

Seasonal And Annual Climate Profile of Adama District, East Shewa, Oromia, Ethiopia

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Abstract

This study scrutinizes climate profile and appraises its social and economic values in reducing climate-related impacts on Agricultural product over Adama district. The study used CHIRPS data, daily, decadal, monthly, seasonal and annual station data used from NMA. Statistical methods applied to generate recent climate characteristics and climate events of district and secondary data from published and unpublished sources, and systematically analyzes the data both using qualitative and quantitative analysis. The result showed that the trend of gradual, extreme events and meteorological drought increased agriculture vulnerability in the study area. According to the 38 years (1981-2019) CHIRPS Rainfall estimates from rain gauge and satellite observations/CHIRPS Blended with station data/ and the 31 years meteorological gauged station data (NMA). The highest Annual and seasonal average Maximum Temperature recorded over district is 29.7⁰c & 31.0⁰c during 2011 and lowest

is 13.1⁰c & 10.4⁰c respectively. The maximum temperature trend has been increasing but the minimum temperature has been decreasing which shows the climate changes over district. Averagely season starts during May while the season starts at minimum period of April. The season ends averagely at the end of September and the minimum ends at October. Averagely the LGP of district is more than 4 months and minimum and maximum is 3 and 4 months respectively. Overall, the results of Belg and Annual rainfall trend have been decreasing while Bega and Kiremt seasonal rainfall amount has been increasing. The driest year over district was happened during El-Nino year 1987, 2002 & 2015 in contrast the wettest year of district during La-Nina Year 1999, 2000 & 1998. The coldest year and the warmest were during 2014 and 2017 correspondingly. Kiremt and Belg season rainfall variability increases in the recent decade.

Keywords: CHIRPS; Rainfall; Temperature; Season; CV; SPI.

I. Introduction

Adama district is districts in the Oromia region of Ethiopia. Parts of East Shoa provinces located in the Great Rift Valley, it is bordered on the south by the Arsi Zone, on the southwest by Koka Reservoir which separates it from Dugda Bora, on the west by Lume, on the north by the Amhara Region, and on the east by Boset [Figure1] [1]. It is found in Awash River basin. Highland is 85%, low land 10% mid-land 5%, Soil types of district are: Andsoil 74.3% and, cambisoil and luvisols 25.7%. Notable local landmarks include the Sodere and Gergedo hot springs, and Boku Femoral [1]. Identifying climate profile is important to socio-economic activity of the area. The impacts of severe climatic events on livelihoods were frequent and cyclic. The 1994 heavy and unseasonal rain has also damaged crops [2]. The UNDP Climate Change profile for Ethiopia shows that the mean annual temperature has increased by 1.3⁰c between 1960 and 2006, at an

average rate of 0.28⁰c per decade [3]. Rainfall varies over Ethiopian Great Rift Valley [4]. Ethiopian agriculture is mostly characterized by extreme dependence on rained system [5]. The area has three seasons with two rainy seasons locally known as *Kiremt* ({*Ganna* (June-September)} the main rainy period and {*Belg* (*Arfaasaa*) (February-May)} which is the small rainy period. *Bega* (October-January) when dry and cold period dominate the district [6]. The 38 years (1981-2019) CHIRPS rainfall estimates from rain gauge and satellite observations/CHIRP blended with station data/ and the 31 years meteorological gauged station data [7]. Mean annual rainfall of gauged station ranges from 678.1-973.5mm [Figure3], and average annual maximum & minimum temperature is 29.7⁰c and 13.1⁰c, respectively [Graph3 and 4].

II. Description of Study Areas

Adama district extends between 8.14°-8.44° N and 39.04°-39.25° E longitude. It is located in the East Shoa Zone with the border of Lume, Dodota, Boset, Amahara Region, and Bora. The study area covers 37 kebeles & 4

towns and found in the Awash River basin .The altitude of district is range from 1500-2300m asl. [Map1]. Natural resources include forest (known natural resources of district) with different topography and elevation with River and tributaries

