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Rainfall and Temperature Trend Analysis at Wuchale Station, South Wollo Zone, Northern Ethiopia

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Abstract: Climate change has become a distressful event throughout the world in recent years. Long term rainfall and temperature variations are one of the main determinants of climate variability of one's area. The frequency and severity of climate related shocks has increased in many parts of Ethiopia and are likely to continue with increasing trend in global warming. The aim of this study is to determine trends of variation in temperature and rainfall at Wuchale station in South Wollo Zone of Amhara regional state. Monthly rainfall and temperature record data was obtained from National Meteorological Agency for the period of 1986–2018. Mann-Kendall's test and Sen's slope estimator were used to detect the trend and magnitude of changes, respectively. The results revealed that a significant declining trend of annual rainfall by the rate of 108.86mm and a significant increasing trend of maximum temperature by the rate of 0.2°C per decade was observed. However, non-significant decreasing trend of *belg* rainfall by 16mm and minimum temperature by 0.1°C per decade and increasing trend of *kiremt* rainfall by the rate of 40mm per decade was observed over the study period. The coefficient of variation ranged from 25.64 to 60.29, indicates moderate to high rainfall variability and precipitation concentration index ranged from 11.77 to 20.66, indicates moderate to strong distribution of rainfall in the study area. Therefore, development planners should develop and provide high-value crop varieties that resist uncertain rainfall during crop maturation period for accelerating adaptive processes and adopt short maturing crop varieties that can escape early season droughts and be able to mature earlier than the existing varieties.

Keywords: Climate Variability, Standardized Rainfall Anomaly, Trend, Wuchale

1. Introduction

The climate of the Earth is part of the wider environmental landscape, involving variability and change from time to time and from place to place. Climate change has become a distressful event throughout the world in recent years and it will continue to be even more so in the coming decades [41]. The Earth's surface temperature has been warmed more over the last three decades than during any other time since 1850 throughout the world. In addition to robust multi-decadal warming, the globally averaged surface temperature exhibits substantial decadal and inter-annual variability [17]. The last three years were the hottest since records began. With this warming comes climate change, causing extreme storms, droughts and floods [36]. Climate variability resulted in significant vulnerability to some ecosystems and many human systems, a fact that has been made especially clear by the impacts of extreme climate-related events globally and regionally [17].

The Fifth Assessment Report (AR5) presents strong evidence of warming over land across Africa has increased over the last 50–100 years [17]. Many parts of Africa already experienced high variability in rainfall, which threatens the livelihoods of many peoples especially the very poor who depend on rain-fed agriculture [21, 1]. The equatorial and southern parts of eastern Africa has been experienced a significant increase in temperature since the beginning of the early 1980s including Ethiopia [10, 3].

The Fifth Assessment Report of IPCC [17] indicated an increase in temperature of 0.8-1°C has already been observed in East Africa. Ethiopia is one of the Sub-Saharan African (SSA) countries that are extremely vulnerable to climate change and registered in the extreme risk category which ranks 7th in the list of countries most at risk from climate change in 2015 [15, 23]. According to UNDP climate change country profile, the average annual temperature of Ethiopia increased by 1.3°C between 1960 and 2006 [25]. Rainfall in Ethiopia shows a high inter-annual and inter-seasonal variability and since the spatial and temporal variation of precipitation is high [19]. In fact, the recent IPCC report notes that "in regions of high or complex topography such as the Ethiopian Highlands, downscaled projections indicate an increase in rainfall by the end of the 21st century" [17].

The impact from climate change in Ethiopia is already apparent which can be explained by increasing temperature and declining rainfall, particularly the northern parts which are exceptionally vulnerable to drought [6]. Over the last two decades, the frequency and severity of climate related shocks has increased in many parts of the country and are likely to continue with this increasing trend in the future [37, 4, 18]. Some findings reveal a decrease in annual rainfall of most Ethiopian highlands, while other indicated normal to above normal rainfall in some parts of the country [16].

