International Journal of Weather, Climate Change and Conservation Research, 11(1),1-13, 2025
Print ISSN: ISSN 2059-2396 (Print)
Online ISSN: ISSN 2059-240X (Online)
Website: https://www.eajournals.org/
Publication of the European Centre for Research Training and Development -UK

Time Series Analysis of Rainfall and Temperature (1988-2018) in Musawa Local Government Area of Katsina State, Nigeria

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doi: https://doi.org/10.37745/ijwcccr.15/vol11n1113 Published December 31, 2025

Citation : Udeh E.L., Abdullahi T.Y., Bulama L. (2025) Time Series Analysis of Rainfall and Temperature (1988-2018) in Musawa Local Government Area of Katsina State, Nigeria, *International Journal of Weather, Climate Change and Conservation Research*, 11(1),1-13

Abstract : *Rainfall and temperature data spanning a period of 30 years (1988-2018) for Musawa station were used to determine the trend in annual rainfall, minimum and maximum temperature for the region. Five-year running mean was calculated for annual rainfall and mean temperature for the Musawa station. The decadal means were compared with the long-term mean. Evidence from the station considered shows that there was significant increase in annual rainfall amount and mean temperature in the last decade of the study. It means, therefore, that we are experiencing wetter conditions in the area. Increasing annual rainfall totals portend both good and ill. Good, because there is improvement in water supply to an otherwise marginal area. Ill, because flooding, dam collapse as a result of excessive rainfall and daily rise of temperature on an impervious terrain which could lead to damage to life and property. Generally, the rainfall patterns and trends of the study area (1988-2018) has been characterized with oscillations between wet and dry conditions, and that generally the decades 1980s and 1990s were the driest of all. The wettest is seen in the 2000s. The findings revealed that the region is becoming wetter in terms of the climatic elements (rainfall and temperature). The study recommended that more emphasis on dissemination of information on climate variability and changes through the mass media is highly needed, also there is need for extension agents, policy makers and researchers to try and get farmers to effectively adapt to climate change.*

Keywords: analysis, annual rainfall, climate change, temperature, time series

INTRODUCTION

Agriculture largely depends on climate, hence climatic factors such as precipitation, solar radiation, wind, temperature, relative humidity solely determine distribution of crops and their productivity. Rosenthal (2003) observed that changes in temperature and precipitation directly affect crop production and can even alter the distribution of agro-ecological zones; especially in Africa, and agricultural losses can result from climate variability and the increased frequency of changes in temperatures and precipitation (including drought and floods). Food and Agriculture Organisation (FAO, 2005) reported that by 2100, Nigeria and other West African countries are likely to have agricultural losses of up to 4% due to climate change. Given that rainfall and temperature changes will present a major threat to so many smallholder farmers, especially in northern Nigeria who account for most of the food crops produced in Nigeria and rely directly on rainfall for their foods and livelihood (Ikpe, 2021).

The Sudan savannah bioclimatic zone is characterized by a savannah type climate with alternating wet and dry seasons (Ariko et al. 2024). Rainfall in this region varies from 1500mm per annum in the southern part to 400 mm in the northern part. The rainy season lasts from about 7 months (April to October) in the southern part to as low as 3 months (July to September) in the northern part (Ati, 2002). The rainfall intensity is very high between the months of July and August. As a result, though the environment is generally dry, crops are frequently lost through too much rain. It also results in rapid surface run-off, soil erosion and water-logging (Pollock, 1968; Udo, 1970). Besides, inter annual variability is high (Iwegbu, 1993). Because of the large inter-annual variability of rainfall, this zone is subject to frequent dry spells, often resulting in severe and widespread droughts, capable of large-scale destruction of plants, animals and human life (Ati, 2002).

