

## ASSESSMENT OF ANNUAL MINIMUM TEMPERATURE IN SOME PARTS OF NORTHERN NIGERIA

ADAKAYI, P.E. AND \*ISHAYA, S.

Department of Geography and Environmental Management, University of Abuja, Abuja

### Abstract

*This work attempts investigating the pattern of minimum temperature from 1971 to 2006, an attempt was also made to predict the pattern from 2007 to 2030. The aim of the study therefore is to see the behaviour of minimum temperature as we study Climate Change in Northern Nigeria. This will enable us to know the trend of change for this study period. The following objectives helps in achieving the set aim; determine variations in minimum temperature, determine the trend of minimum temperature in the study area and predicting the values of the element for the period, 2007 – 2030, this was also subjected to time series analysis. The data was collected from the Nigerian Meteorological Agency, Maitama, Abuja. The length of data was thirty-six (36) years from eleven (11) stations. Simple Statistical Measures of mean, median, maximum, minimum, standard deviation, variance, skewness, kurtosis and coefficient of variability were used for discerning the patterns and distribution of minimum temperature. The results achieved indicate that the study area could be divided into two on the basis of low minimum temperature (1970s and 1980s) and high minimum temperature (1990s and 200s). During the predicted period, 2007 – 2030, mean annual minimum temperature continue to increase from 21.1°C in 2007 to 21.5°C in 2030. Minimum temperature varies slightly in the region, and it has not varied significantly over the study period.*

**Key Words:** Annual, Minimum temperature, predicted, variability, Northern Nigeria

### Introduction

Change is an inherent characteristic of climate, therefore climate change is not an issue in any part of the world. The issue is the rapidity of change occasioned by human activities. The levels of emission of greenhouse gasses, levels of land degradation, grazing etc. contribute enormously to the rapidly changing climate (Ferro, 2005). Minimum temperature change is one extreme of climate change, so the study will give us a very good understanding of the issues of

climate change. Ayoade (2003) noted that the crucial issue is the degree of variability and duration and that minor fluctuations or variations constitute not more than a “noise” in the climate series and that man can easily adapt to such. However when fluctuations in climate constitute significant departures from the normal conditions or become prolonged to constitute a new climate state, then there are problems of adjustment and the environment, man and his activities become vulnerable. The rapidity of

variations or change in climate also heightens the vulnerability of man, his socio – economic activities and the ecosystems in general to change.

Griffin (2001) noted that the climate of North Africa is influenced by the ever evolving desert/monsoon system. Within such context, it is quite natural for aridity and humidity to occur in close proximity in time and space with seasonal and longer term cyclical changes emphasizing the duality. This study will compliment earlier studies on the climate of Northern Nigeria which form part of this great North Africa.

During the Pleistocene and Holocene, a large Lake occupied the Chad Basin; it had an overflow into the Benue–Niger River system (Pachur and Altmann, 1997). The recent situation is a far cry from the past. It is well known that the Lake Chad has almost disappeared from Nigerian territory. This situation could be linked in the present study by the new emerging pattern of minimum temperature.

Pachur and Altman (1997) have noted that the divide in the Southern and South Eastern flanks of the Chad Basin have been subjected to considerable erosion since the Messenia and are now no doubt considerably lower than during that stage. The Northern divide has been by the Pliocene aridity. The role of vegetation disruption on local climate usually involves perturbations to the surface energy balance which in turn alter energy and moisture fluxes in the lower atmosphere. However, once the vegetation is depleted, the local atmosphere is further influenced by increased dust loads.

Most modelling efforts lead to a conclusion that increased mineral aerosol loads will cool the surface, warm the lower atmosphere, stabilize the atmosphere, and reduce local rainfall (Moulin *et al.*, 1997). Besides all these, it is observed that areas

in North Africa with severe desertification were warming faster than nearby areas with less magnitude of desertification. Furthermore, desertification appeared to have its greatest impact in temperatures from high-sun months and its least impact during the low-sun months.

The cold dry North East (NE) wind is enhanced by the near cloudless skies during the dry period of the year. The clear skies allow almost all insolation to be taken back to space leaving very little energy in the biosphere. With this high energy fluctuation, plant productivity is at its lowest ebb, and this partly accounts for the advancement of the Sahara. The sand particles also act as alternative surfaces, adding to further loss of energy from the biosphere. During the rainy season, the moisture content of both the atmosphere and the earth surface. Similarly the heavy cloud cover acts as blanket for terrestrial radiation thereby preventing loss of energy from the earth surface (Giorgi and Pal, 2004).

