

Seasonal And Annual Climate Profile of Boset District, East Shewa, Ethiopia

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Abstract

This study scrutinizes the climate profile and appraises its social and economic values in reducing climate-related impacts on Agricultural products over the Boset 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applied to generate recent climate characteristics and climate events of district and secondary data from published and unpublished sources, and systematically analyzes the data both using qualitative and quantitative analysis.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/CHIRP Blended with station data/ and the 31 years meteorological gauged station data(NMA). Averagely the season starts during the end of May while the season starts at the minimum period of April 1st decade. The season ends averagely at the end of September to October the first decade, and the minimum ends on September

2nd decade. Averagely the LGP of the district is more than 4 months, and the minimum and maximum are 3 and 5 months, respectively. The highest Annual and seasonal average Maximum and Minimum Temperature recorded over the district is 31.7^oC and 32.9^oC during 2017 and 2015, and the lowest is 14.3^oC (2017) and 10.0^oC (2017), respectively. The maximum temperature trend has been increasing, but the minimum temperature has been decreasing, which shows the climate changes over the district. Overall, the results of Belg and annual rainfall trends have been decreasing while Bega and Kiremt seasonal rainfall amount has been increasing. The driest year over the district has happened during El-Nino years 1987, 2002, and 2015 in contrast to the wettest year of the district during La-Nina Year 1999, 2000, and 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

Boset district is one of the districts, or districts, in the Oromia Region of Ethiopia. Parts of east Shewa provinces located in the Great Rift Valley (GRV), Boset district, is bordered on the south by the Sire and Dodota, on the west by Adama district, on the east by Merti, on the north by the Amhara region, and on the northeast by Fentale; southeast by Jeju.

The total land coverage is 124 160 hectares—the altitude range from 1200-1800 meters above sea level. Most part of Boset (about 89%) belongs to the tropical (Gammoggi/Kolla) Agro-climatic zone, and the remaining smaller section (about 11%) is sub-tropical (Badda Daree/woina Dega). Boset woreda District; Finance, Economic, and Development office] [1]. The identifying climate profile is important to the 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 1.3^oc between 1960 and 2006, at an average rate of 0.28^oc per decade [3]. Rainfall varies over the Ethiopian Great Rift Valley [4]. Ethiopian agriculture is mostly characterized by extreme dependence on a 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 periods 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].

The annual rainfall range from 649 mm to 951 mm (Figure3), whereas daily extreme heavy fall over the district recorded was 92.1mm during *Belg* season in 2003(Table2).The daily extreme maximum and

minimum temperatures are 38.3°C and 2.5°C, respectively. Boset is among the agriculturally rich districts of the east Shewa zone. It is rich in crop production and livestock rearing. The northeastern section of the district, with its tropical agro-climatic zone, is more suitable for animal rising than cultivation.

The major soils of Boset, Andosols, though have low water retention capacity, are quite productive, especially during periods of sufficient rains. The production of commercial crops like fruits and vegetables takes place along the plains of the basin awash. Nura Era and Degaga fruits and vegetable state farms are found in the district.

II. Description of Study Area

Boset woreda is found in Awash major catchment area, which is located between 8025'-8°50'N latitude and 39°16'-39°50'E longitude. Boset, together with Fentale, forms the northeastern part of the East Shewa Zone. Amhara region in the north, Fentale in the northeast, Arsi Zone in the east, in the east, Adama district in the south, Adama and lume border Boset in the North West. With a total surface area of 151406.6 km², it is the second-largest district coming only after Ada'a-Liben (Figure1).