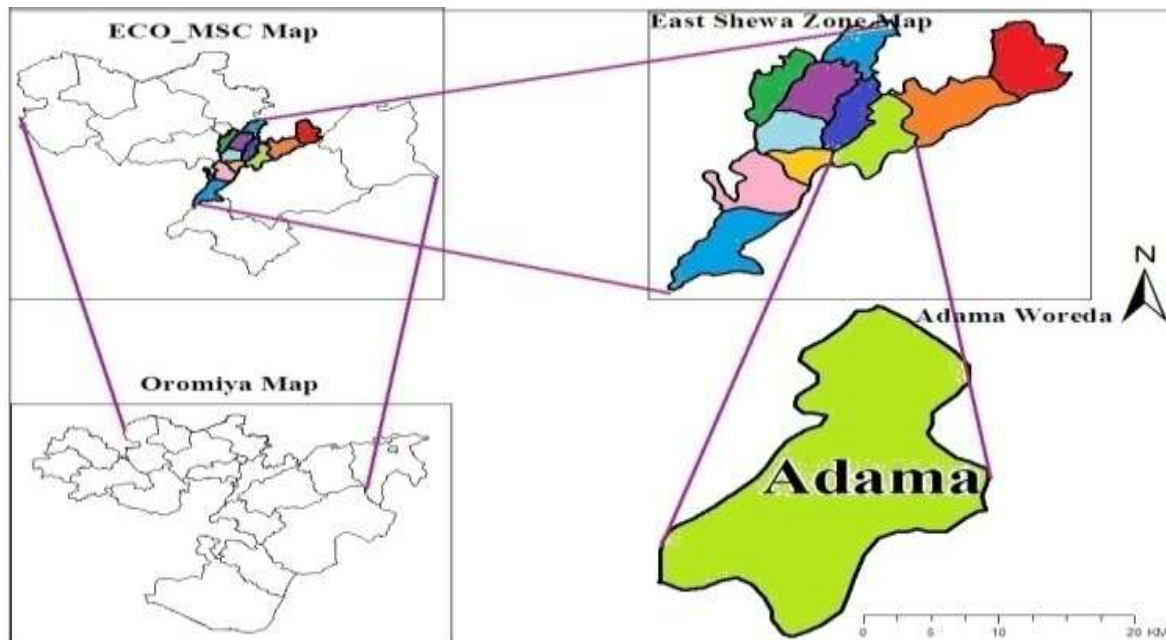


Figure 1. Adama District Location

III. Data and Methodology

GIS Arc maps, GeoCLIM software, Kutools for excel and Instat used for data manipulation and analysis to generate output. CHIRPS data, daily, decadal, monthly, seasonal and annual station data used from NMA (ECO MSC). Statistical methods applied to generate recent climate characteristics and climate events of district.

A. Data Analysis and Results

The trend of rainfall and temperature were examined using standardized precipitation index (SPI). It provides an area average index of relative rainfall based on the The analysis with inputs of Rainfall data was done using GIS to interpolate rainfall spatial distribution of district, GeoCLIM to identify average, anomaly, coefficient of variation, percentage and meteorological drought, Instat to identify probability of Dry and Wet

standardization of rainfall totals, and calculated for season and annual. According to, the standardized anomalies (Z) of inter-annual and seasonal variability in rainfall

as where, x is an annual average, x is long-term mean and SD is standard deviation. Annual rainfall variability has been calculated using the coefficient of variation (CV), which expressed as

Where, CV, is coefficient of variation, SD, is standard deviation and x is the long-term rainfall mean. The degree of rainfall variability which is CV is classified as less variable (CV<20%), moderate variable (20% to 30%) and high variable (CV> 30%). days, LGP, Onset and Cessations of District, to calculate Rainfall coefficient of variation, Range, Minimum, Maximum, mean and standard deviation, Excel for Monthly, Seasonal and Annual mean & Total rainfall and Temperature trends.