A Regional Climate Model (RCM) within a General Circulation Model (GCM) can be made for higher resolution climate fields to be produced (Giorgi and Pal, 2004). In order to get an idea of the nature of the climate change resulting from increased GHG concentrations, the mean differences between the control run (current climate) and the perturbed run (future climate) are calculated. Most climate change projections are made for fixed times (e.g. the 2020s, the 2050s, and the 2080s) or 30 years climatological periods (e.g 2071 – 2100) in the future. Changes could occur in climate statistics using these models (McGregor *et al.*, 2005) such as extreme events when mean states move upwards or downwards. There could also be changes in scale and shape of the distribution.

Climate projections for the period 2071 – 2100 under A2 and B2 scenarios reveal considerable warming in all seasons ranging from 1.5°C to 5.5°C with temperatures generally 1°C - 2°C in the case of low emissions (Beniston, 2005; Ferro, 2005; Giorgiet. al., 2004; Jones, 2001; Kjellstrom, 2004). Maximum warming occurs in Northern and Eastern Europe in winter. In summer this is found over Western and Southern Europe.

A feature of the period 1946 – 2004 is symmetric warming (Klein – Tank and Konnen, 2003) meaning that there has been an approximately equal increases in the occurrence of both cold and hot extremes and no change in temperature variability that we can talk of climate change. However within this period, two “asymmetric” sub-periods, namely 1946-1975 and 1976-1999 may be identified due to contrasting relationship between the mean and extremes. For 1946 – 1975 a period of slight cooling occurred across Europe with an associated decrease in the number of warm extremes. However the annual number of cold extremes did not increase, implying a decrease in temperature variability. In contrast pronounced warming and an increase in the annual warm extremes at a rate of two times faster than the expected change in cold extremes, which implies increased variability characterized the period 1976 – 1999 (Klein – Tank and Koonen, 2003). It is in the light of all these that this work looked at minimum temperature trend in Northern Nigeria from 1971 – 2006 and estimates from 2007 – 2030.

Arising from the above, a study of one climatic extreme, the minimum temperature is very essential toward an accurate understanding of climate change in Northern Nigeria. To put it more clearly, we can ask the following questions:

- i. Is the minimum temperature changing in the Study Area?
- ii. What is the nature and direction of change?
- iii. What are the characteristics of minimum temperature?

The aim of this work is to exhibit the nature and pattern of minimum temperature in the study area. Arising from this aim, the study attempted to address the following objectives; characterize minimum temperature in the study area, determine the variability and trend of the element and predict values of the element from 2007 to 2030 and determine the trend.

The main assumption of this study is that minimum temperature has not changed significantly between 1971 and 2006 and will not change significantly between 2007 and 2030.

## **Methodology**

### ***Methods of Data Collection***

The work covers eleven (11) synoptic weather stations for thirty-six (36) years in Northern Nigeria. Series of Statistical analysis were carried out to achieve our stated objectives. This study used secondary data collected from the Nigerian Meteorological Agency, Maitama, Abuja for a period of thirty-six (36) years from eleven (11) synoptic weather stations. Necessary adjustments were made for cases of missing data such as averaging and interpolation. The eleven (11) synoptic weather stations are Bauchi, Gusau, Kano, Katsina, Kaduna, Maiduguri, Nguru, Potiskum, Sokoto, Yola and Yelwa (figure 1).

Other derivatives of minimum temperature were computed and used for further analysis. Such derivatives include Simply Statistical Measures.