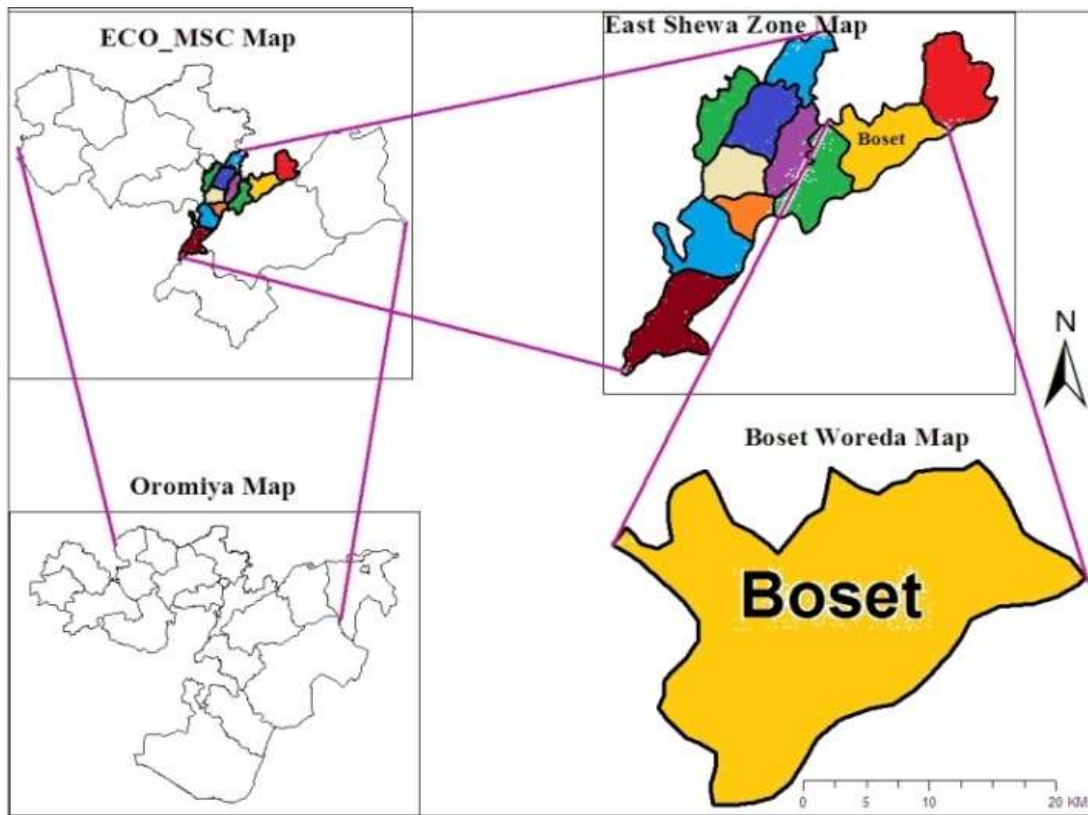


Figure1. Boset district location

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 the district.

A. Data Analysis and Results

The trend of rainfall and temperature were examined using the standardized precipitation index (SPI). It provides an area average index of relative rainfall based on the standardization of rainfall totals and calculated for a season and annual. According to, the standardized anomalies (Z) of interannual and seasonal variability in rainfall as

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

Where x is an annual average, x

is the long-term mean, and SD is the standard deviation. Annual rainfall variability has been calculated using the

Where CV is the coefficient of variation, SD is the standard deviation, and \bar{x} is the long-term rainfall mean. The degree of rainfall variability, which is a CV, is classified as less variable ($CV < 20\%$),

$$CV = \frac{SD}{\bar{x}} * 100$$

The analysis with inputs of Rainfall data was done using Geographical Information System (GIS) to interpolate spatial rainfall distribution of district, GeoCLIM to identify average, anomaly, coefficient of variation, percentage and meteorological drought, Instat to identify the

coefficient of variation (CV), which expressed as

moderate variable (20% to 30%), and high variable ($CV > 30\%$).

probability of dry and wet days, LGP, onset and cessations of the district, to calculate rainfall coefficient of variation, range, minimum, maximum, mean and standard deviation, excel for monthly, seasonal and annual mean and total rainfall and temperature trends.