The gross features of rainfall patterns in this region, as in other parts of the country are usually in association with what is often called the Inter Tropical Discontinuity (ITD) (Nicholson, 1981; Kanote, 1984; Hayward and Oguntoyinbo, 1987; Oladipo, 1993). The movement of the ITD northwards across the country between January and August, and its retreat from the southern fringe of the Sahara Desert, after August, cause much of Nigeria to experience seasonal rainfall (Olaniran and Summer, 1989). The ITD itself is the boundary at the ground between the dry Tropical Continental (cT) air of northern origin and the moist Tropical Maritime (mT) air of southern origin.

It has been argued that the convergence of trade wind and monsoonal airflow, in the region of the ITD, is unable to produce sufficient vertical motion (and depth of clouds) to induce rainfall (Hulmes and Tosdevin, 1989). The relevance of the ITD therefore lies in its provision of a framework for following the south/north motion of the rain bearing maritime air mass (mT). Within the mT air mass is enclosed several rainfalls producing systems, such as the disturbance lines (especially the easterly waves), squall lines and the two tropospheric jet streams. It is the magnitude of these systems that influences the amount and seasonal distribution of rainfall over the region (Kamara, 1986; Hayward and Oguntoyinbo, 1987; Muller and Oberlander, 1987; Ayoade, 1988; Hastenrath, 1991).

Agricultural production in the zone as in many parts of the country is largely rain-fed. Agricultural production follows the rhythm of the seasons with most of the farming activities occurring during the rainy season which last between 7 months in the southern part of the zone to 4 months in the extreme north. During the dry season, secondary occupations like weaving (of caps and mats) and dyeing are practiced. The short rainy season limits crop production to only those crops that can grow and mature within a short time. These crops include millet, cowpea, ground nuts, maize and rice (Adamu, 2000). Agriculture is largely of the subsistent type and land holding are characteristically small and fragmented. Most of the farming activities is carried out by subsistent farmers who grow these crops only for food and the little left over is sold in the market to meet urgent financial needs. It is based on extensive cultivation and the main tools consist of hoes, cutlasses, axes and knifes. There is much dependence on manure, and recently, artificial fertilizers to prevent loss of soil fertility. Irrigation farming is also much practiced here. The fadamas (low laying areas) are used for dry season cropping of vegetables and sugar cane (Chambers, 1990).

MATERIALS AND METHODS

Musawa is located between Latitude 11° 57′ 08″ N to 13° 71′ 27″ N and Longitude 6° 15′ 48″ E to 9° 18′15″ E. The boundary of the study area which commenced from Latitude 12^0 00 N on the southern frontier going northward up to Latitude 13^0 45′ N has been chosen because it corresponds with areas severely affected by climatic fluctuation. The climate of Northwestern Nigeria is tropical wet and dry as well as semi-arid steppe types. Agriculture is the predominant economic activity in the study area, the types of crops produced includes millet, sorghum, rice, cowpea, soya beans, wheat, groundnut, maize, cotton, and seseme (Mohd 2003)