$$Z = \frac{(X - \bar{X})}{SD}$$

$$CV = \frac{SD * 100}{X}$$

IV. Discussion and Results

A. Spatial distributions of Seasonal Rainfall average over Adama District

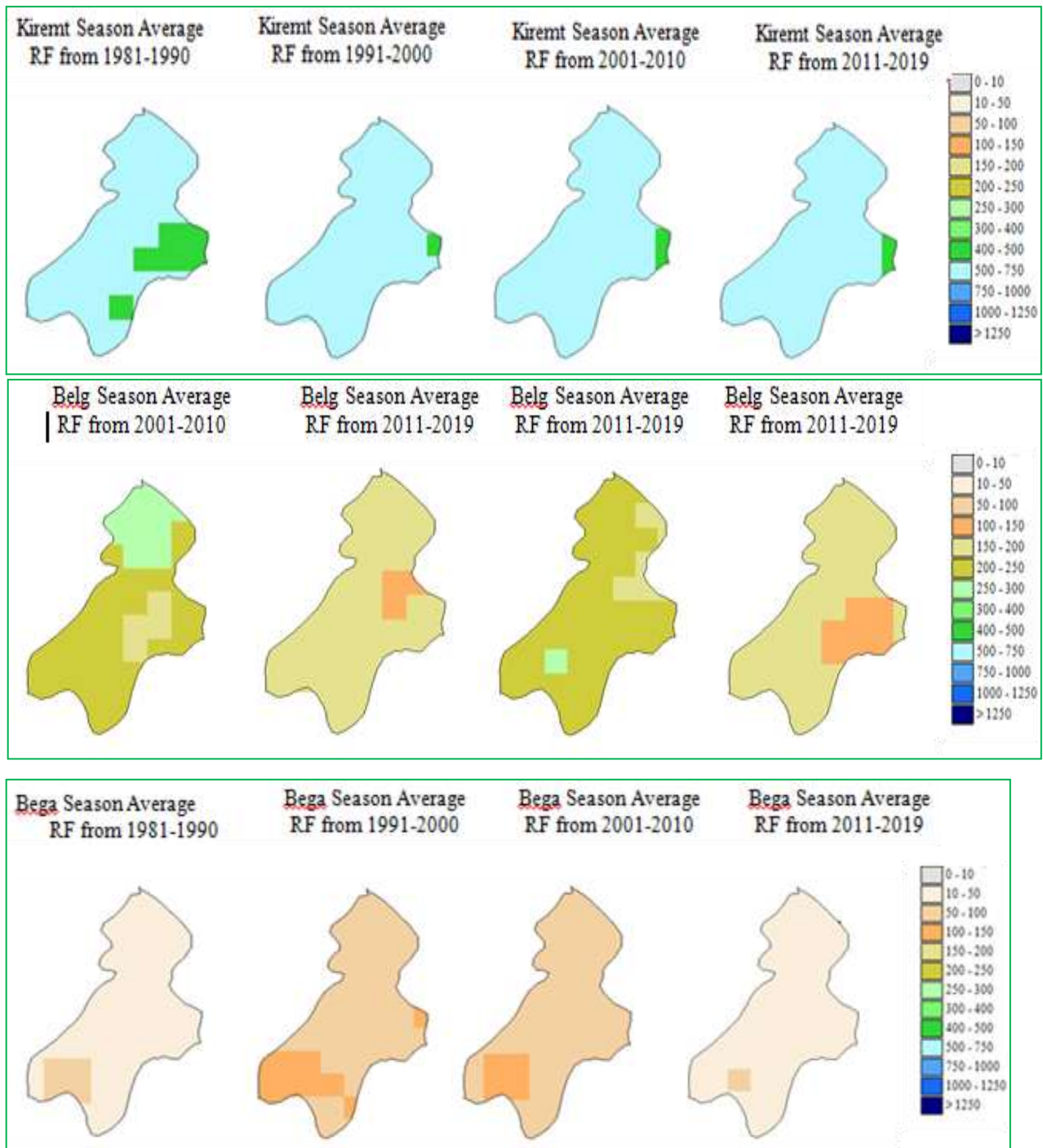


Figure 2. Kiremt, Belg and Bega Seasonal Average Rainfall for nine years from 1981-1990, 1991-2000, 2001-2010 and 2011-2019 map analysis.

From the GeoCLIM tool of CHIRPS data analysis output results the average seasonal rainfall indicates that Kiremt and Belg seasons decrease from 1991-2000

whereas Bega season increases. In 2011-2019 Decade Belg and Bega season shows that more decreasing rainfall values (Figure 2). During the seasons was more

decadal rainfall decreasing in Belg season (from 1981-2010 better than from 2011-2019).
1990 better than from 1991-2000) and also (from 2001-