IV. Discussion and Results

A. Spatial Distributions of Seasonal Rainfall Average over Boset District

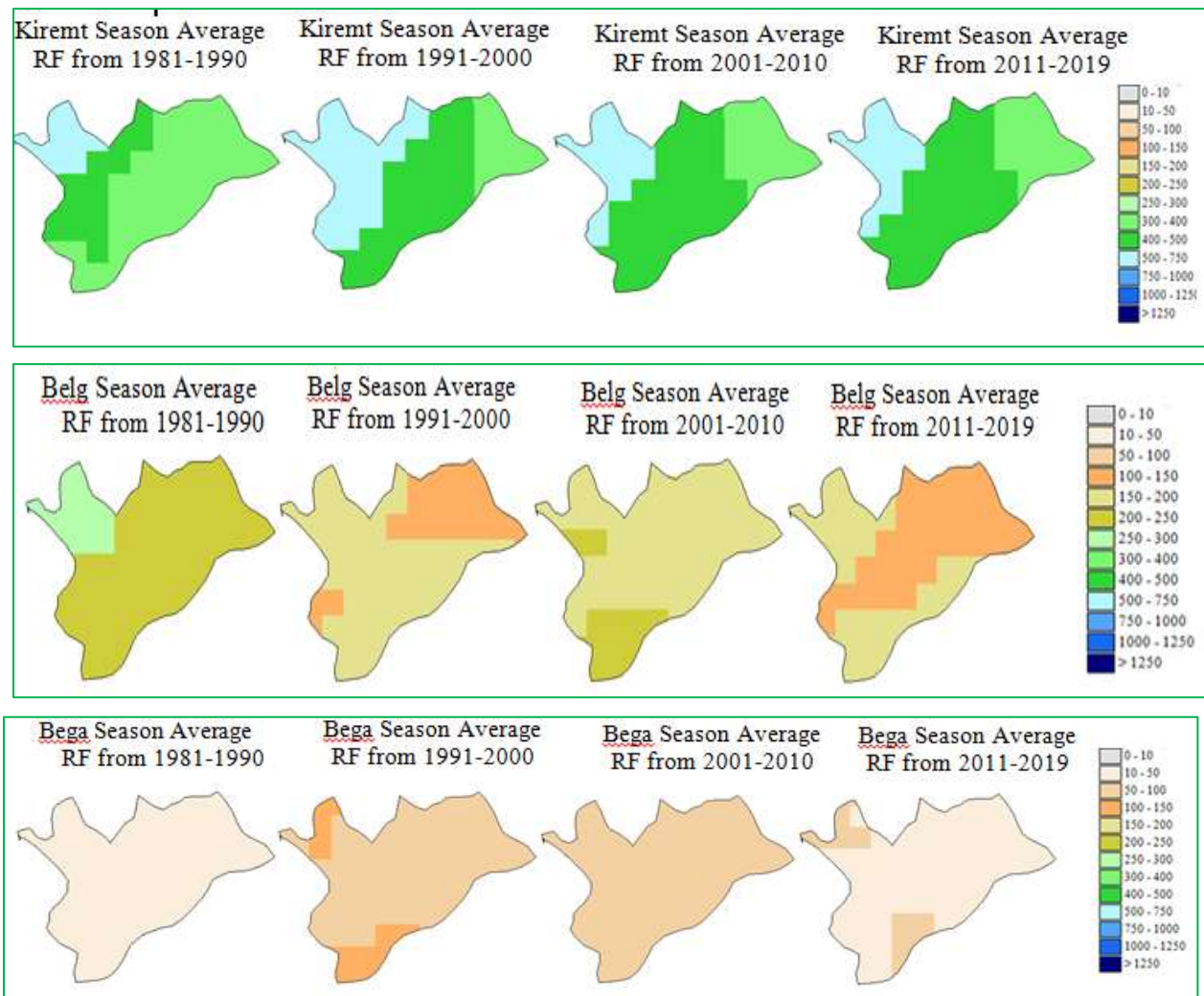


Figure 2. Kiremt, Belg, and Bega Seasonal Average Rainfall for nine years from 1981-1990, 1991-2000, 2001-2010, and 2011-2019 map analysis.

From the Geoclim data analysis output results, the average seasonal rainfall indicates that *Kiremt* and *Bega* season increases from 1991-2000, whereas *Belg* season decreases. In 2011-2019 Decade *Belg* and *Bega* season

show that more decreasing rainfall values (Figure2). During the seasons was more decadal rainfall decreasing in *Belg* than others.

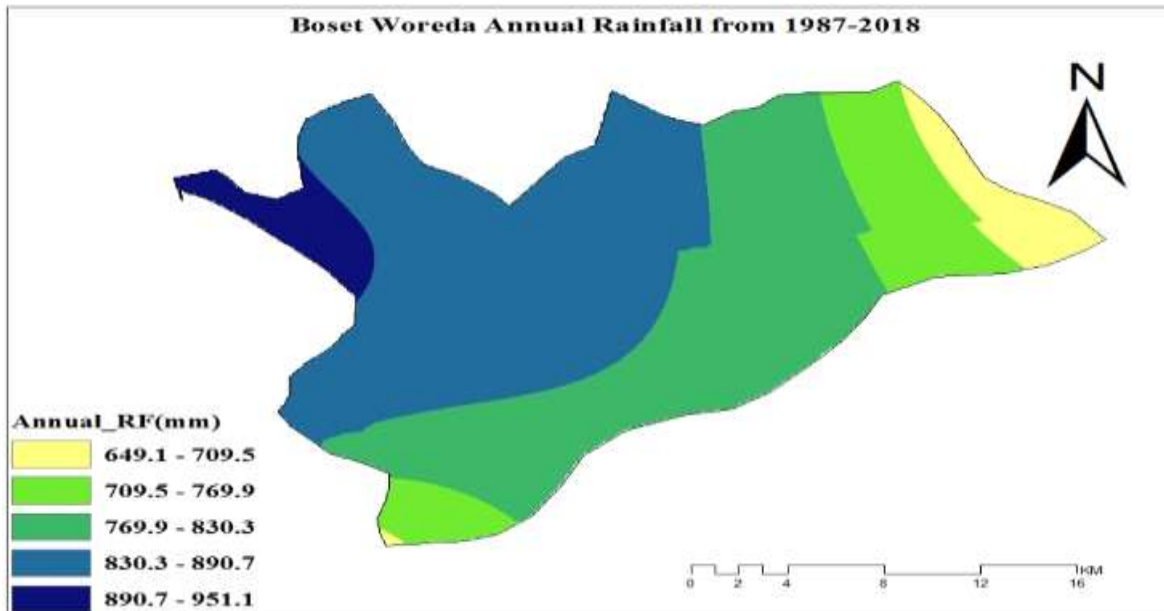


Figure3. Boset District station data spatial total annual rainfall from 1987-2018.