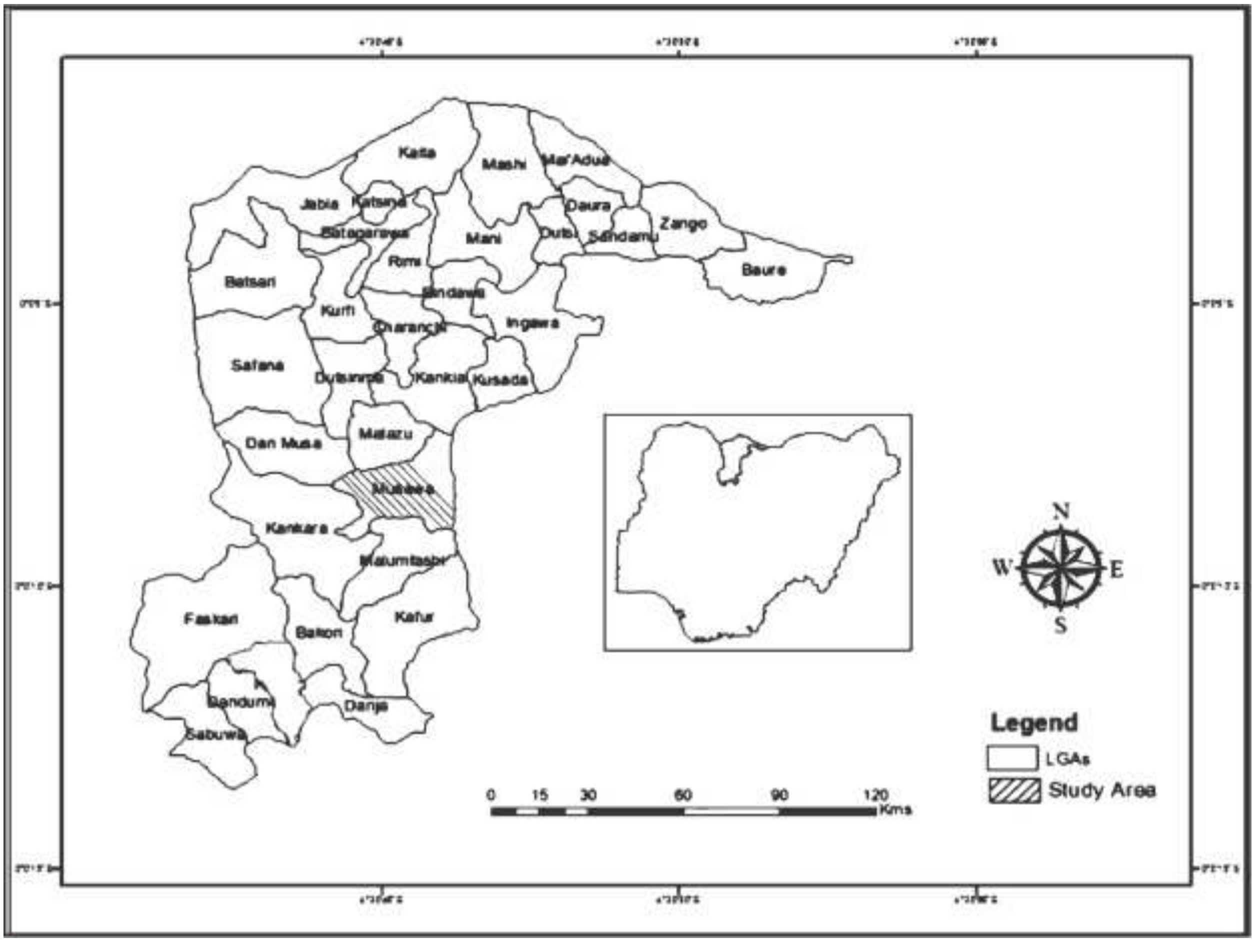

Figure 1: Musawa showing the study area.
Engraved from GIS lab Geography Department BUK (2024).

Methods

The research was based on secondary data. Millet and Cowpea production data (yield/hectare) covering a period of thirty years (1988-2018) was obtained from National Agricultural Extension and Research Liaisons Service (NAERLS), Zaria, Kaduna State, while monthly rainfall and temperature data for the same period was obtained from the archive of the Nigerian Meteorological Agency (NiMet).

Trend analysis of temperature, rainfall, millet and cowpea were carried out using Microsoft Excel Tool (2017). Similarly, the relationships between rainfall and the yield of Millet and cowpea, and temperature in the study area were tested using bivariate correlation analysis.

Rainfall summaries were conducted in two forms: firstly, rainfall summaries by stations in order to explain the spatial variations. Secondly, rainfall summaries to explain the temporal variation.

Further analyses were carried out using line graphs, Pearson Product Moment Correlation PPMC and time series analysis was also undertaken to observe trends in both the data collected (1988-2018).