In some parts of the country, weather related events such as erratic rainfall, longer drought periods and floods are increasing in both magnitude and frequency [15]. Some studies in South Wollo Zone of Northern Ethiopia showed that there is a complex patterns of rainfall, declining tendency in spring, decrease in mean annual consecutive dry days and increased in consecutive wet days significantly, change in rainfall patterns into mono-modal (summer) and the inter-annual and seasonal rainfall variability is becoming high [39].

2. Methodology

2.1. Description of the Study Area

The study was carried out at Wuchale station, South-wollo zone of Amhara regional state, Ethiopia; which is geographically located at 11°30′N-39°36′E latitude and 11°50′N-39°60′E longitudes. The topography of the study area is characterized by mountainous, undulating, valley and plain lands. Altitude varies from 1200 to 3627 meter above sea level which supports the presence of all agro-ecological zones. The area receives an annual rainfall amount ranging from 500 mm to 1500 mm. The district has bimodal rainfall patterns, *i.e.* short rains (*Belg*) from mid-February to the end of April and long rains (*Kiremt*) from the end of June and lasts until mid-September. The average yearly minimum and maximum temperature is 12.5°C and 22.5°C, respectively (Ambassel District Office of Early Warning, 2018).

2.2. Data Set

Observed monthly rainfall and temperature data was obtained from the National Meteorological Agency (NMA) of Ethiopia. As adopted by WMO, the choice of the time series is in line with the convention of using 30 years weather data which characterizes climate of an area. Thus, in order to cover the study area, recorded rainfall and temperature data were collected for 33 years (1986-2018) from NMA. Rainfall and temperature data were inserted in to Microsoft excel 2010 spreadsheet following the month of year entry format.

2.3. Data Analysis Techniques

Seasonal and annual mean monthly time series data of climatic parameters, viz. temperature (maximum and minimum) and rainfall variability, was computed using excel spreadsheet for the period 1986-2018. Long-term variations in seasonal and annual rainfall trends over the study period was computed by using the non-parametric Mann–Kendall's test [22, 20] and Sen's slope estimator through MAKESENS Microsoft Excel add-in software developed by the Finnish Meteorological Institute. Mann-Kendall statistics (S) is the most widely used non-parametric statistical methods which is less sensitive to outliers (extraordinary high values within time series data) and it is the most robust as well as suitable for detecting trends in precipitation and temperature. It shows whether there is a decreasing or increasing trend of precipitation and temperature records.

The test statistic S, which has mean zero and a variance computed by equation (3), is calculated using Equations (1) and (2), and is asymptotically normal [14]. The test statistic (S) for the Mann-Kendall test is given as:

$$S = \sum_{i=1}^{N-1} . \sum_{j=i+1}^{N-1} sgn\ (Yj - Yi) \qquad (1)$$

Yj and Yi are data values in two consecutive periods; the tr end test is applied to Y_i data values (i = 1, 2,... N − 1) and Y_j (j = i + 1, 2,... N). The data values of each Y_i are used as a ref erence point to compare with the data values of Y_j which is g iven as:

$$\text{Sign}\ (Y_j\text{-}Y_i) = \begin{cases} 1 & \text{if } Yj - Yi > 0 \\ 0 & \text{if } Y = 0 \\ -1 & Yj - Yi < 0 \end{cases} \qquad (2)$$

The mean of S is = 0 and the variance σ^2 is:

$$\sigma^2 = \sqrt{\frac{N(N-1)(2N+5) - \sum_{i=1}^{n} t_i(t_i-1)(2t_i+5)}{18}} \qquad (3)$$

Where: N is the number of data, t_i is the number of data in the i^{th} group and n is the number of tied groups (a set of sample data having the same value). In case the sample size n > 10 the standard normal variable Z is computed by using (4) [9].

Computation for Z score as:

$$Z = \begin{cases} \frac{S-1}{\sqrt{V}} & \text{if } S > 0 \\ 0 & \text{if } S = 0 \\ \frac{S+1}{\sqrt{V}} & \text{if } S < 0 \end{cases} \qquad (4)$$

Positive values of Z shows an increasing trend, while the negative values of Z indicate decreasing trends.