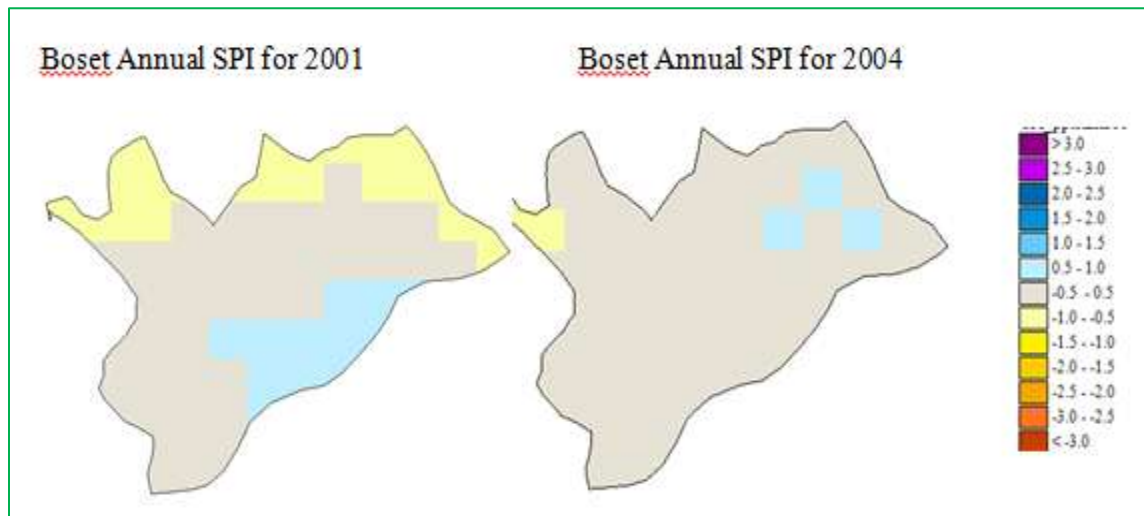
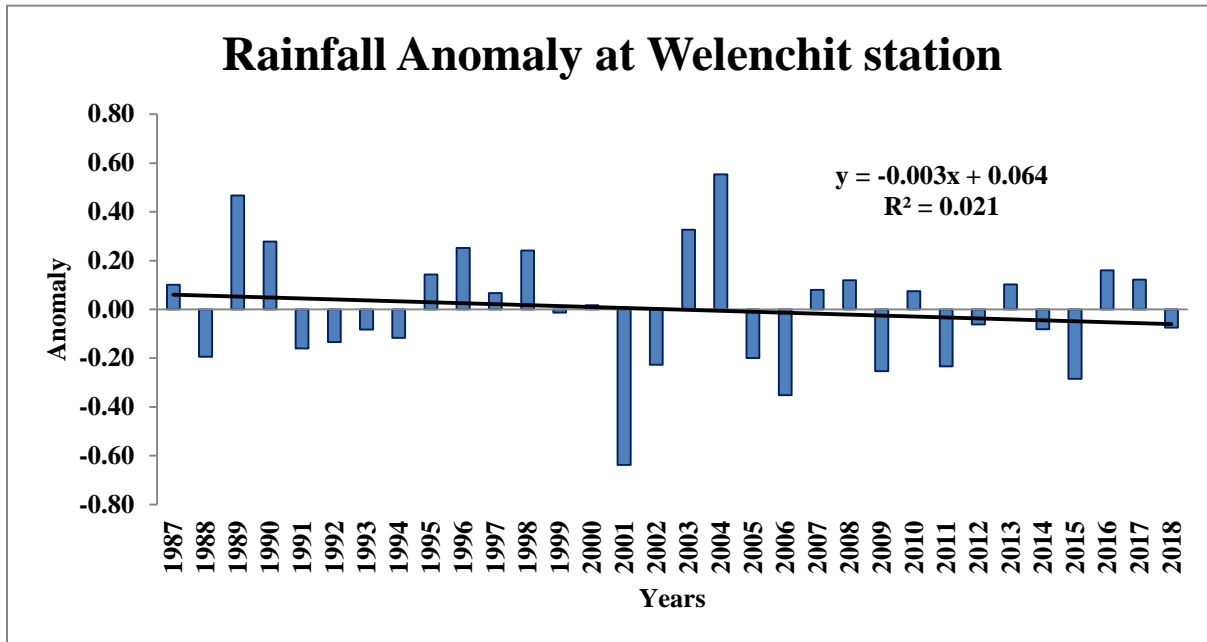