Two types of data analyses were used for this study, the descriptive statistics and the inferential statistics. Pearson Product Moment Correlation (PPMC) was used to correlate rainfall, temperature and cowpea production in Musawa LGA. Abubakar (2019) view Pearson Product Moment Correlation (PPMC) as coefficient of correlation used to measure the degree of association between bivariate variables. When a researcher is interested in measuring two variables on a single experimental unit, the resulting data becomes bivariate data. The coefficient of correlation is a single number that indicates the strength and direction of the relationship between two variables.

RESULT AND DISCUSION

Changing Trends of Annual Rainfall and Temperature

The results on the descriptive statistical feature of rainfall trends of annual rainfall and temperature in the area are presented in Table 1.

Table 1: Descriptive statistical feature of rainfall for Musawa station

S/N	STATISTICS	N
1	Mean	1234.721
2	Standard Error	79.4048
3	Median	1234.2
4	Mode	#N/A
5	Standard Deviation	442.1072
6	Sample Variance	195458.8
7	Kurtosis	5.216629
8	Skewness	1.655369
9	Range	2196.18
10	Minimum	680.02
11	Maximum	2876.2
12	Sum	38276.36
13	Count	31

Source: Field Data Collection, 2018

The result show that the maximum amount of rainfall within the area was 2876.2, while the minimum was 680.02. Generally, the results on the descriptive features of the study area portends a typical savanna area.

Analysis of rainfall trends

The patterns of rainfall in the study area is complex. The upwards trends of rainfall amount are

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Online ISSN: ISSN 2059-240X (Online)
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Publication of the European Centre for Research Training and Development -UK

most noticeable in Musawa.