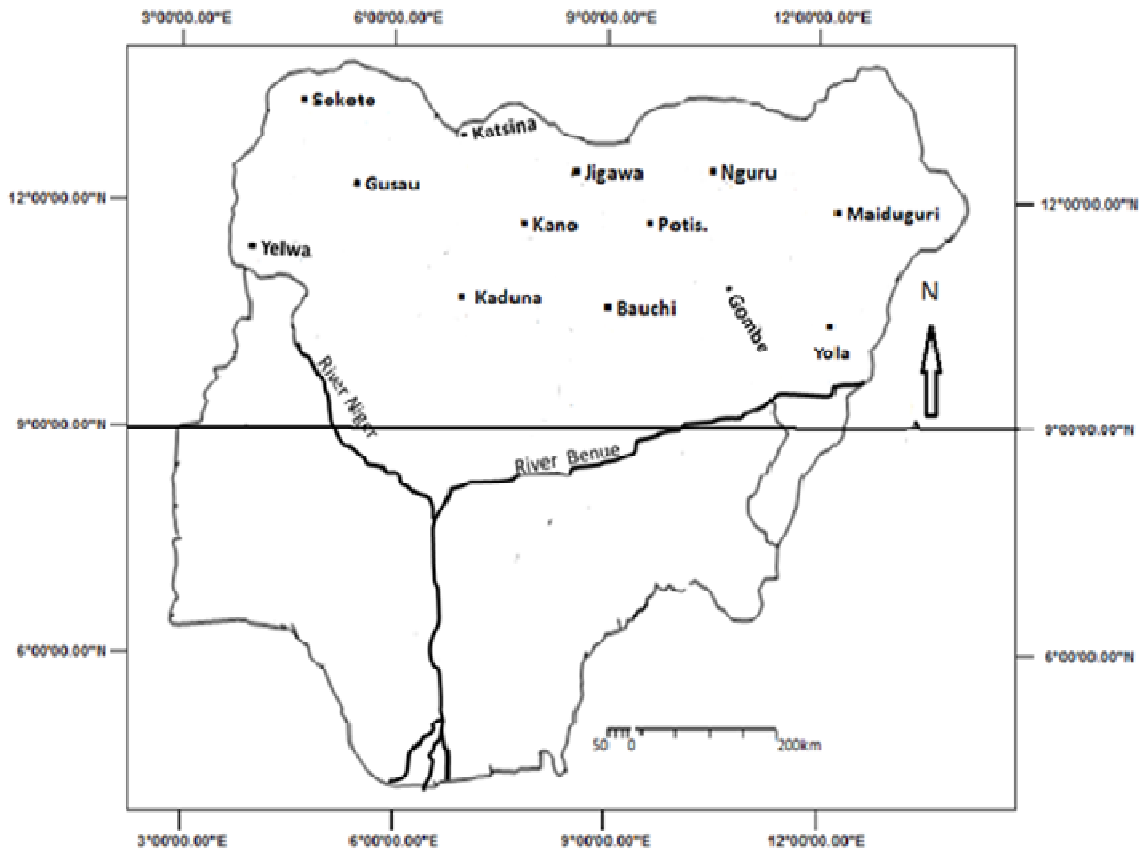


Figure 1: Climatic Stations in the Study Area

**Methods of Data Analysis**

The data collected and derived were subject to trend analysis, both collected and predicted. They were to show temporal patterns and distributions. The SPSS software package was used for the analysis. The normality test, Fisher’s standardized coefficient of Skewness ( $Z_1$ ) and Kurtosis ( $Z_2$ ) were used to determine if the data were normally distributed to warrant the use of parametric statistics in

their further analysis. These statistical analyses yielded the following statistics

- Variations in minimum temperature
- Trends in minimum temperature

**Results and Discussions**

The results indicate that a lower minimum temperature than the mean value occurred since 1985 to date (figure 2).

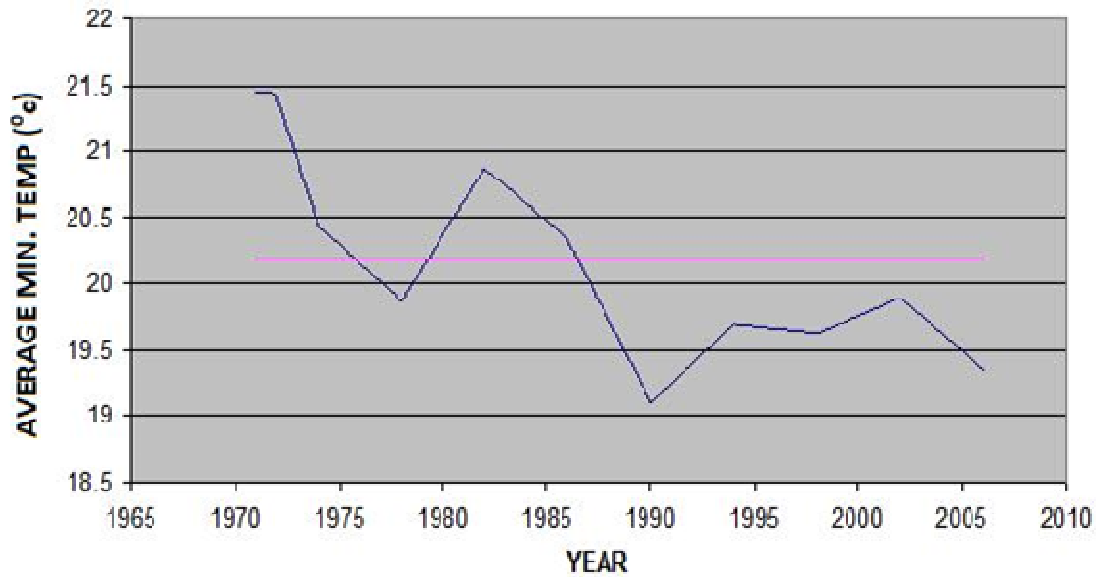


Figure 2: The time series graph of the average minimum Temperature In all the stations between 1971 and 2006

The value for 1999 has been the lowest in the recorded period of study. This is followed by the year 2006.