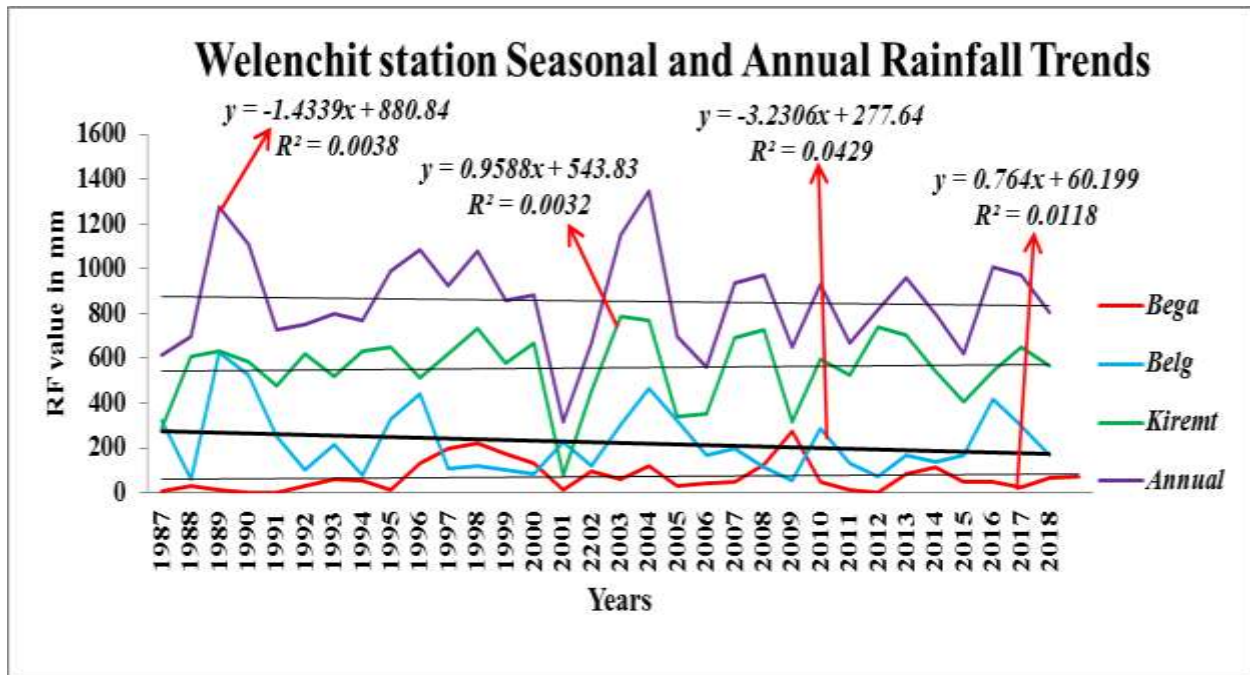
Figure 4. Boset district annual rainfall from 1987-2018.

From the station data, rainfall anomaly indicates during the year of 2001 (-0.64) the driest and 2004 (0.55) the wettest and SPI from Chirps data analysis during the

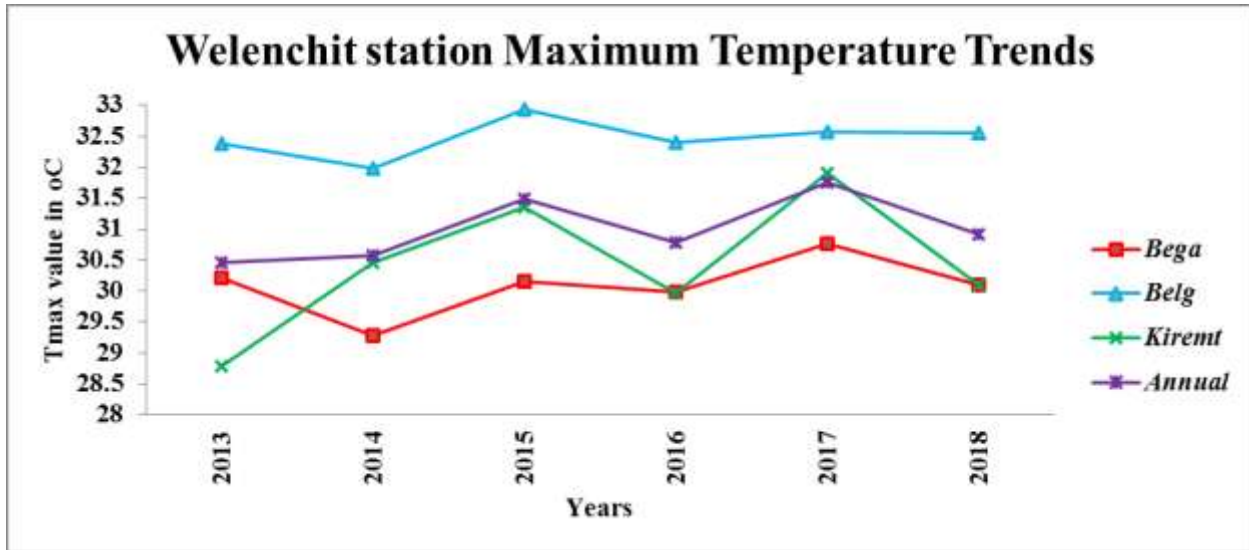
year of 2001 was moderately dry while 2004 was average (Graph1 and Figure4), respectively.