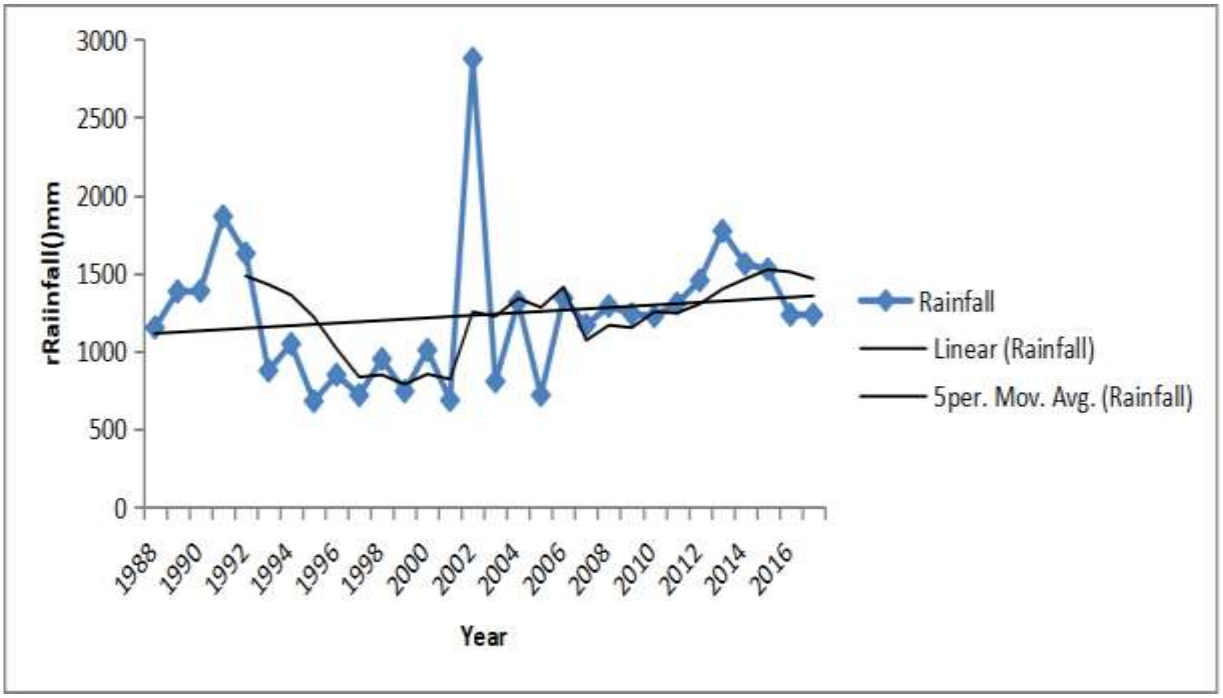

Figure 2: Mean Annual Rainfall in Musawa Between 1988 to 2018
Source: Field Data Collection, 2018

The trend analysis revealed that the length of rainy season increases on average between 1988 to 1992 and decreases from 1993 to 2000 and from 2001 to 2003. There is high increase of rainfall which lead to flood in the urban Katsina and it environ including Musawa which might be as a result of climatic change of anthropogenic factors in the area, and also from there in 2004 it begins to maintain its optimum status up to date. The 5 years period moving average however it shows lowest duration of the rainy season were experienced between nineties (Fig. 2). The results agree with the findings of Ejeh and Ikpe (2022) which reported an oscillating, but an increase in the total annual rainfall in Potiskum Local Government Area of Yobe State, Nigeria. The result further confirms the resport of Nnachi et al (2020) which reported increase in rainfall.

Table 2 of three decadal SPI in Musawa revealed that rainfall in the area was near normal in most of the years. However moderately dry years were experienced five times in the years of 1995, 1997, 1999, 2001, 2005 and extremely wet year were witnessed once in 2002 and moderately wet years were experienced also in two years 2013 and 1991. All the other years experienced near normal rainfall trend.

Table 2: Three Decadal SPI in Musawa

S/N	YEAR	SPI VALUE	REMARKS
1	1988	-0.1	Near normal
2	1989	0.3	Near normal
3	1990	0.3	Near normal
4	1991	1.4	Moderately wet
5	1992	0.8	Near normal
6	1993	--0.8	Near normal
7	1994	-0.4	Near normal
8	1995	-1.2	Moderately dry
9	1996	-0.8	Near normal
10	1997	-1.1	Moderately dry
11	1998	-0.6	Near normal
12	1999	-1.1	Moderately dry
13	2000	-0.5	Near normal
14	2001	-1.2	Moderately dry
15	2002	3.7	Extremely wet
16	2003	-0.9	Near normal
17	2004	0.1	Near normal
18	2005	-1.1	Moderately dry
19	2006	0.2	Near normal
20	2007	-0.1	Near normal
21	2008	0.1	Near normal
22	2009	0.0	Near normal
23	2010	-0.0	Near normal
24	2011	0.1	Near normal
25	2012	0.4	Near normal
26	2013	1.2	Moderately wet
27	2014	0.7	Near normal
28	2015	0.6	Near normal
29	2016	-0.0	Near normal
30	2017	-0.0	Near normal
31	2018	0.0	Near normal

Source: Data Collection 2018

The annual SPI values were determined for trend analysis. The result of the SPI revealed more positive in three decades, confirming that the climate is getting wetter in recent years. The five period moving averages and the rainfall regime in the area was highly variable in the area. The trend line show improvement in rainfall on average in the study area. Ikpe et al. (2016).

Temperature Analysis in Musawa

The simple statistical measures of maximum temperature for the study area is presented in Table 3.