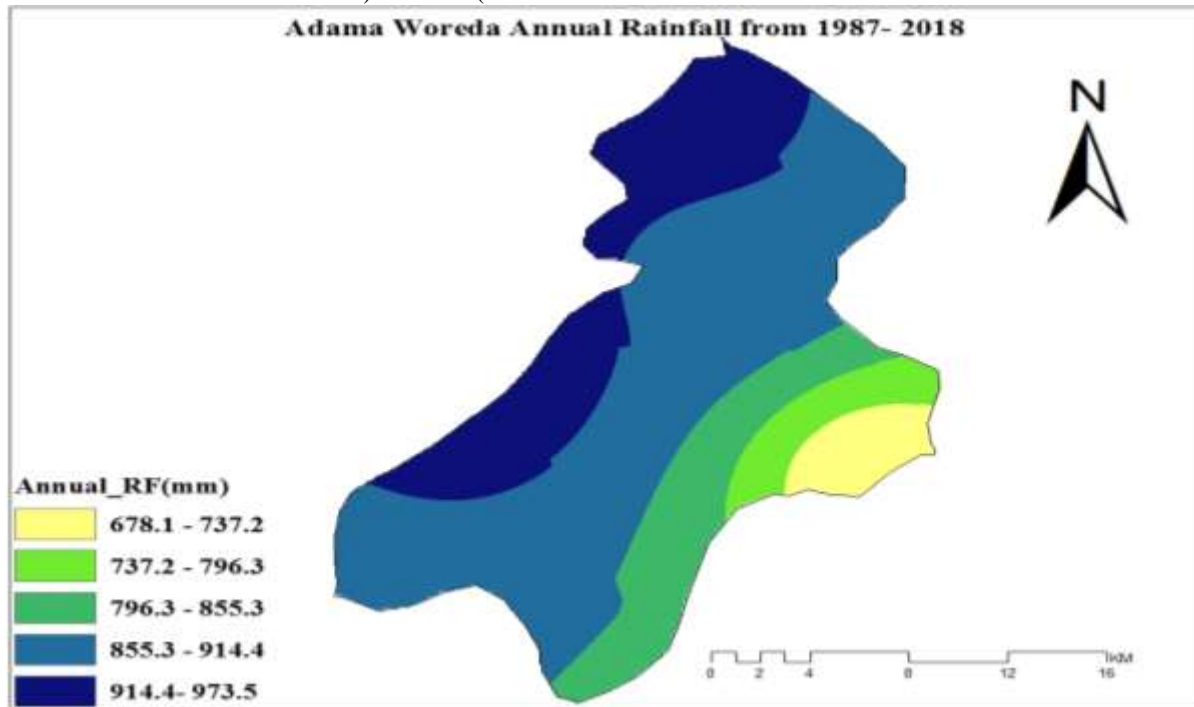


Figure3. Adama District annual rainfall distribution from 1987-2018

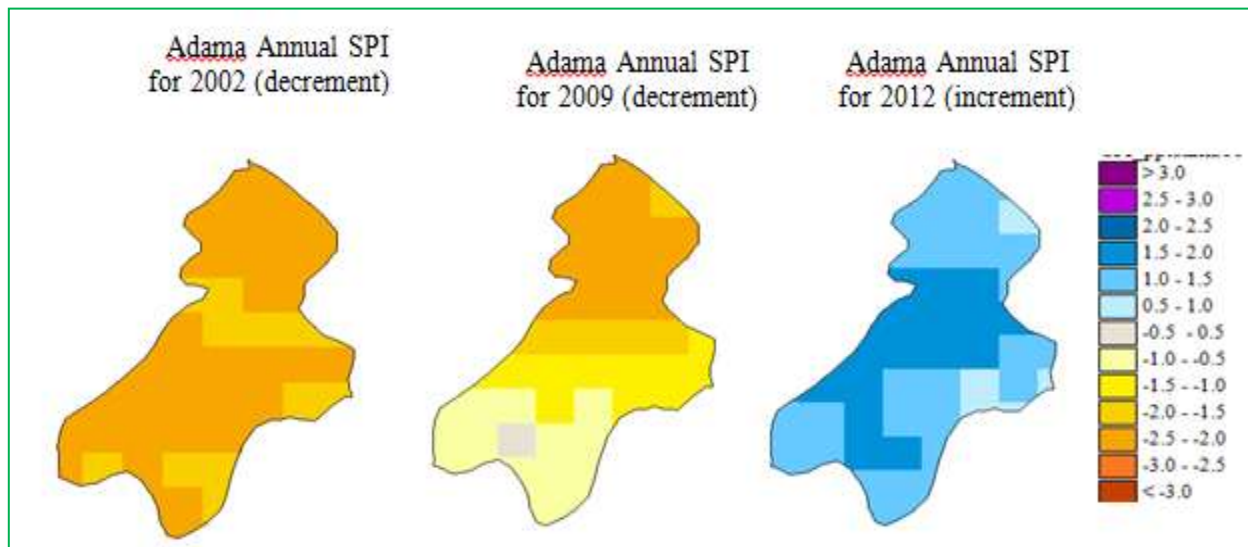
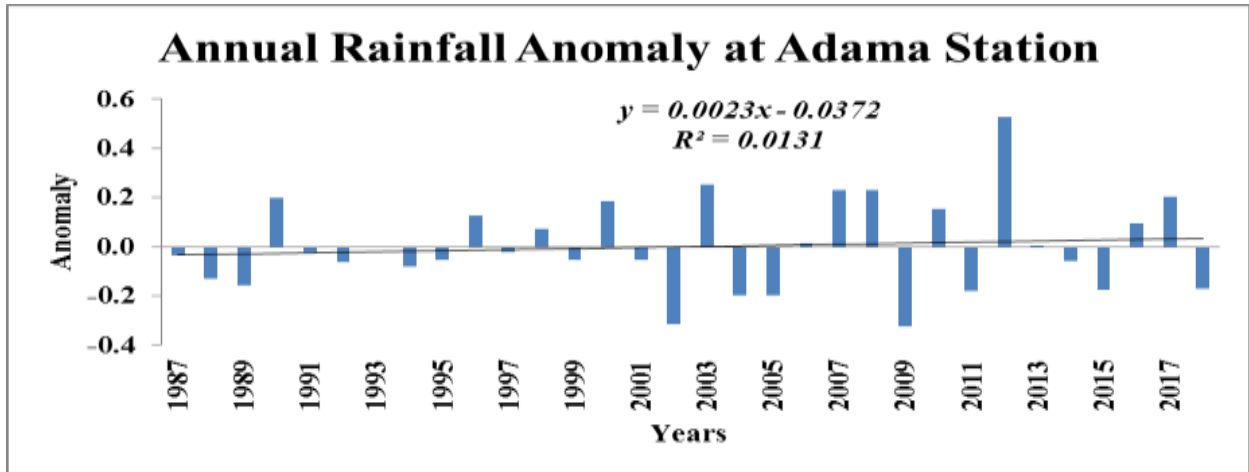


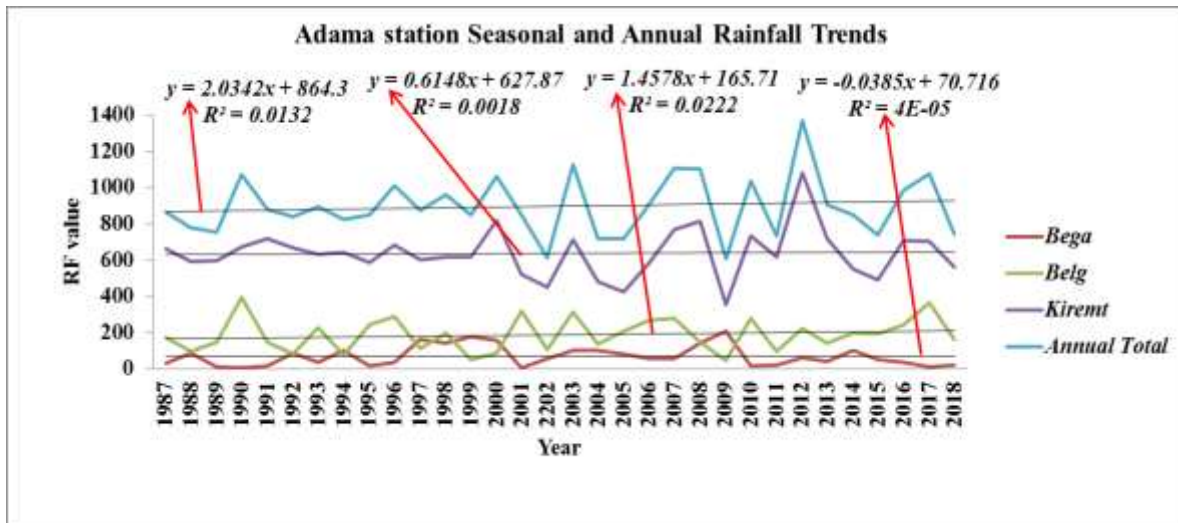
Figure 4. Adama District Annual Rainfall from 1987-2018.