The magnitude of rainfall and temperature trend is measured using Sen's slope estimator. If a linear trend is present in a time series, the change per unit time (the true slope) of all data pairs (Qi) can be estimated following the equation developed by Sen [32].

$$Qi = \frac{Yj - Yi}{j - i} \quad (5)$$

Where: i = 1, 2, 3…, N; Yj and Yk refer the data values at times j and i ($j > i$), respectively.

Coefficient of variation, precipitation concentration index and standardized rainfall anomaly were used as descriptors of rainfall variability.

Coefficient of variation (CV)

Intra-seasonal (spatial and temporal) rainfall variability was analyzed using the CV formula by Hare [13].

$$CV = \frac{\sigma}{\mu} x\ 100 \quad (6)$$

Where, CV is coefficient of variation; σ is standard deviation and μ is the mean. According to Hare [13], CV (%) values with < 20% as less variable, 20- 30% as moderately variable and > 30% as highly variable.

Precipitation Concentration Index (PCI)

In order to know monthly distribution of seasonal and annual rainfalls during the observation periods (1986-2018); PCI was employed following Oliver [31] formula:

$$PCI_{annual} = \frac{\sum_{i=1}^{12} pi^2}{(\sum_{i=1}^{12} pi)^2}.100 \quad (7)$$

$$PCI_{kiremt} = \frac{\sum_{i=1}^{4} pi^2}{(\sum_{i=1}^{4} pi)^2}.33 \quad (8)$$

$$PCI_{belg} = \frac{\sum_{i=1}^{3} pi^2}{(\sum_{i=1}^{3} pi)^2}.25 \quad (9)$$

Where: Pi is the rainfall amount of the i^{th} month; and Σ = summation over the 12, 4 and 3 months *i.e.,* equation 7 is for annual PCI while equations 8 and 9 are utilized for the analysis of seasonal scales (*Kiremt* and *Belg* seasons).

As PCI value increases, the more concentrated the precipitation. According to Oliver's classification: i. PCI < 10 indicates uniform precipitation distribution (low precipitation concentration), ii. PCI values in the range of 11–15 indicates moderate precipitation concentration; moderate distribution, iii. PCI values in the range of 16-20 indicate irregular distribution, iv. PCI > 20 indicates a strong irregularity (*i.e.*, high precipitation concentration).

Standardized Rainfall Anomalies (SRA)

The SRA is the most widely-used index to determine drought severity over time. Standardized anomalies of rainfall were calculated and used to assess frequency and severity of drought for the period 1986 to 2018. The SRA estimation depends on the long-term rainfall record for a given period. Accordingly, the SRA (also called Standardized Anomaly Index) were calculated and graphically presented to examine inter-annual fluctuations of rainfall and also to determine dry and wet years in the study area over the period of observation [2]. The study applied Agnew and Chappel's [2] drought severity assessment method. It can be described as:

$$S = \frac{Pt - Pm}{\sigma} \quad (10)$$

Where: S is standardized rainfall anomaly, Pt is annual rainfall in year t, Pm is long term mean annual rainfall over a period of observation and σ is the standard deviation of annual rainfall over the period of observation.

The magnitude or severity of drought effect is strongly associated with the timing of the start of rainfall deficiency, its duration and intensity of the drought hazard.

Table 1. *Drought classes and corresponding SRA values.*

SRA values	Drought classes
≥ –0.84	No drought
-0.84 to –1.28	Moderate drought
–1.28 to –1.65	Severe drought
≤ –1.65	Extreme drought

Source: Agnew and Chappel's [2]

3. Result and Discussions

This part presents the analyses of trends in extreme rainfall and temperature indices, which are commonly used for climate change studies as well as their temporal and spatial patterns in Wuchale station of South Wollo Zone, Ethiopia.