The time series straight line equation is of the form  $y = 0.0035x + 19.74$  (figure 3)

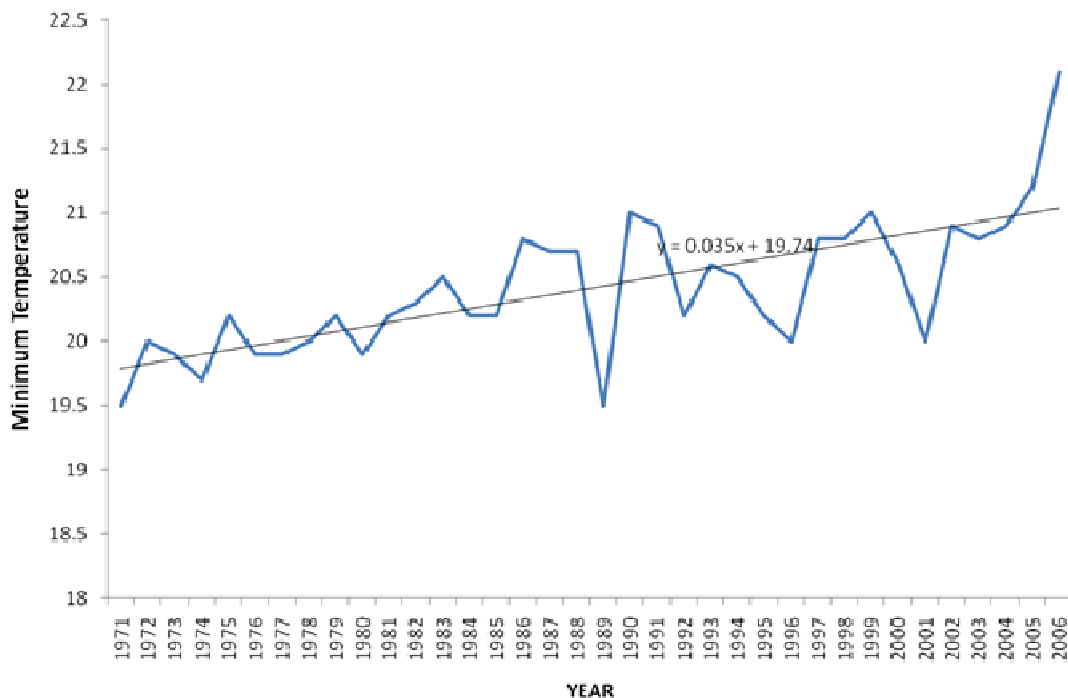


Figure 3: the time series graph of the mean minimum temperature in all the stations between 1971 and 2006

This shows the minimum temperature has been decreasing steadily. The implication here is that the range of temperature does not differ significantly. In order to see if this trend will

continue, a time series model of ARIMA (0,2,2) was used. The result of the forecast for the period 2007 to 2030 is shown in table 1.

Table 1: Time Series Modeler

Model Description				Model Type
Model ID	Mean Values of Min.Temp	Annual of 1	Model_1	ARIMA(0,2,2)
Forecast Model Mean Annual Values of Min.Temp-Model_1				
Year	Forecast	UCL	LCL	
2007	21.05986	21.75763	20.3621	
2008	21.08476	21.85645	20.31307	
2009	21.10894	21.9516	20.26628	
2010	21.13239	22.04335	20.22143	
2011	21.15512	22.13211	20.17812	
2012	21.17713	22.2182	20.13605	
2013	21.19841	22.30185	20.09497	
2014	21.21897	22.38324	20.05471	
2015	21.23881	22.46251	20.01512	
2016	21.25793	22.53979	19.97608	
2017	21.27633	22.61518	19.93748	
2018	21.29400	22.68877	19.89924	
2019	21.31095	22.76063	19.86127	
2020	21.32718	22.83084	19.82352	
2021	21.34269	22.89945	19.78592	
2022	21.35747	22.96652	19.74842	
2023	21.37153	23.0321	19.71097	
2024	21.38487	23.09622	19.67352	
2025	21.39749	23.15893	19.63604	
2026	21.40938	23.22027	19.59849	
2027	21.42055	23.28027	19.56083	
2028	21.431	23.33896	19.52304	
2029	21.44073	23.39638	19.48508	
2030	21.44973	23.45254	19.44692	