From the station data rainfall anomaly shown during the year of 2002 (-0.3 value) & 2009 (-0.3 value) the driest but during the year of 2012 (0.5 value) the wettest and SPI shown from Chirps data analysis during the year of

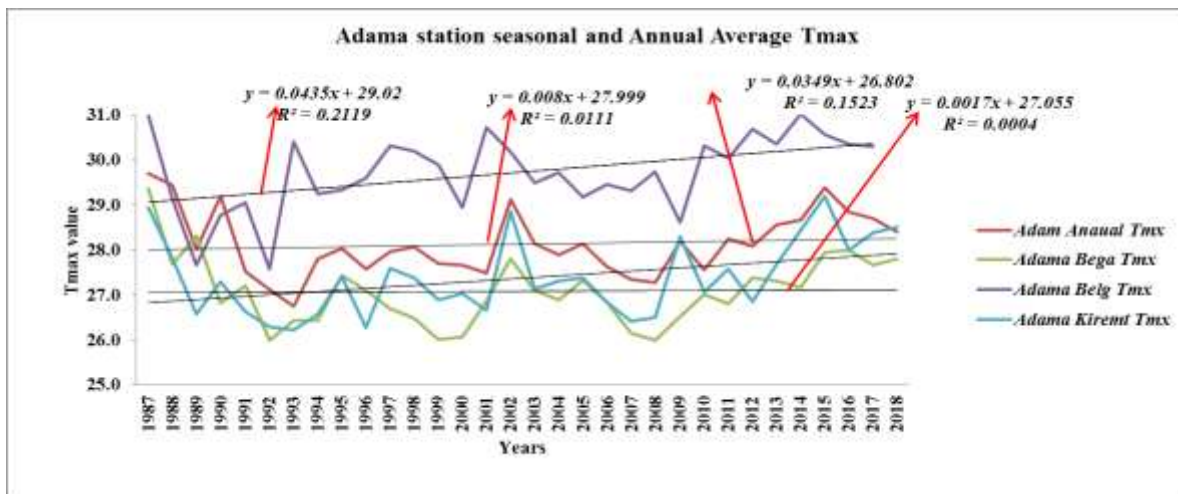
2002 & 2009 was almost moderately dry but during the year of 2012 was moderately wet (*Graph1 and Figure4*), respectively.



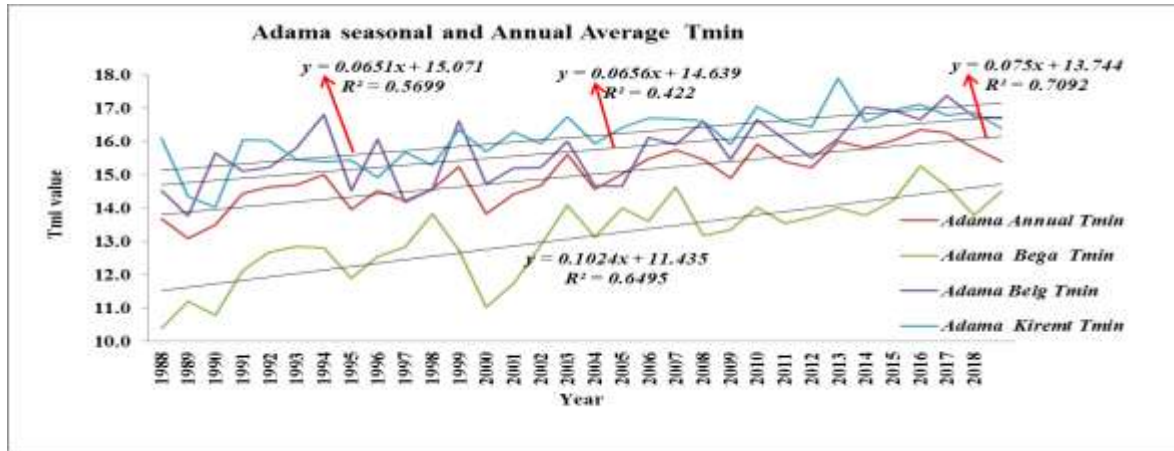
Graph1. Rainfall Anomaly analysis and trend at Adama station



Graph2. Belg, Bega, Kiremt and Annual total Rainfall trends of Adama station



Graph3. Belg, Bega, Kiremt and Annual Maximum average Temperature of Adama station



Graph4. Belg, Bega, Kiremt and Annual Minimum average Temperature of Adama station

