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AN ASSESSMENT OF CHARACTERISTICS OF RAINFALL AND TEMPERATURE VARIABILITY IN DADINKOWA YAMALTU DEBA LGA OF GOMBE STATE, NIGERIA

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ABSTRACT
The study aims to assess the rainfall and temperature pattern to suggest some resilience mechanisms, the farmers' perception of rainfall and temperature variability, and adaptation strategies. Rainfall and temperature data (1989-2018) from the Upper Benue River Basin Development Authority Hydrological Department and a structured research questionnaire were used for this study. Statistical tools commonly used to describe climates such as mean, range, standard deviation, and coefficient of variation were employed. Standardized precipitation Index for the study revealed the first decade (1989-1998) had the highest number of dry years; five (5) moderately dry years, one (1) severe dry year, and one (1) extremely dry year. This was followed by the third decade (2009-2018), with four (4) moderately dry years and one (1) severe dry year. And lastly the Second decade (1990-2018); with only three (3) moderately dry years. Whereas the third decade (2009-2018) had the highest number of wet years with four (4) slightly wet years, two (2) moderately wet years, and one (1) considerably wet year. The second decade (2009-2018) was relatively wet with three (3) slightly wet years, one moderately wet year, one (1) considerably wet, and one extremely wet year while the first decade (1989-1998) had only five 5 slightly wet years. The last two decades (1999-2008 and 2009-2018) were found to be wet while the first decade was dry. The study showed a temporal distribution of annual mean temperature in Dadin-kowa. The result revealed that the region experienced a rising and falling pattern from 1989 up to 2010. The region then started experiencing a rise from 2010 down to the end of the study period. Late onset of rains and increase in temperature have been experienced by the farmers and understood as evidence of variation in climate. The findings of both empirical data and of the questionnaire agreed that there is evidence of climate variability that can be explained in terms of rainfall and temperature variability in the area. The coping strategies employed include the use of locally made fertilizer, irrigation, and change of planting date, mixed cropping, and use of planting period techniques. Thus, awareness raising on climate variability, weather forecasting, and expanding existing irrigation infrastructure among others were recommended to help ameliorate the effects of climate change on the farmers' cropping practices.

Keyword: Rainfall, Temperature, Variability, Dadin Kowa

INTRODUCTION

Rainfall distribution in the tropics has been examined on different time and temporal scales. Almost everywhere in the tropics the annual rainfall characteristics differ from year to year and in addition it varies strongly with places as well. Other rainfall characteristics such as its seasonal and diurnal distribution, intensity, duration, and frequency of rainfall, also show important differences with respect to both places and time with tropical climates. However, there is a general decrease in rainfall in Nigeria which is as a result of so many factors causing either the decrease or increase in some area across the country (Yahaya, 2016). The ultimate source for the earth atmosphere is the solar radiation, once absorbed by the earth or either the atmosphere; it is partly converted into sensible heat or other forms of energy. The degree of conservation of this sensible heat represents what is known as temperature (Aondoakaa, 2012). The annual, seasonal and diurnal basic changes of temperature usually result in an increase or decrease in radiation (Faniran and Ojo, 1999). Climatic elements such as radiation, evaporation, wind, humidity and cloud cover influence temperature. However, these factors that influence surface temperature and its distribution in both space and time are entirely controlled by the movement of the earth and which vary in latitude (Yahaya, Bello, Rukayya & Yuguda, 2020). Climate change results in more frequent flood and drought with large annual and diurnal variation, the temperature distribution increases from morning to afternoon and from summer to winter (Yahaya, Bello & Alhaji 2020).

Temperature varies from place to place and with season. In general, annual, seasonal or diurnal rhythms of temperature reflect the increase or decrease or net radiation over time. Therefore, the distribution of temperature follows the same pattern. The main effects of variability of temperature and precipitation have been evaluated through simulation. Modeling a diurnal and inter annual variability and moisture can result to substantial change in the mean variable of yield (Yahaya, et al 2020). The pattern and amount of rainfall are among the most important factors that affect agricultural activities; the characteristics of rainfall are of considerable interest to farmers. Rainfall variability is officially defined as the amount by which the actual rainfall at any station differs on average from its mean value, either above or below (Yahaya, Bello & Alhaji 2020). The climate of Nigeria has shown considerable temporal and spatial shifts in its variability change since the late 1960s and early 1970s through a careful study of meteorological data (Federal Republic of Nigeria, 2003; Nigerian Meteorological Agency, 2012). Extreme weather and climate events such as drought, flood, and ocean surges etc. have become regular. The impact of these extreme events may be gradual but their destruction of lives and property has a negative impact on the economy. Floods have become an almost annual occurrence, especially in the northern parts of the country with increasing

intensity each year, leaving colossal losses and trauma (Abaje and Giwa, 2010; Nigerian Meteorological Agency, 2012). Adaptation to climate changes refers to all those responses that may be adopted by people to reduce vulnerability (Federal Republic of Nigeria, 2003). It has the potential to alleviate adverse impact, as well as to capitalize on new opportunities posed by climate change. Areas mostly affected were the coastal areas of Nigeria. This is a clear depiction of evidence of global warming because many studies have shown that climate change is associated with global warming which brings more rainfall in most aridity to most continental interiors (IPCC, 2017; Burroughs, 2001 and Elisha, 2017).