Table 3: Simple Statistical Measures of Maximum Temperature in Musawa

S/N	STATISTICALS	N
1	Mean	32.77742
2	Standard Error	0.025699
3	Median	32.8
4	Mode	32.8
5	Standard Deviation	0.143084
6	Sample Variance	0.020473
7	Kurtosis	17.31285
8	Skewness	-3.66172
9	Range	0.8
10	Minimum	32.1
11	Maximum	32.9
12	Sum	1016.1
13	Count	31

Source: Field work 2018

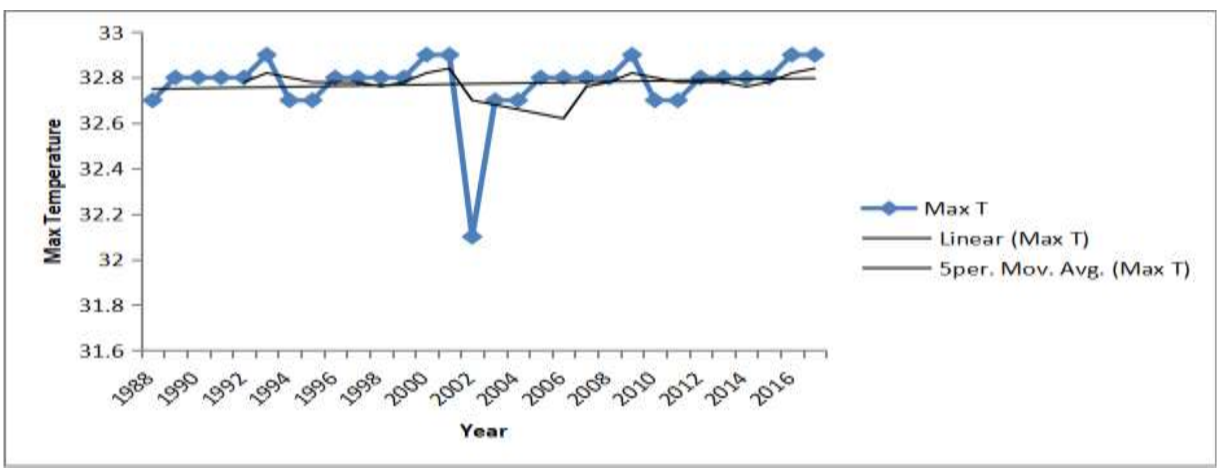

Figure 3: Maximum Temperature in Musawa (1988-2018)
Source: Field work 2018

The time series analysis indicates that the mean maximum temperatures have been below the mean values. For example, the years 1988, 2004 and 2006. The fluctuations were much between 1988 to 1994. However, it has remained higher than the mean value since the year 2001. The mean results show an increase in the temperature of the area. The result of an increasing trend in temperature in Katsina State conforms to the findings of Ikpe et al. (2020) whose study observed a rise in temperature of around 1ºC in Kano State. The result further agrees with the findings of Odjugo (2010) whose study revealed a temperature increase of about 1.1ºC in the semi-arid regions of Nigeria between 1901 and 2005. More so, the findings agree with the result of Mijiyawa and Akpenpuun (2015) which stated that the northern part of Nigeria was experiencing consistent increasing temperature which contributes to a reduction in the rejuvenation rate of land resources and consequently lower crop productivity. The results further agree with the findings of Ariko et al. (2020) which reported that there was significant increase in both temperature and solar radiation in the semi-arid region of Nigeria.

Table 4: Simple Statistical Measures of Minimum Temperatures in Musawa

Station/statistics N	Musawa			
Mean	19.25806			
Standard Error	0.10804			
Median	19.2			
Mode	19.4			
Standard Deviation	0.601539			
Sample Variance	0.361849			
Kurtosis	0.841991			
Skewness	0.644158			
Range	2.5			
Minimum	18.2			
Maximum	20.7			
Sum	597			
Count	31	31	31	31

Source: Field work 2018

The minimum temperature in the study area is presented in Fig. 4. The results show a fluctuating temperature.

