



## Diurnal Temperature Range as Index of Climate Change in Lafia, Nasarawa State, Nigeria

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**ABSTRACT:** The study focused on determining the Diurnal temperature range trend as an index of climate change in Lafia, Nasarawa State, Nigeria. The study relied on remote sensing data- the ERA5 – Temperature, which is the fifth generation reanalysis from ECMWF. The data for the period of forty (40) years was extracted and used to analyze the annual range, diurnal temperature, trend analysis and daily maximum and minimum temperatures. The results shows a decrease in the trend analysis for the decadal and pentad which means that the difference between the daily maximum temperature and daily minimum temperature is no longer wide. However, the trend analysis carried out for the annual DTR shows a positive trend which shows that the Maximum daily temperature is higher than the daily minimum range in the study area. The study recommended for more intense study of DTR in order to stop over generalizing the index of climate change over a macro area..

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Climate change is a global phenomenon happening in different forms and scale at different location world over. Although, there are climate change deniers all over the world and hence the need to keep seeking indexes to established the reality of the changing climate. UNFCC (1992) Defined climate change as a change which is attributed directly or indirectly to human activities that alter the composition of the global atmosphere and which are in addition to natural climate variability observed over comparable time periods. The controversies and times casual attitudes of individuals or governments to climate change could be attributed to lack of knowledge or proper documentation of the facts of climate change. Ogunbode (2021) noted that, while global communities are rallying round to discuss the effects of climate change with millions of dollars being sunk into the process of mitigation, it is so unfortunate that the perceptions about the climate change menace is quite unwelcomed in Nigeria. Agidi *et.al.* (2019) observed that Nigeria is susceptible to the effect of climate change like other developing countries

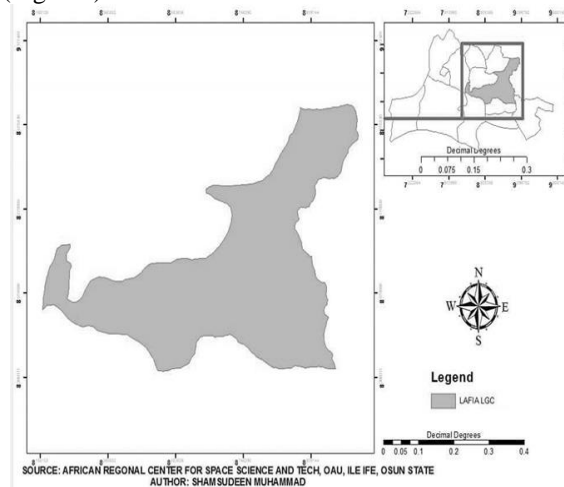
because of her high reliance in nature for economic activities. Studies revealed that signs have shown that Nigeria is already being dogged with sundry environmental complications which can be directly connected to state of climate change (Ayuba *et.al.* 2007). To emphasize the stated fact, Odjogu (2010) observed that the mean air temperature in Nigeria between 1901 and 2005 was 26.6oC while the temperature increase for the 105 years was 1.1oC which was higher than the global mean temperature increase of 0.74oC recorded since 1860 when actual scientific temperature measurement started. IPCC (2007) stressed that if this temperature trend continues without check, the rate of increase will be 4.5<sup>o</sup>C by 2021. Daily temperature mean is generally used as a universal measure of climate change. However, it was noted that mean temperature alone is not sufficient to explain or reflect the complicated variation of climate. Sun *et.al.* (2004), noted that diurnal temperature range is a very good indicator of climate change. The Diurnal Temperature Range being an important index of climate change is defined by Karl, *et.al.* (2004) as the

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difference between daily T-max and T-min, it embodies the asymmetric variation in the diurnal changes of these surface air temperatures, and it is considered as a pointer of climate changes because of its sensitivity to radiative energy balance. Even though, there are so many studies on Diurnal temperature range all over the world and climate variation all over the world and in Nigeria very few looked at Diurnal Temperature range as an indicator of climate change. Other studies considered Diurnal Temperature range at the regional or national outlook, this study aim at focusing on a local outlook. Dike *et,al* (2019) observed that regionally averaged DTR has decreased significantly ( $-0.34^{\circ}\text{C}$  per decade) over the Nigerian Sahel (north of  $10^{\circ}\text{N}$ ), but there has been a slight increasing trend ( $0.01^{\circ}\text{C}$  per decade) over the Nigerian Guinea Coast. It becomes imperative to study Diurnal Temperature Range (DTR) Lafia to ascertain the trend and behavior in order to fill the gap in knowledge and bring to bear the issue of climate change in Nigeria.