3.1. Rainfall Pattern and Distribution

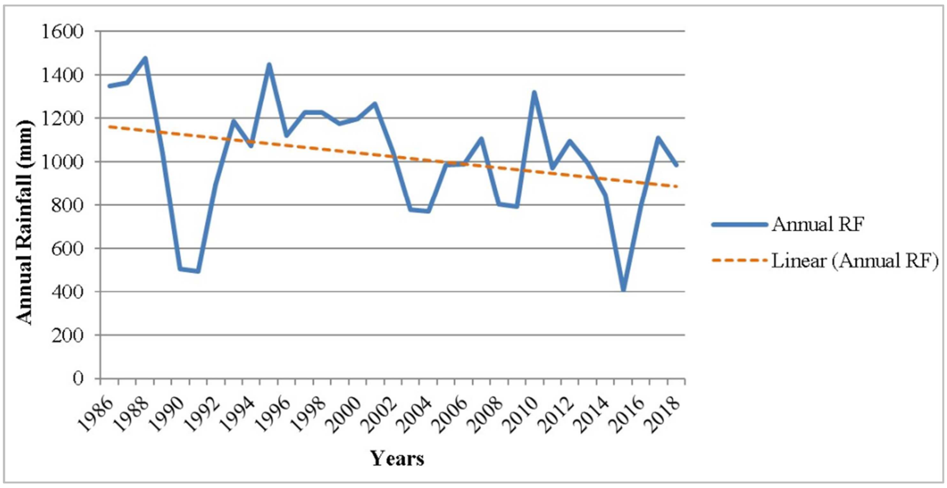
3.1.1. Annual Rainfall Pattern and Distribution

The results showed that, the average total amount of annual rainfall ranges between 407mm in 2015 (the driest year) to 1479mm in 1988 (the wettest year) over the study period of 1986 to 2018. In addition, 45.5% of the total years for the period (1986-2018) had recorded annual rainfall below the long term average (1025.16mm). The analysis of linear time series of the meteorological rainfall data over the years (1986-2018) showed a decreasing amount of annual rainfall (Figure 1). This result is in line with other studies by Teshome Menberu [34] and Mekonnen Daba [26] who indicated a momentous inter-annual variability and slight rate of decline of annual rainfall in Dembia district of Northwest Ethiopia and western Oromia, respectively. However, the result is in contradicted with Mohammed Gedefaw *et al.,* [28] and Mulatu Liyew *et al.*, [29] who show an increasing time series of annual rainfall in Amhara region and Upper Blue Nile basin.

3.1.2. Seasonal (Kiremt and Belg) Rainfall Pattern and Distribution

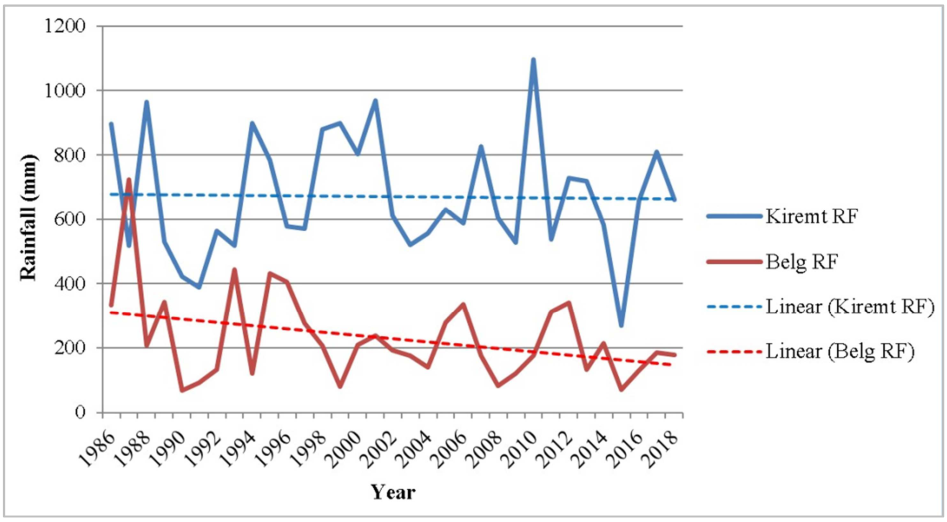
Apart from annual rainfall, season-to-season variability in rainfall is also critical for smallholder farmers. There are two rainy seasons in the study area, *i.e., Belg* (March-May) which is the short rainy season and *Kiremt* (June-September) which is the long rainy season. The main growing season is *Kiremt* while the second growing season is *Belg*. The results indicated that, *Kiremt* and *Belg* seasons contributed 65.33% and 22.33% to the total amount of annual rainfall, respectively. The *kiremt* season rainfall varies from 270mm to 1096mm, whereas *belg* season rainfall varied from 68mm to 723mm (Figure 2).

