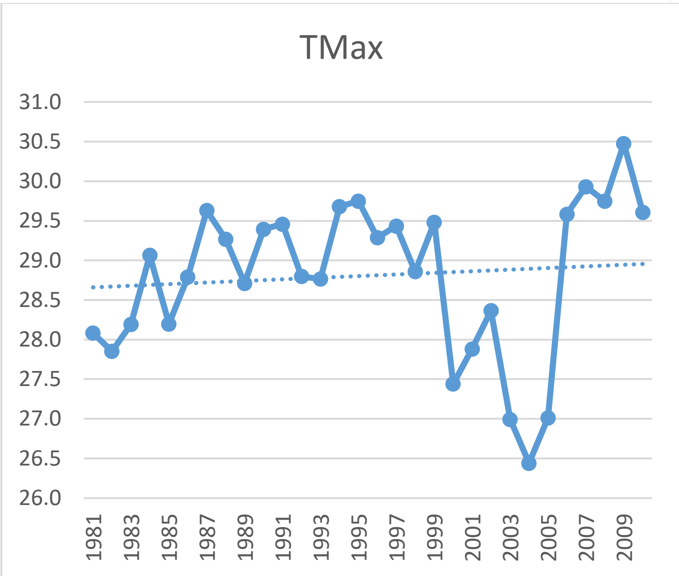


Figure 4.11-13 Time series for mean maximum temperature (T_{max}) for East and West Hararghe

5. CONCLUSIONS

As earlier stated, the main goal of the ACREI Project is to develop and implement adaptation strategies and measures that will strengthen the resilience of vulnerable smallholder farmers, agro-pastoralists and pastoralists in the Horn of Africa to climate variability and change. In line with the IGAD Drought Disaster Resilience Sustainability Initiative (IDDRSI) programme, the National Adaptation Plans of Action (NAPAs) and Development Strategies/Visions of participating countries. In close partnership with the National Meteorological and Hydrological Services (NMHSs), ICPAC leads component 3 of the project while FAO and WMO lead Components 1 and 2 respectively. In order to effectively implement the above three components, baseline data and information that is easily accessible to the users is one of the key activities as highlighted under project activity 3.1.4. Baseline climate data analysis in the three countries were undertaken by organizing a workshop in Naivasha between April 15 and 19 This was followed with site specific workshop in each of the three member countries.

This report provides a summary of the observed baseline rainfall characteristics including rainfall intensity and associated variance; probability of exceedance of specific rainfall thresholds and associated variance; mean characteristics of wet/dry days and associated variance; probability of occurrence of specific wet/dry spells; Onset, cessation and length of growing seasons. Mean, maximum and minimum temperature baseline statistics were also presented. The report shows significant variations in rainfall characteristics in East and West Hararghe Districts. The trend patterns were not consistent for the whole county as cases of slight positive and negative trends were evident over parts of East and West Hararghe Districts. There were however clear evidences of increase in frequency and recurrences of the above and below rainfall events at all locations.

An overall increase in mean, maximum and minimum temperatures were observed in East and West Hararghe Districts though the trends were not statistically significant. The observed increasing trends however, is consistent with global warming trends that are being observed worldwide, the short duration of data used could not enable us associate the observed warming trends in East and West Hararghe Districts to climate change and global warming signals.

The climate baselines from this report will serve as information material for all components of the project as well as the partners and stakeholders. It will also help to achieve project output 3.4.1 on Documentation and dissemination of good practices and lessons learned on the use of climate information in agricultural decision making; output 3.4.2 on Conducting regional and national learning forums; and output 3.4.3 on Improved regional food and nutrition security assessment coordination including capacity building on attribution of food insecurity to various climate related hazards. The workshop outcomes include among others:-

i. Capacity building of NMHs on latest climate products and tools available for analysis of historical climate;
ii. Provided training materials to NMHs on the use of Climate Data Tools (CDT) and other related tools;
iii. Availability of climatological baselined based on analysis of historical climate of project sites including monthly climatology, rainfall intensity, historical onsets, rainfall and temperature trends among others;
iv. Availability of location specific climate products and services on which the climate hazard and other risk management maps can be created;
v. Review of the ACREI project work plan and development of site specific integrated roadmap with local communities and partners for effective project implementation;

The report therefore has therefore provided firm foundation on which all components of the ACREI project are being implemented in Ethiopia.

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Figure 4.11-1