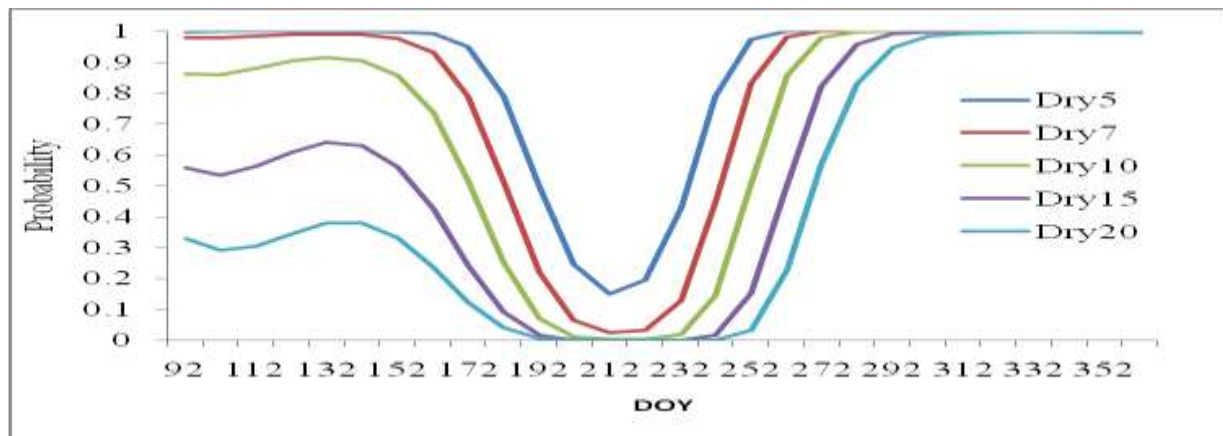
Table1. Adama district Seasonal and Annual Rainfall summary statistics

Rainfall	Belg	Bega	Kiremt	Annual
Maximum	394.4	208.2	1084.1	1370.7
Minimum	47.4	7.7	353.4	609.0
Range	347.5	200.5	730.7	761.7
Mean	189.76	70.1	638	897.9
Standard Deviation	91.8	55.9	135.3	165.9
Coefficient of variation	48.4%	79.8%	21.2%	18.5%

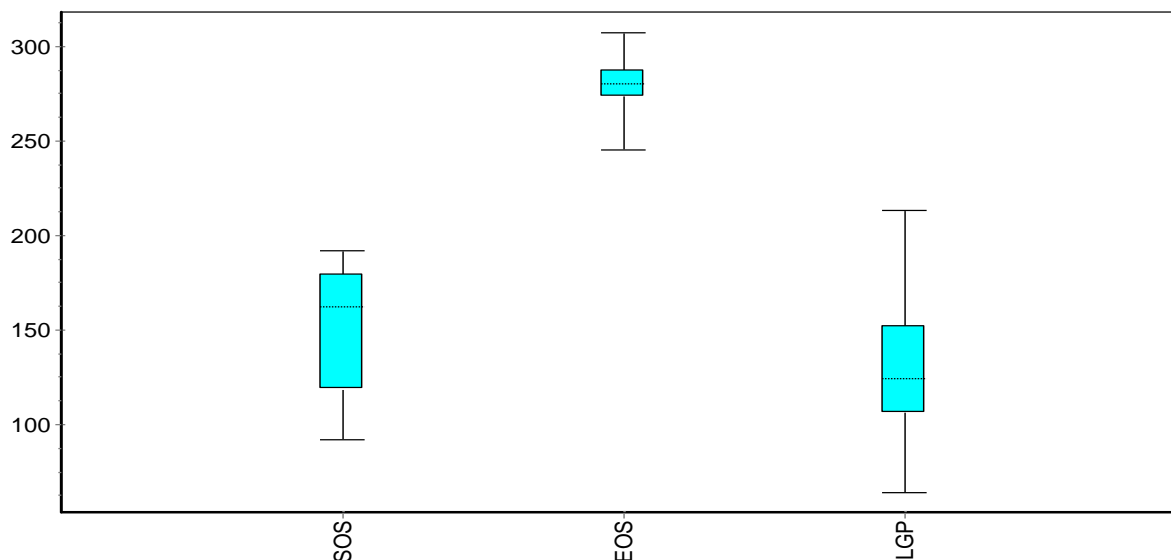
Table2. Adama district Rainfall and Temperature Extreme Events

Parameters	Seasons	Values	Years
Extreme Heavy fall	Belg	104.8mm	2001
Extreme Maximum Temperature	Belg	36.1°C	2016
Extreme Minimum Temperature	Bega	3.0 °C	2000

Graph5: Probability of dry spell days over Adama station



Graph6.SOS,EOS and GP of adama station



Adama district has a Bi-modal rainfall pattern with mean annual rainfall 897.9mm and 18.5% coefficient of variation respectively, which is Medium year to year rainfall variability. The rainy season over the district on average extends from June to September. Average annual maximum & minimum temperature are from 29.7 °c and 13.1 °c respectively. The highest Annual

and seasonal average Maximum Temperature recorded over district is 29.7 °c & 31.0 °c during 2011 and lowest is 13.1 °c & 10.4 °c respectively (Graph 3 and 4).

considered as below normal rainfall while above 973.5mm is considered as above normal rainfall(Figure3). The wettest year were 2012 over Adama in contrast to this driest years were 2002 and 2009(Graph1). Averagely the season starts during May while the season starts at minimum period of April. The season ends averagely at the end of September and the minimum ends at October. Averagely the LGP of district is more than 4 months and minimum and maximum is 3 and 4 months respectively (Graph5 and 6)

The annual standard deviation of district is 165.9mm. This indicates that the normal Annual rainfall for this district ranges from 678.1mm to 973.5mm annual rainfall below 678.1mm is

rainfall amount has been decreasing. The temperature trend has been increasing the value which shows the climate change over district (Graph1).