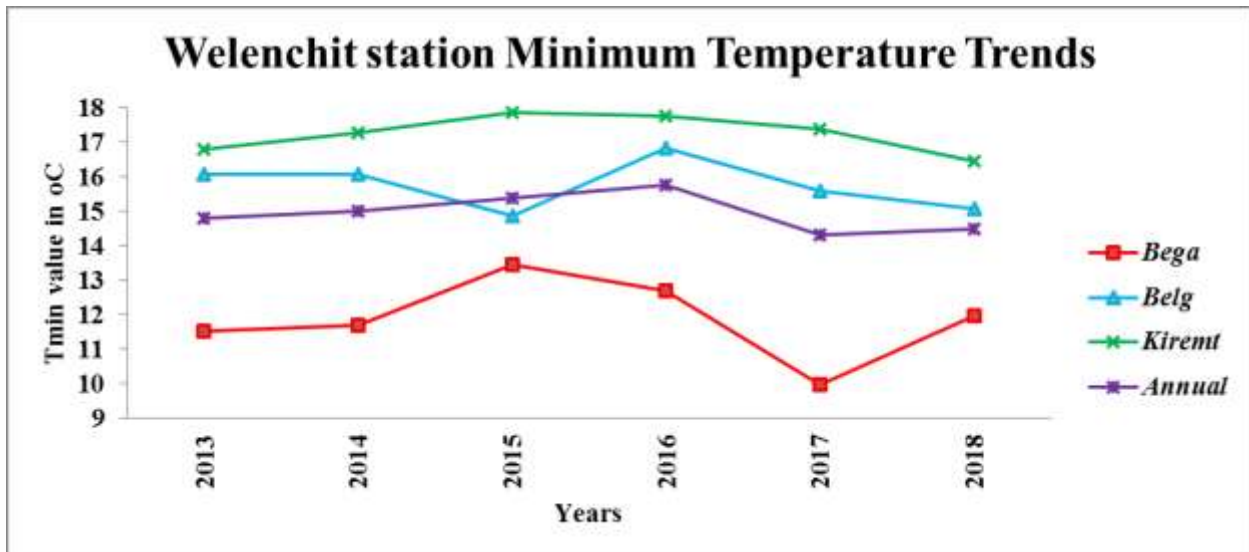
Graph1. Rainfall Anomaly at Welenchiti station



Graph2. Belg, Bega, Kiremt and annual total rainfall trends of Welenchiti station



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



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

From the graph above *Belg* and *Kiremt* is a rainy season, while *Bega* is the dry and cold period. *Kiremt* rainfall amount had 65.3%; *Belg* had 26.2%, and *Bega* had 8.5% from the annual rainfall received over the district. In 2004 annual rainfall amount of 1348.6mm was recorded, which is the highest annual total rainfall over the district while the lowest of the district was 314.0mm in 2001 (*Table1*).

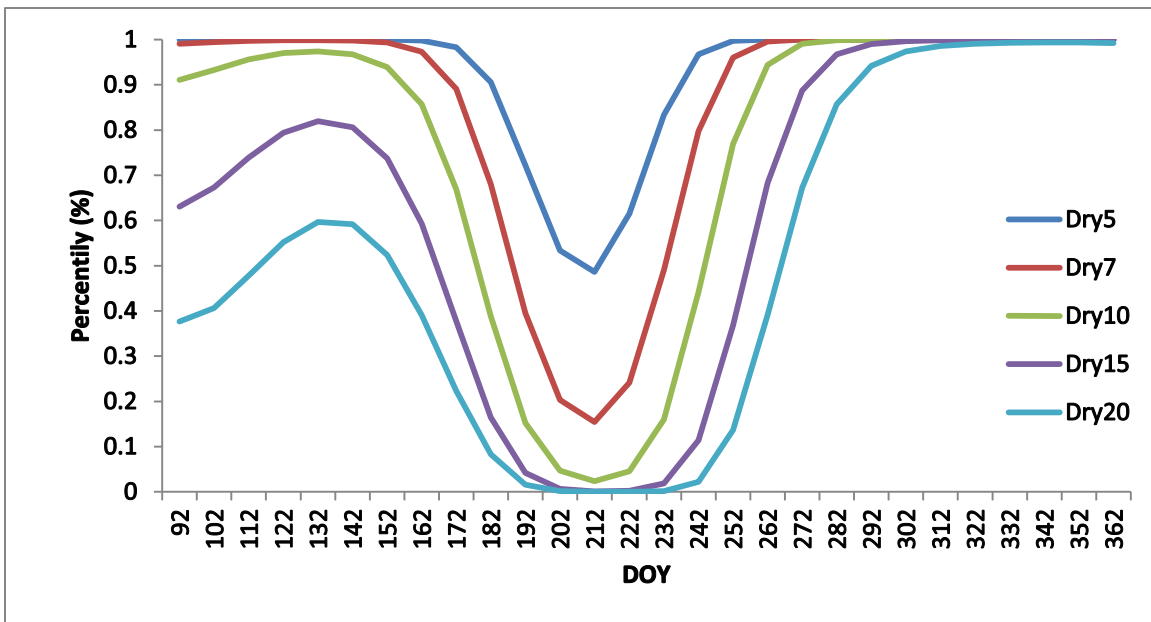
The highest annual and average seasonal maximum and minimum temperature recorded over the district is 31.7°C and 32.9°C during 2017 and 2015, and the lowest

is 14.3°C (2017) and 10.0°C (2017), respectively (*Table1*).