## MATERIALS AND METHODS

**Study Area:** The study area is Lafia the capital of Nasarawa State, Nigeria. It is located at approximately latitude  $8^{\circ} 24' \text{N}$ ,  $9^{\circ} 1' \text{E}$  and longitude  $8^{\circ} 13' \text{E}$ ,  $9^{\circ} 8' \text{N}$  in the North Central region of Nigeria. Lafia has a total landmass of about  $2797.53 \text{ km}^2$  and shares boundary with Plateau State in the North East, Obi and Doma L.G.A in the South, Nasarawa Eggon in the West and Wamba LGA in the North respectively as shown in (Figure1).



**Fig 1:** Map of Lafia (Study Area)

Lafia L.G.A has a tropical sub-humid climate, with two distinct seasons which are wet season and dry season. The wet season lasts for seven months which is between April and October, while the dry season is between November and March (Agidi *et,al*. 2018). Rainfall is moderately high in Lafia, ranging from

1200mm to 1600mm (Binbol, 2005). Average maximum and minimum daily temperatures are  $35^{\circ}\text{C}$  and  $21^{\circ}\text{C}$  in rainy season and  $37^{\circ}\text{C}$  and  $16^{\circ}\text{C}$  in dry season respectively (Agidi, *et,al*. 2018). The town is becoming urbanized since 1996 when it assumes the status of the Nasarawa State capital. Subsistent agricultural activities are the main stay of most of the habitat, it also host a lot of educational institutions like the federal university Lafia, Faculty of Agriculture Nasarawa State University, College of Science and Agriculture, Nasarawa State Polytechnic Lafia amongst others. Lafia is has the Migili, Eggon, Alago and Kanuri as the main indigene but has become cosmopolitan due to it citing as the administrative center of Nasarawa state.

### Data Collection

**ERA5 – Temperature:** ERA5 is the fifth generation reanalysis from ECMWF. It provides several improvements compared to ERA-I, as detailed 120 by Hersbach and Dee (2016). The analysis is produced at a 1-hourly time step using a significantly more advanced 4D-var assimilation scheme. Its horizontal resolution is approximately 30km and it computes atmospheric variables at 139 pressure levels. Data for the 1979-2018 periods was released in March 2019. ERA5 temperature data was downloaded and aggregated to the daily time step for this work.

**Data Extraction method:** The daily temperature (minimum and maximum) datasets were obtained from the ERA5 data archive respectively. The data were downloaded from these web archived saved in Network Common Data File (NetCDF) format. The Ferret PMEL modeling software and FORTRAN programming language were used to extract the data Netcdf and translate it to spreadsheet formats. The scripts from high level programming languages were required for data extraction and data conversion. The Ferret PMEL software and FORTRAN compiler were installed and operated on the Linux Operating System. The extracted temperature data is for daily Maximum and daily Minimum from January 1981- December 2020.

**Methods of Data Analysis:** The temperature data were subjected to quality control and homogeneity assessment before being used in this study. DTR index which is defined as the difference between Tmax and Tmin (Peterson 2005) was investigated as an index of climate change. Daily DTR data was obtained by subtracting daily minimum temperature from daily maximum temperature for each day. Then, temporal averages were conducted for annual to get Diurnal Temperature Range time series. The inherent trends were computed using the hypothesis was tested for

statistical significance based on the Mann–Kendall rank test. A trend was considered to be statistically significant at  $p < 0.05$ . The correlation coefficients were tested for significance based on the Student’s t-test. These methods are widely accepted for their robustness in examining trends in climate data (e.g. Dike, *et al* 2019, Shen *et al.* 2014; Abatan *et al.* 2016).

### RESULTS AND DISCUSSIONS

Figure 2 shows the DTR of Lafia in decades from 1981-2020. Four decades were gotten: 1981-1990, 1991-2000, 2001-2010 and 2010-2020. There appears to be a stable DTR in the first three decades and a sharp decrease in the last decade. The trend analysis shows a negative trend which implies that DTR is decreasing in the study area. This implies that the difference between a  $T_{max}$  and  $T_{min}$  is not much, leading to a decrease in DTR. The result further shows that the decrease in the DTR starts from the turn of millennium year 2000, which roughly coincides with the period of intense urbanization in Lafia due to the citing of state headquarters. This finding agrees with the outcome of Dike *et al.* (2019) which noted that DTR is on the decrease across the northern part of Nigeria. Which shows that climate is changing in the study area.