Moreover, the time series of *Kiremt* and *Belg* season rainfall has showed a decreasing series over the past three decades (Figure 2). This is in line with previous study by Tsegamariam Dula [35] in Abeshege district who showed a declined series in both *Kiremt* and *Belg* rainfall. The decreasing in time series of *Belg* season rainfall could be the main cause for decreasing of annual rainfall.



Source: Computed from NMSA data, 2019

Figure 1. *Annual rainfall variability time series in Wuchale station (1986-2018).*



Source: Computed from NMSA data, 2019

Figure 2. *Kiremt and Belg rainfall variability time series in Wuchale station (1986-2018).*

3.2. Rainfall Variability Analysis

3.2.1. Coefficient of Variation

Coefficients of variation (CV) have been computed in order to investigate the annual and seasonal rainfall variability. It revealed that annual rainfall was moderately variable ($20 < 25.64 < 30$) compared to seasonal rainfall as indicated in Table 2. This is in line with Solomon Abirdew *et al.,* [33] and Yimer Mohammed *et al.,* [39] who show a moderate variability of annual rainfall in Woreilu and Indibir station, respectively.

Table 2. *Annual and seasonal rainfall variability at Wuchale Station for 1986–2018.*

Annual			***Kiremt season***			***Belg season***		
Mean (mm)	**SD**	**CV**	**Mean (mm)**	**SD**	**CV**	**Mean (mm)**	**SD**	**CV**
1025.16	262.93	25.64	669.74	187.91	28.05	228.94	138.04	60.29

SD = Standard deviation, CV = Coefficient of Variation, PCI = Precipitation concentration index

Source: Computed from NMSA data, 2019.

From the result, the CV is ranged from 28.05% (*Kiremt*) to 60.29% (*Belg*) for the period 1986–2018 (Table 2). *Kiremt* rainfall was moderately variable, whereas high CV was observed in *Belg* season which is highly variable. The annual rainfall is less variable as compared to *Kiremt* and *Belg* season rainfalls. In general, the results showed higher inter-seasonal rainfall variability in the study area during the observation period (1986-2018). This was in agreement with Gebre Hadgu *et al.,* [11] who indicated a high CV in *Kiremt* season (30%) and in *Belg* season (50%) in northern Ethiopia and with Desalegn Yayeh and Filho W. L [8] who indicates high rainfall variability in *Belg* season in Northwest highlands Ethiopia. In addition, the result is in line with Dereje A., *et al.,* [7] who founds that *Belg* rainfalls is much more variable in Amhara region and with Yimer Mohammed *et al.,* [39] who report moderately to higher (24% - 57%) inter-seasonal rainfall variability in South Wollo zone.

3.2.2. Precipitation Concentration Index

The PCI values for Wuchale station were calculated based on equation 8 and 9 given by Oliver [31]. Therefore, the result for annual rainfall distribution showed that PCI value of 20.66 which indicates the strong irregular distribution of annual rainfall (Table 3). From the result, 54.55% of the total years for the period (1986-2018) had recorded PCI values below 20.66. This mean that the annual rainfall totals was concentrated in few years. The result is in agreement with the findings by Dereje A., *et al.,* [7] who indicated moderate to high concentration in Amhara region.