In general, *Belg* and annual rainfall trends have been decreasing while the annual *Bega* and *Kiremt* seasonal rainfall amount has been increasing. The maximum temperature trend has been increasing, but the minimum temperature has been decreasing, which shows climate change over the district.

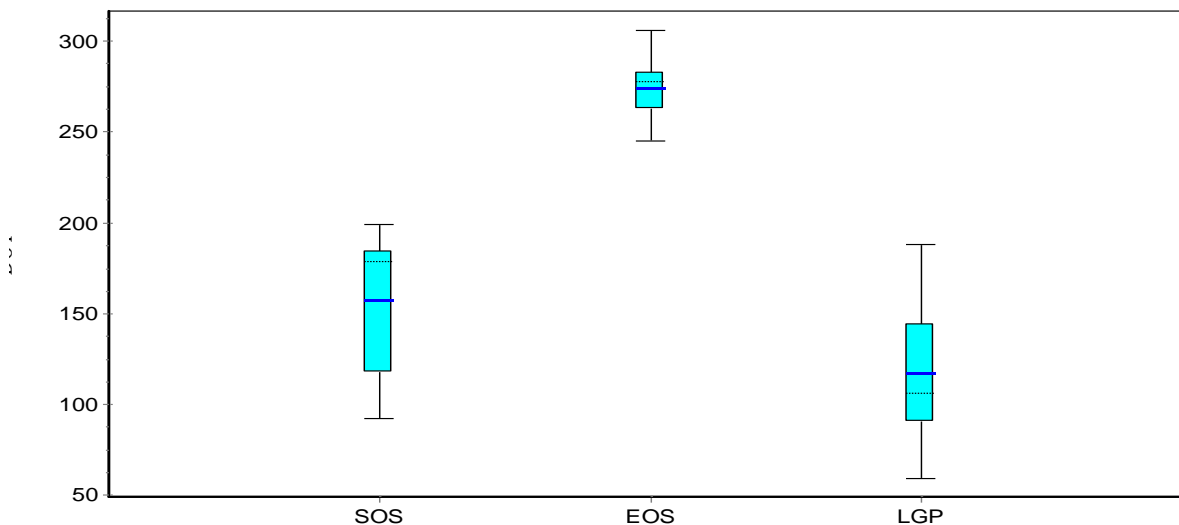
Rainfall(mm)	Belg	Bega	Kiremt	Annual
Maximum	625.1	273.2	786.6	1348.6
Minimum	56.1	1.6	76.5	314.0
Range	569	271.6	710.1	1034.6
Mean	224.3	73.2	559.5	857.2
Standard Deviation	146.3	69.1	158.9	217.9
Coefficient of variation	65.2%	94.5%	28.4%	25.4%

Graph5. Probability of dry days, onset, cessation, and LGP of district



The probability of dry days of greater than 5-10 days is the highest during Belg and Bega except for Kiremt season when medium-dry days of greater than 15-20 dry days (Graph5).

Graph 6. Graph of SOS, EOS, and LGP of Welenchiti



Averagely the season starts during the end of May while the season starts at the minimum period of April 1st decade. The season ends averagely at the end of September to October the first decade, and the minimum ends on September 2nddekade. Averagely the LGP of the district is more than 4 months, and the minimum and maximum are 3 and 5 months, respectively (Graph6).

Boset district has a Bi-modal rainfall pattern with mean annual rainfall 857.2mm with 25.4% coefficient of variation, respectively, which is the high year to year rainfall variability. The rainy season over the district, on average, extends from June to September. The average annual maximum and minimum temperatures are from 31.7^oc and 14.3^oC, respectively.

The annual standard deviation of the district is 217.9mm. This indicates that the normal annual rainfall for this district ranges from 857.2mm to1034.6mm annual rainfall below 857.2mm is considered as below normal rainfall while above 1034.6mm is considered as above normal rainfall. As indicated on the (Graph2) the

wettest year was2004 over Boset in contrast to this driest year was 2001.

4.2. Extreme Event and Meteorological Drought over Boset 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 heatwaves, droughts, tornadoes, and hurricanes, highest and lowest temperatures, heavy fall.