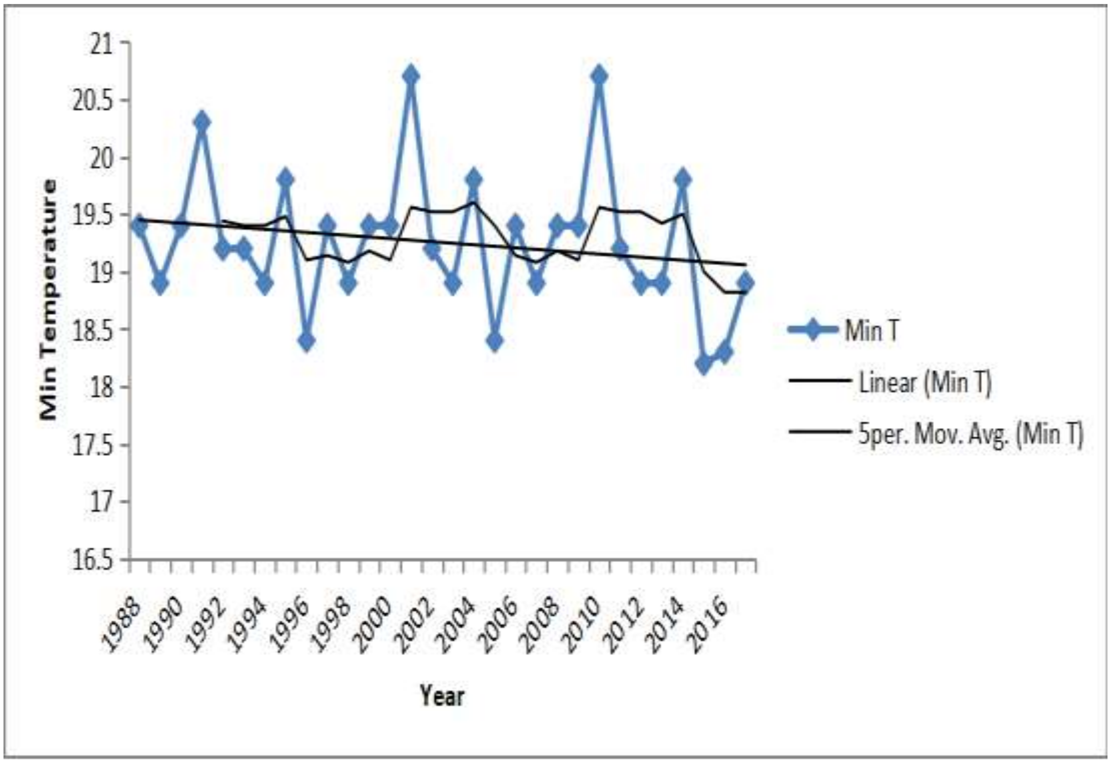

Figure 4: Minimum Temperature in Musawa (1988-2018)
Source: Field Data Collection, 2018

The result in Fig. 4 show that the minimum temperature in the study area (1988 – 2018) was reducing, meaning that the temperature in the area was getting low (a cold situation). Temperature plays a significant role in agriculture. In general, higher temperature is associated with higher radiation and higher water use (Nnachi et al, 2018).

CONCLUSION

This study has analysed time series analysis of rainfall and temperature in Musawa LGA of Katsina State. The results showed a situation of increased rainfall, reduced number of rain days, increased mean maximum temperature and decreased mean annual minimum temperature. The results show that mean minimum temperature may increase from 19.2°C in 2018 this is an increase of 0.6°C. the prediction show that there will be a slight increase in the range of temperature, this is an indication of warmer Musawa.

Recommendations

Based on the findings of the study, the following recommendations are made:

i. More emphasis on dissemination of climate variability and changes through the mass media is highly needed. Government should broadcast programmes to enlighten farmers on adaptation and copping strategies to reduce factors that aggravate climate variability and change.

ii. There is need for extension agents, policy makers and researchers to try and get farmers to effectively adapt to climate change. This can be achieved by providing free extension advice; information on early warning signals and improved farmer education to create proper awareness on climate related issues and effective adaptation processes that can be employed by farmers from 1988-2018 years interval.

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