Table 3. *Annual and seasonal precipitation concentration index (PCI).*

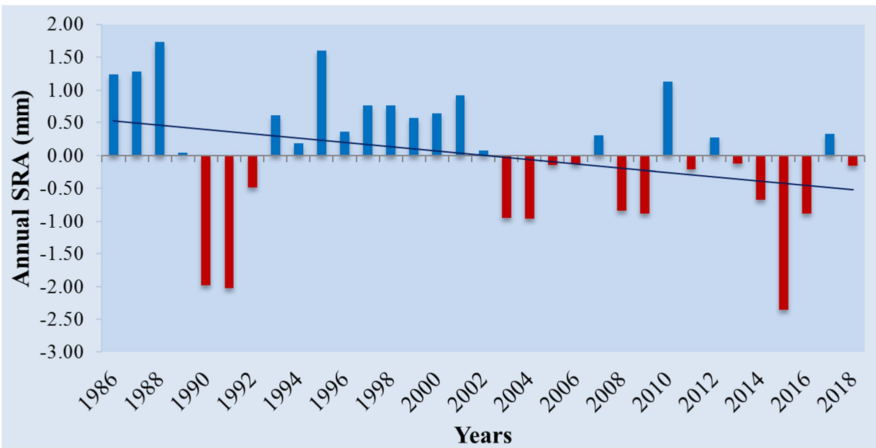
Variable	Moderate	Irregular	Strongly irregular	Average PCI
Annual rainfall	1986, 1989, 1993, 1996, 1997, 2011,	1988, 1992, 1995, 2000, 2005, 2006, 2007, 2008, 2009, 2014, 2018	1987, 1990, 1991, 1994, 1998, 1999, 2001, 2004, 2010, 2012, 2013, 2015, 2016, 2017	20.66
Kiremt season	1988-2014, 2016-2018	2015	1987	12.71
Belg season	1986, 1987, 1990, 1991, 1993, 1995, 1999-2010, 2012, 2015, 2017, 2018	1988, 2013	-	11.77

Source: Computed from NMSA data, 2019.

The seasonal rainfall distribution results showed that PCI values were 12.71 and 11.77 for *Kiremt* and *Belg* rainfall, respectively, indicating moderate seasonal distribution of rainfall. 69.7% of the total years for *Kiremt* and 51.52% for *Belg* season had recorded PCI values below 12.71 and 11.77, respectively. This shows a moderate precipitation concentration which implies more or less the seasonal rainfall total was concentrated throughout the seasonal months. However, very strongly irregular rainfall distribution was observed in annual rainfall than seasonal rainfall. Therefore, effects of annual rainfall variability in Wuchale district could be more pronounced than seasonal rainfall variability. This study is in agreement with Dereje A., *et al.,* [7] who show moderately irregular distribution of seasonal rainfalls in Amhara region. However, the result is in contradicted with the result by Muluken Mekuyie [30] who indicated high concentrations of seasonal rainfall in Afar region of Ethiopia.

3.2.3. Standardized Rainfall Anomalies (SRA)

SRA is a drought severity index over time. Standardized rainfall anomaly index calculated for a period of (1986-2018) for the study area showed that the annual rainfall exhibits cyclic wet and dry conditions with positive and negative anomalies. Results from SRA indicated that three extreme (in 1990, 1991 and 2015) and five moderate (in 2003, 2004, 2008, 2009 and 2016) droughts was occurred over the three decades.



Source: Computed from NMSA data, 2019

Figure 3. *Standardized anomalies of annual rainfall in Ambassel District for 1986-2018.*

The frequency and duration of droughts has increased which could further complicate food insecurity and famine. For instance, the frequency of drought occurrence before 1997 was two times in ten years (25% probability) extremely and from 1997-2007 it occurred two times (25% probability) moderately, while after 2008 it occurred four times (50% probability) both extremely and moderately. This implies that the occurrences of drought were increasing every ten years over the period of 1986-2018 (Figure 3). This is supported by Desalegn Yayeh and Filho W. L [8] in Northwest highlands Ethiopia, Mekonnen Daba [26] in Western Oromia and Menberu Teshome and Addisu Baye [27] in Lay Gayint district who found that rainfall anomaly, especially droughts, has been increasing over time. However the result is in contradicted with Solomon Abirdew *et al.,* [33] who founds a decreasing of drought years in Indibir, Guragae zone.

Moreover, the results also indicated that, only the years 1989 and 2002 received near normal rainfall amount (same to the long-term average rainfall) than the others over three decades (Figure 3). This shows that the area has experienced significant number of drought years. This is supported by Muluken Mekuyie [30] in Southern Afar region and Yimer Mohammed *et al.,* [39] in South Wollo. Generally, the time series analysis of normalized rainfall anomaly data showed deficiency and fluctuation of rainfall, which had high influences on smallholder farmers over the studied agro-ecological zones, where the majority of the farmers have been left vulnerable to drought and then to a reduction in crop productivity.