Belg and *Kiremt* is a rainy season, while *bega* is the dry and cold period. *Kiremt* rainfall amount had 80.1%; *Belg* had 20.1% and *Bega* had 7.8% from the annual rainfall received over district. In 2012 annual rainfall amount of 1370.7mm were recorded which is the highest annual total rainfall over district while the lowest of district were 614.4mm and 609mm in 2002 and 2009 respectively (Graph1).

4.2. Extreme event and meteorological drought over Adama district

Definitions of extreme event: Records are distinguished as daily (largest/smallest for that day on the calendar), monthly (largest/smallest value during that month), or all-time (largest/smallest value ever observed at that station). Summary information for recent periods (year-to-date, month-to-date, last 30 days) is provided in tabular format. Extreme events such as heat waves, droughts, tornadoes, and hurricanes, highest and lowest temperature, heavy fall.

In general, *Kiremt* seasonal, *Belg* seasonal and Annual Rainfall trend has been increasing while *Bega* seasonal

Definitions of meteorological drought: This type of drought all about the weather and occurs when there is a prolonged period of below average precipitation, which creates a natural shortage of available water. Meteorological drought is defined in terms of the magnitude of a precipitation shortfall and the duration of this shortfall event.

The following figures shown kiremt season SPI for El Nino, La Nina and Neutral years.

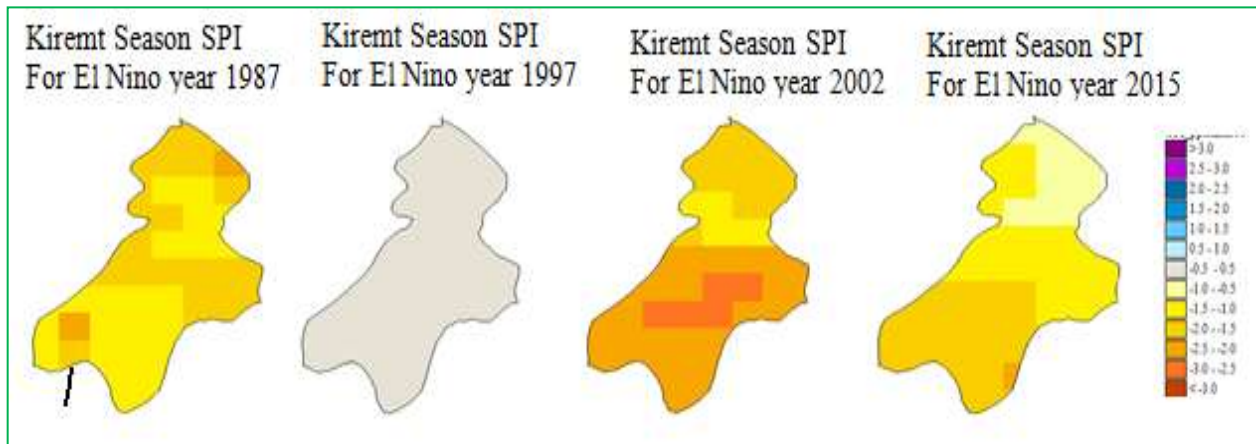


Figure 5. Kiremt standard precipitation index (SPI) for El Nino years 1987, 1997, 2002 and 2015 CHRIPS data map analysis.

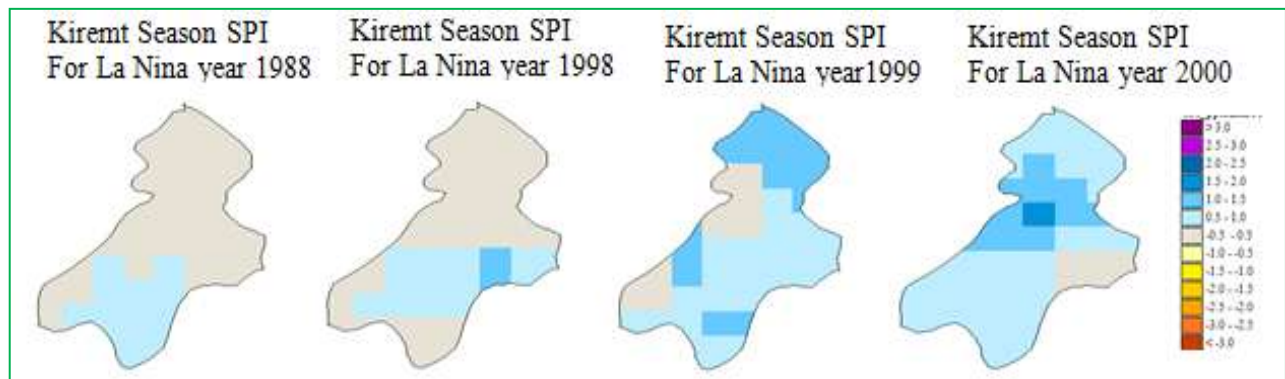


Figure 6. Kiremt standard precipitation index (SPI) for La Nina years 1988, 1998, 1999 and 2000 CHRIPS data map analysis.