Therefore, based on these backgrounds this study assessed rainfall and temperature variability as they affect agricultural production, to suggest some resilience mechanism in Dadinkowa, Yelmaltu-Deba Local Government Area in Gombe State.

The following objectives will be looked into;

1. To assess the characteristics of rainfall variability in Dadinkowa (1989-2018).
2. To examine temperature variability in Dadinkowa (1989-2018).

STUDY AREA

The study area is Dadin-Kowa, one of the eleventh districts that make up the Yemaltu-Deba local government area of Gombe state. It lies between latitude 10° 12' 42" to 11° 23' 11" N and longitude 11° 23' 11 to 11° 28' 54"E (Figure 1), with an elevation of 451.61 meters (1481.66 feet) above sea level. It is bounded to the East by a national boundary with Borno to the west Gombe, to the North Kwami and Funakaye and to the South with Kaltungo and Balanga. It has a total land area of 170.49 sqkm with a population of 190,000 people (based on 2006 census) and a projected population of 235, 000 as of 2022.

Dadin–Kowa is characterized by a tropical sub-humid climate with two distinct seasons (wet and dry season). The dry season starts in November and ends in April. This is the period when the area is under the influence of dust harmattan northeast trade winds that are usually blown from the Sahara Desert while the rainy season is set in May and lasts through October (UBRBDA, 2017).

The study area's yearly temperature is 30.54ºC (86.97ºF) and it is 1.08% higher than Nigeria's averages. Gombe typically receives about 66.84 millimetres (2.63 inches) of precipitation and has 96.26 rainy days (26.37% of the time) annually. (UBRBDA, 2017).

The study area is located within the southern landscape that forms parts of the low plain of the Benue -trough. The plains are believed to be tectonic in origin. Other parts of the study area are composed of undulating lowlands and a network of hills developed with granite, migmatite, pegmatite and gneiss (Muhammad, 2014). Most of the area that lies between the Benue valleys are composed of sand stones. The land mass of the area is found towards the north, notably in Biu ranges.

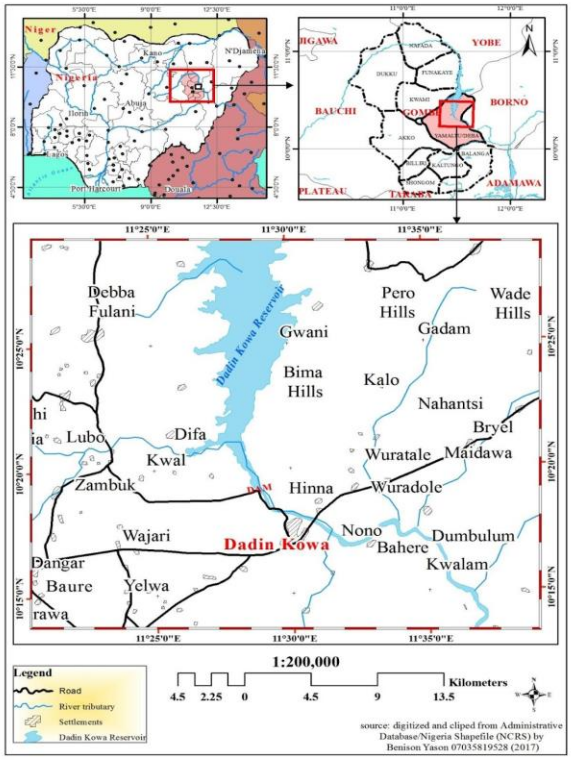

Figure 1: Study Area

Source: GIS Lab Gombe State University

The area is drained by numerous fast flowing streams and rivers that take their sources from the Biu plateau and flow into river Benue which also marks the southern border. The major soil unit of the study area belongs to the category of lithosols and tropical ferruginous soils (Nyaba, 1995 as quoted in Yahaya, et al 2020). Dadin–Kowa falls within the Guinea Savannah zone. However, clearance of vegetation for farming, fuel wood extraction for domestic and cottage industrial uses and saw milling has led to the development of regrowth vegetation of various levels of several developments.