3.3. Rainfall Trend Analysis

3.3.1. Annual Rainfall Trend Analysis

Mann-Kendall trend test and Sen's slope estimator was applied to the times series of annual rainfall. The result, as indicated in Table 4, confirmed a statistically significant decreasing trend in the long-term annual rainfall by the rate of 108.86mm per decade over the past three decades (1986-2018. The result is in line with Teshome Menberu [34] and Mekonnen Daba [26] who indicated a significant decline of rainfall trends in Dembia district of Northwest Ethiopia and western Oromia, respectively. However, the result is in contradict with the finding of Yimer Mohammed *et al.,* [39] who founds the absence of significant and clear trend in the annual rainfall pattern in South Wollo zone.

Table 4. *Mann-Kendall trend test for annual rainfall (1986-2018).*

Variable	Mann-Kendall's trend		Sen's slope test
	Test Z	Sig. level	Q
Annual rainfall	-2.14	*	-10.886

*indicates statistical significance at 0.05% level; Sig. level = significance level
Source: Computed from NMSA data, 2019.

3.3.2. Seasonal Rainfall Trend Analysis

Mann-Kendall non-parametric trend and Sen's slope test were also run for seasonal rainfalls. As a result, seasonal (*Kiremt* and *Belg*) rainfall trends confirmed a statistically non-significant increasing trend in *Kiremt* rainfall by the rate of 16mm per decade and statistically non-significant decreasing trend in *Belg* rainfall by the rate of 40mm per decade over the past three decades (1986-2018) in the study area (Table 5). This result agrees with the findings of Yitbarek Seleshi & Camberlin [40] who reported the absence of significant trends in the main (*Kiremt*) and short (*Belg*) rain period in many parts of Ethiopia except the eastern, southwestern and southern parts, but in contradict with Muluken Mekuyie [30] and Yimer Mohammed *et al.,* [39] who founds a significant trends in Afar region and South Wollo (Mekaneselam and Dessie stations), respectively.

Table 5. *Mann-Kendall trend test for seasonal rainfall (1986-2018).*

Variables	Mann-Kendall's trend		Sen's slope test
	Test Z	Sig. level	Q
Belg rainfall	-1.43		-4.000
Kiremt rainfall	0.59		1.607

Source: Computed from NMSA data, 2019

3.4. Temperature Variability and Trend Analysis

3.4.1. Temperature Variability Analysis

The results showed that the mean monthly highest (warmest) and lowest (coldest) temperatures were 30.4°C observed in June and 6.7°C in December, respectively. In case of season, *Belg* was the warmest and *Kiremt* was the coldest season in the study area. The annual average maximum temperature ranges between 23.9°C in 1986 and 27.1°C (warmest year) in 2015, whereas the annual minimum temperature ranges between 9.99°C (coldest year) in 2017 and 12.74°C in 1992 during the past three decades, showing the existence of high variability of temperature in the study area. As the hottest year (2015) in the record, the result is in line with WMO [38] which indicates the year 2015 as the hottest since modern observations began in the late 1800s. The annual mean temperature was 18.7°C. The annual average minimum and maximum temperatures were 17.5°C and 19.4°C, respectively.

The time series of annual average and maximum temperature is increasing, whereas the minimum temperature is decreasing in time series over the last three decades (1986-2018) (Figure 4). This result is in agreement with previous findings by Muluken Mekuyie [30] on annual maximum temperature in Afar Region has been increasing; Birhanu Hayelom *et al.*, [5] who shows a reduction in annual minimum temperature in Southern Tigray and Mulatu Liyew *et al.*, [29] who shows increasing of annual average temperature in Upper Blue Nile basin over two decades.