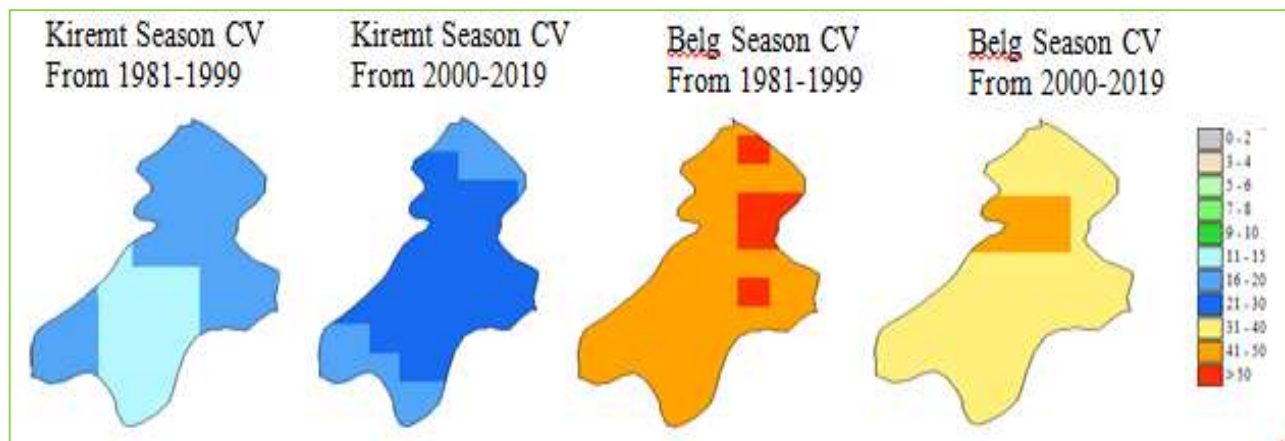


Figure 7. Kiremt and Belg coefficient of variation (CV) from 1981-1999, 2000-2019 and 1981-1999, 2000-2019 respectively using CHRIPS data map analysis.

V. Conclusion

Adama district is a Bimodal (Belg and Kiremt) Rainfall benefiting areas when Bega is the dry, cold period & the harvesting time. Kiremt rainfall amount accounts 80.1%; Belg had 20.1% and Bega had 7.8% from the annual rainfall received over district. The highest rainfall variability is during Bega season. Mean Annual Rainfall ranges from 678.1mm to 973.5mm and average annual maximum & minimum temperature is 29.7⁰c and 13.1⁰c Celsius, respectively. Extreme events and meteorological drought recently happened over district. Averagely the season starts during May while the season starts at minimum period of April. The season ends averagely at the end of September and the minimum ends at October. Averagely the LGP of district is more than 4 months and minimum and maximum is 3 and 4 months, respectively.

VI. Acknowledgements

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Among four El-Nino year happened 1987, 1997, 2002 and 2015, the strongest is 2002 whereas 1997 is medium. As La -Nina year identified the strongest over district was 2000. Variability increases both Kiremt and Belg season from long decade to recent but the highest rainfall variability were during Belg seasons 1981-1999.

In general, Belg and Bega seasonal Rainfall trend has been decreasing while annual and Kiremt seasonal has been increasing. The temperature trend has been slightly increasing the value which shows climate change over district. More Rainfall variability at recent decade over district during El-Nino and La-Nina happened and Extreme event and Meteorological drought occurred of dry days.

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VII. References

- [1] East Shoa Economic and Development Office and Adama district; Finance and Economic Development Office
- [2] Abate Feyissa. (2009). "Climate Change Impact on Livelihood, Vulnerability and Coping Mechanisms: A Case Study of West-Arsi Zone", Ethiopia, 2009. LUCSUS, Lund University SE-22644, Lund, Sweden.
- [3] McSweeney., C., New., M., Lizcano.,G. and Lu., X. (2010). "The UNDP Climate Change Country Profiles Improving the Accessibility of Observed and Projected Climate Information for Studies of Climate Change in Developing Countries". Bulletin of the American Meteorological Society, 91, 157-166
- [4] Getnet Feyissa. (2010). "Comparative Analysis of Climate Variability and Impacts in Central Rift Valley and Adjacent Arsi Highlands Using GIS and Remote Sensing". Department of Earth Sciences Faculty of Science Addis Ababa University, Addis Ababa, Ethiopia.
- [5] "Rainfall variability and crop production in Ethiopia Case study in the Amhara region". (Woldeamlak, 2009)
- [6] Korecha, D.andBarnston, A. G. 2007, "Predictability of June-September Rainfall in Ethiopia", Journal of American Meteorology Society135, 628-649., NMSA 1996, Degafu 1987
- [7] National Meteorological Agency of Ethiopia Eastern and Central Oromia Meteorology Service Centre
- [8] Linso Timungpi and Micky Teron, "The Impact of Climate Change and Forced Movement: an Overview of the Incompetence of Laws for Climate Change Refugees" SSRG International Journal of Humanities and Social Science Vol-5,Iss-2,2018.