MATERIALS AND METHODS

One source of data was used for this study. Rainfall and Temperature data that were obtained from the Hydrological department of the Upper Benue River Basin Development Authority office located at Yamaltu Deba local government, Gombe State. (Secondary Sources) was used. This includes monthly and annual rainfall data in (mm) and temperature for Dadinkowa, for a period of 30 years (1989-2018).

The approaches that were used for the study of rainfall and temperature variability and trend include both statistical and graphical approaches. The statistical approach includes: arithmetic means, standard deviation and coefficient of variation. Statistical Package for Social Sciences (SPSS) was used for analysis. Also the trend and variability over the period was analyzed using the arithmetic mean to determine the average of monthly and annual values. This was applied to determine the value of the mean month and mean annual rainfall and temperature value for the period of 30 years (1989-2018).

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$$\sum_{i=1}^{n} xi = X \text{ where}$$

$$\frac{}{n}$$

Xi = is the yearly rainfall in mm and temperature

$\sum = \sum =$ Summation

i = is representing the years e.g. 1989

n - is the number of observations

X = is the mean yearly rainfall and temperature

The yearly mean rainfall and temperature was used to compute the standard deviation and coefficient of variation.

RESULTS AND DISCUSSION

Rainfall Variability in Dadinkowa (1989-2018)

The rainfall data for Dadinkowa (1989-2018) was collected and analyzed because rainfall is an important climatic element, it is very important to study its variation. Table 1 presents the descriptive statistics of rainfall distribution in the study area.

Table 1: Descriptive Statistics of Rainfall in Dadinkowa (1989-2018)

Statistic	Dadinkowa
Mean	874.17
Standard deviation	118.71
Coefficient of variance	13.57
Minimum	599.4
Maximum	1119.3
Range	519.9

Source: Fieldwork 2022

The mean annual rainfall for Dadinkowa meteorological station (1989-2018) was 874.17mm, with the standard deviation of 118.17 and a coefficient of variation of 13.57%, the station showed a minimum rainfall of 599.4mm and the maximum rainfall of 1119.3mm, this gives a range of 519.9mm. This implies that the annual rainfall is moderate in the station.

In other words the trend shows that rainfall is received from 1989-2018 having standard deviation values less than their corresponding mean values showing different variation in the distribution of rainfall over the years in the Study area. Furthermore, the values of standard deviation (SD) and coefficient of variation (CV) clearly indicated the variability in annual distributions of rainfall in the study area.

Table 2: Rainfall Characteristics of Dadinkowa for Three Decades (1989-1998, 1999-2008, 2009-2018)

Years	1989-1998	1999-2008	2009-2018
Mean	807.9	936.7	877.9
Standard deviation	111.8	108.9	115.71
Coefficient of variation	7.22	8.60	7.58
Minimum	599.4	793	724.8
Maximum	945.7	1119.3	1055

Source: Fieldwork, 2022

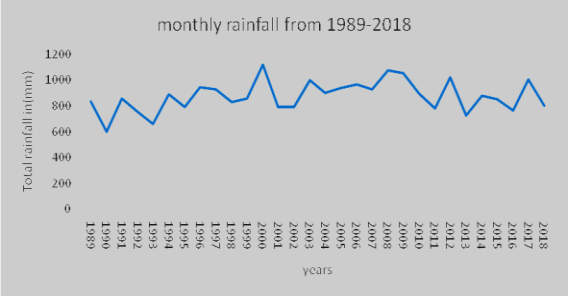

Figure 2: Annual Rainfall Trend Fluctuations in Dadinkowa

Table 3: Variability test

Statistic	Rain	Tmax	Tmin	Tmean
Mean	122.914	34.692	21.328	28.010
Variance	525.011	1.269	1.674	0.933
Standard deviation	22.913	1.127	1.294	0.966
Variation coefficient	0.186	0.032	0.061	0.034

Note: Tmax: Maximum Temperature, Tmin: Minimum Temperature, Tmean: Annual Mean Temperature

The result of the variability of rainfall, maximum temperature and minimum temperature is shown on table 4.1.2. The result shows that the rainfall has an annual mean of 122.914, the variance of 525.011, standard deviation of 22.913 and the variation coefficient which measure the variability of the climate elements is therefore, 0.186. The annual maximum temperature has a mean of 34.692, the variance of 1.269, standard deviation of 1.127 and the variation coefficient which measure the variability of the climate elements is therefore, 0.061. The minimum temperature has an annual mean of 21.328, the variance of 1.674, and the standard deviation of 1.294 and the coefficient of variance which measures the variability of the climate elements is therefore, 0.061. The result of the annual temperature of the study area has a mean of 28.010, the variance of 0.933, and Standard deviation of 0.966 and the coefficient of variance which measures the variability of the climate elements is therefore, 0.034.