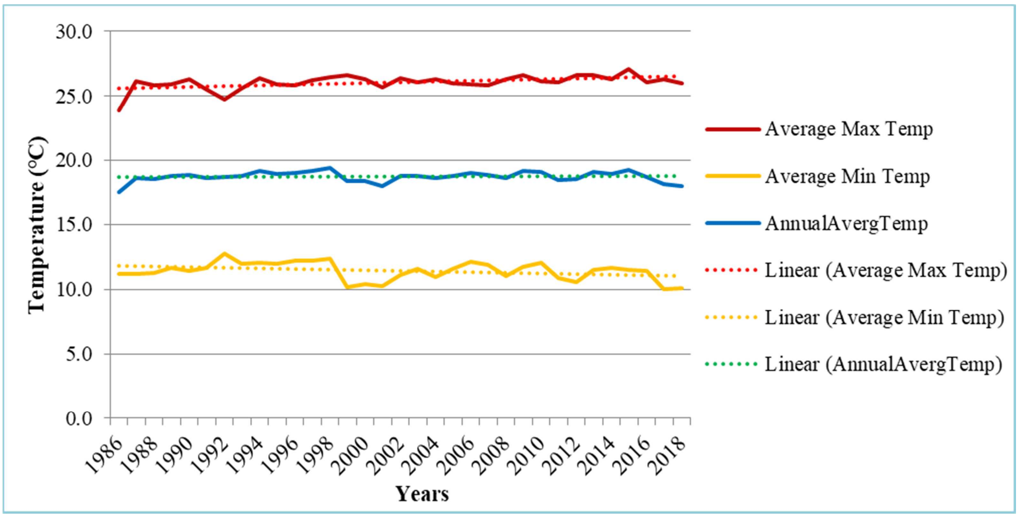


Figure 4. *Long-term annual, maximum and minimum average temperature variability at Wuchale station (1986–2018).*

3.4.2. Temperature Trend Analysis

Mann-Kendall and Sen's slope test result confirmed a statistically significant increasing trend in maximum temperature by the rate of 0.2°C per decade; whereas a non-significant increasing trend in annual average temperature by the rate of 0.04°C and non-significant decreasing trend in minimum average temperature by the rate of 0.18°C per decade over the period of 1986-2018. The result is in consistent with Birhanu Hayelom *et al.*, [5] and Muluken Mekuyie [30] who found a significant increasing trend for maximum temperature by 0.25°C in Southern Tigray and 0.083°C in Afar Region every ten years while negative trends are detected for annual temperature by Mekonnen Daba [26] in western Oromia. The research further indicated the significant increasing trend of maximum temperature in the study area agreed with the recent trends of global warming as reported by [17].

Table 6. *Mann-Kendall trend test for temperature (1986-2018).*

Variables	Mann-Kendall's trend		Sen's slope test
	Test Z	Sig. level	Q
T min	-1.43		-0.018
T max	2.53	**	0.020
Annual Temp	0.52		0.004

**indicates statistical significance at 0.01% level
Source: Computed from NMSA data, 2019

Therefore, the increased in temperature and decreasing of rainfall could lead to frequent drought and reduction of agricultural yields as well as water stress in the surrounding study area.

4. Conclusion and Recommendations

The findings from this study showed decreasing in amount of annual and *Belg* rainfall, while *Kiremt* rainfall increased slightly over the study period (1986-2018). *Belg* season rainfall showed more variability and decreasing amount as compared to the *kiremt* rainfall. The results further showed the shrinkage of long rainy seasons and this adversely affected agricultural productivity. In addition, the results also indicated that decreasing of annual rainfall and ounce increase in average temperatures. However, Mann Kendall test statistic results also revealed a significant declining trend in the long-term annual rainfall and a significant increasing trend was observed in maximum temperatures, whereas there was no significant change in seasonal rainfall as well as in the minimum temperature for the period 1986-2018. Moreover, the area has experienced significant number of drought periods both in frequency and duration. Therefore, as the rainy seasons are recently becoming more and more unpredictable and uncertain, it is recommended to develop and provide high-value crop varieties and technologies that resist uncertain rainfall during crop maturation period for accelerating the adaptive processes. In addition, since the rainy seasons are shrinking, it is profitable to adopt short maturing crop varieties that can escape early season droughts and be able to mature earlier than those of the existing varieties.

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