The result shows that mean minimum temperature will continue to increase from 21.1°C for 2007 to 21.5°C in 2030. This is an increase of 0.4°C. When this is compared to mean annual maximum temperature increase of 0.9°C (Adakayi, 2012) it is realized that there will be a slight increase in the range of temperature. This is an indication of a warming Northern Nigeria.

Generally we have a situation of increased rainfall in the last ten (10) years

of this period of prediction, reduced number of raindays, increased mean annual maximum temperature and increase mean annual minimum temperature (Adakayi, 2012). The forecasted minimum temperatures in the study area were subjected to time series analysis and yielded a straight line equation of the form  $y = -11.44 + 0.016x$  and a coefficient of determination  $R^2=0.927$  (figure 4).

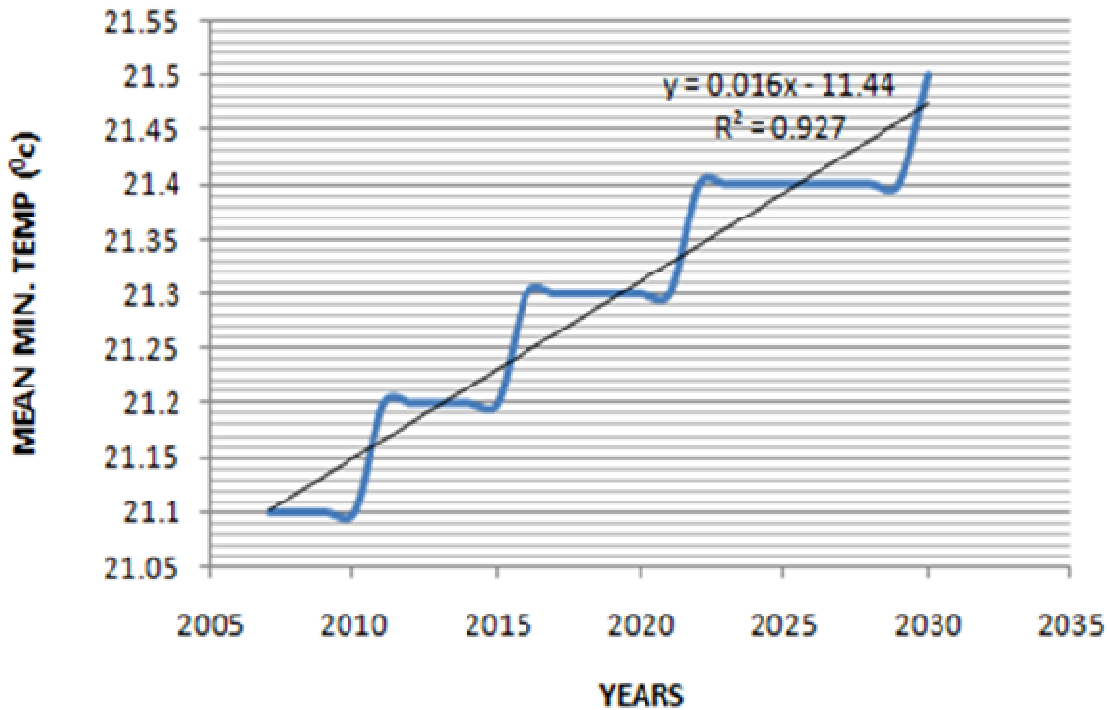


Figure 4: the time series graph of the mean min. temp. in all the stations between 2007 and 2030 (forecast)

This means that the forecast is significant. There is a general upward trend in minimum temperature between 2007 and 2030. Its range is much smaller than that of maximum temperature (Adakayi, 2012).

### Conclusions

The 1970s and 1980s were years of lower minimum temperature while the 1990s and 2000s were years of higher minimum temperature. Therefore the region could be divided into two on this basis.

During the forecast period of 2007 to 2030, minimum temperature increased from 21.1°C in 2007 to 21.5°C in 2030, an increase of 0.4°C in 23 years. The annual range of minimum temperature is very slight like in earlier studies.

Departures from the mean state of minimum temperature have not been significant. This type of study must be done in other regions of Nigeria and Africa.

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