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 have shown *kiremt* season SPI for El Nino, La Nina, and Neutral years. (Refer figures below)

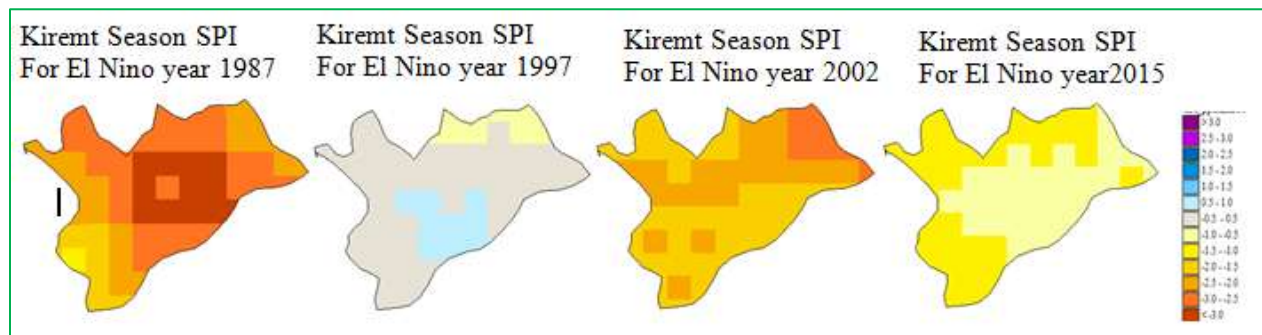


Figure6. Kiremt standard precipitation index (SPI) for El Niño years 1987, 1997, 2002, and 2015 CHRIPS data map analysis.



Figure7.Kiremtstandard precipitation index (SPI) for La Niña years 1988, 1998, 1999, and 2000 CHRIPS data map analysis.

Kiremt and Belg season coefficient of variation (CV)

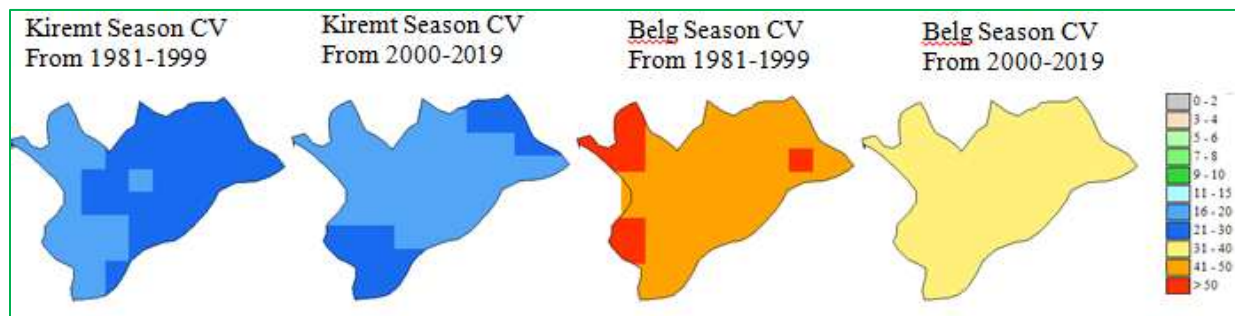


Figure 8. Kiremt and Belg coefficient of variation (CV) from 1981-1999, 2000-2019, and 1981-1999, 2000-2019, respectively using CHRIPS data.

Among the four El-Niño years happened 1987, 1997, 2002, and 2015; the strongest is 1987, whereas 1997 is medium (Figure 6). As La -Niña year identified, the strongest over district was 1999 (Figure7). Variability

increases both Kiremt and Belg season from a long decade to recent, but the highest rainfall variability was during Belg seasons 1981-1999 (Figure8).

Table 2. Boset district Station data Rainfall and Temperature Extreme Events

Parameters	Seasons	Values	Years
Extreme Heavy fall	Belg	92.1mm	2003
Extreme Maximum Temperature	Kiremt	38.3°C	2014
Extreme Minimum Temperature	Bega	2.5°C	2017

V. Conclusion

Boset district is found in Belg and Kiremt rainfall benefiting areas when the Bega is the dry and cold period, and it is the harvesting time. Kiremt rainfall accounts from the annual total amount of 65.3%, Belg season has 26.2 %, and Bega had 8.5% from the annual rainfall amount received over the district. The highest rainfall variability is during the Belg season. Mean annual rainfall ranges from 857.2mm to 1034.6mm and average annual maximum and minimum temperature is 29.0°C and 7.7°C Celsius, respectively. Averagely the season starts during the end of May while the season starts at the minimum period of April 1st decade. The season ends averagely at the end of September to October the first decade, and the minimum ends at September 2nd decade. Averagely the LGP of the district is more than 4 months, and the minimum and maximum are 3 and 5 months, respectively (Graph 5 and 6). Frequency of extreme events and meteorological drought recently happened over the district. Among the four El-Niño years that happened in

1987, 1997, 2002, and 2015, the strongest is 1987, whereas 1997 is medium (Figure 6). As La -Niña year identified, the strongest over district was 1999 (Figure 7). Variability increases both Kiremt and Belg season from a long decade to recent, but the highest rainfall variability was during Belg seasons 1981-1999 (Figure 8).

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 the district. More rainfall variability in recent decades over the district during El-Niño and La-Niña happened, and extreme event and Meteorological drought occurred. The season starts at the end of May and ends at the end of September. The average LGP of the district is more than 4 months, and the minimum and maximum are 3 and 5 months, respectively. The area has a high probability of dry days.

Acknowledgments

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VI. References

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