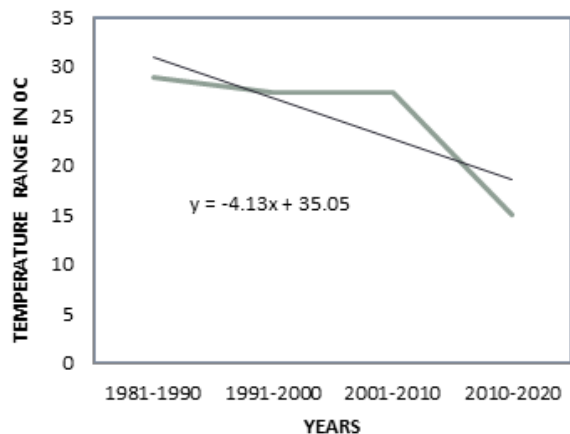


Fig 2: DTR DECADAL trend

Figure 3 shows the result of Pentad DTR over the study area. DTR from 1983-2020 was divided into pentad, which is five years intervals to observe the DTR. Eight pentads were gotten. In this case, instead of lumping all years in a decade, we chose to use Pentad; this may take note of some tiny information that would have been overgeneralized in the decade analysis. The Pentad trend analysis indicates a negative or a downward trend. With Pentad years between 1991-1995, we witness the first decrease in DTR. Then a rise and a sharp decrease in pentad from 2001-2005, before the final decrease from 2011-2015 and 2016-2020.

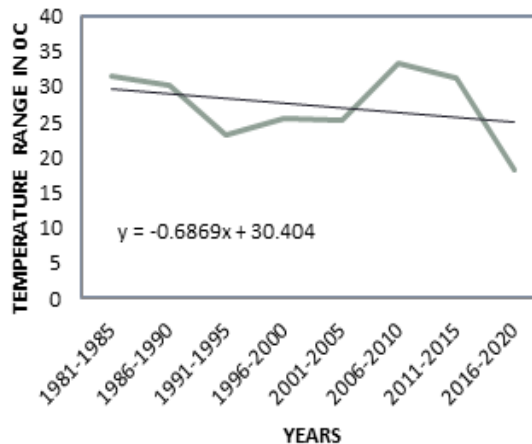


Fig 3: DTR PENTAD trend

The result shows that the last decade is the period of intense decrease in daily temperature range, which roughly coincided with the moment of intense urbanization in Lafia, Nasarawa State. It will be safe to say from the year 2016 to 2020, witness a high index of climate change in the study area. This agrees with the findings of NOAA and NASA in Alejandra (2020) that the years 2010-2019 was the hottest decade since record keeping began 140 years. This period ushered so many dramatic changes in climatic events which made the doubter believe that truly the climate is changing.

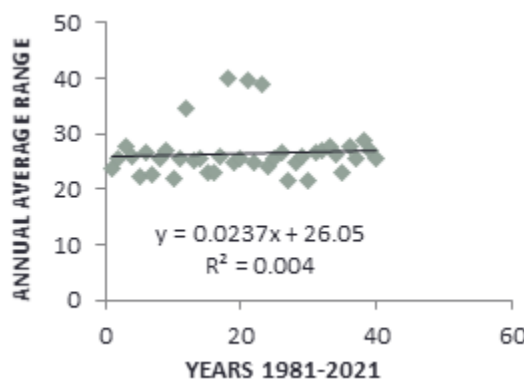


Fig 4: lafia DTR mean annual trend

The annual trend analysis of the mean DTR of the study area shows a marginally increasing trend. This agrees with the findings of Dike *et al.* (2019) which noted that there is a positive increase in annual DTR trend over Guinea savannah of Nigeria where the study area falls in. This may also be as a result of little or insignificant differences in the inter-annual variation of temperature in the tropics. The hypothesis was tested using the Mann-Kendall test analysis; the result of the hypothesis shows that the calculated value is greater than the table value at 95%

significance level. Hence we reject the null hypothesis which states that there is no significant difference in DTR and accept the alternate hypothesis.

*Conclusion:* The study undertook a trend analysis to ascertain the diurnal temperature range behavior in Lafia, Nigeria. The study found out that there is a progressive decline in the Diurnal Temperature Range (DTR) by decades and Pentad for the past forty years which is enough evidence of a changing climate. The study however observed a relatively little positive increase in the annual Diurnal Temperature Range, This might likely be as a result of little or no differences in inter annual variation of temperature.

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