According to Durdu (2009) when (CV <= 0.1 or 10%) indicates low variability, (CV <= 0.4 or 40% and > 10%) indicates moderate variability while when (CV >0.4or 40%) indicates high variability. Therefore, the analysis indicates that (Rainfall has a CV of 18.6%, Maximum temperature has a CV of 3.2%, Minimum temperature has a CV of 6.1% and annual mean of temperature has a CV of 3.4%). This means that rainfall, Tmax, Tmin and Tmean have low variability for the period of study.

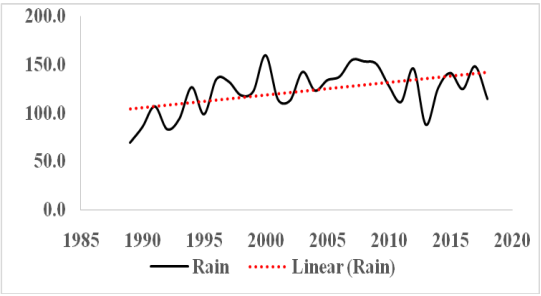

Figure 3: Annual Rainfall Distribution in Dadinkowa (1989-2018)

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Figure 3 showed a temporal distribution of inter annual rainfall in Dadinkowa (1989-2018). The results show that the region experienced fluctuations of increase and decrease, the pattern continuing until 2009 where it experienced a decrease in rainfall, and an increase in 2010. There was a massive drop in the rainfall for 2012 and 2013 recorded a high amount of rainfall indicating an upward linear trend in the region. This finding goes in line with work of Aliyu and Tanko (2015), who affirmed that, there is variability in the pattern of rainfall in terms of its intensity and duration in Kabo Local Government Area. More over these findings corroborate with that of Ayal and Muluneh, (2014) who reported that the majority of respondents perceived that seasonal and annual rainfall amount and number of rainy days has been decreasing, while drought frequency and severity increased from time to time in their localities in Ethiopia.

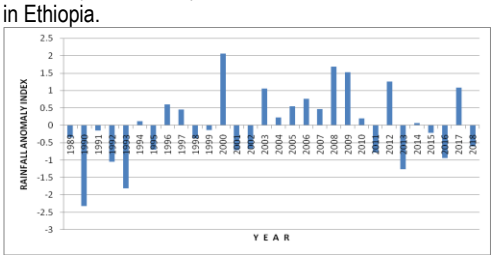

Figure 4: Rainfall anomaly in Dadinkowa (1989-2018)

Figure 4. Shows graphical presentation of the standardized anomaly index which in the first decade (1989-1998) the highest rainfall recorded was in 1996 (Slightly increased moisture) whereas the year 1990 were said to be the year with lowest amount of rainfall (Extremely dry). In the second decade (1999-2008) 2000 was the year that recorded highest amount of rainfall (Extremely wet) while 2002 was the year with low amount of rainfall (Moderately dry) and lastly the third decade (2009-2018), 2009 recorded high amount of rainfall (Considerable increase in moisture) whereas the year 2015 recorded the lowest amount of rainfall (Moderately dry). From this presentation, it is clear that the second decade (2009-2018) recorded more rainfall than any of the three decades and the first decade is little drier with the lowest amount of rainfall recorded.

Table 4. Rainfall Anomaly in the Study Area (1989-2018)

1989-1998	SPI	1990-2008	SPI	2009-2018	SP
1989	Mod D	1999	Mod D	2009	CIM
1990	Ext D	2000	Ext w	2010	SIM
1991	Mod D	2001	Mod D	2011	Mod D
1992	Mod D	2002	D	2012	MIM
1993	Sev D	2003	MIM	2013	Sev D
1994	SIM	2004	SIM	2014	SIM
1995	Mod D	2005	SIM	2015	Mod D
1996	SIM	2006	SIM	2016	Mod D
1997	SIM	2007	SIM	2017	MIM
1998	Mod D	2008	CIM	2018	Mod D

Source: Guenang (2014)
(Ext D) Extreme drought <-1.65
(Sev D) Severe drought <-1.28
(Mod D) Moderately drought <-<0.84
(SIM) Slightly increased moisture <+0.94
(MIM) Moderately increased moisture <+1.28
(CIM) Considerably increased moisture <+1.65
(Ext W) Extremely increased moisture <+2.33

TABLE 5: Frequency of Dryness of the Study Area, 1989-2018

Decades	Mean	Moderately Dry	Severe Dry	Extremely Dry
1989-1998	807.9	5	1	1
1999-2008	936.7	3	0	0
2009-2018	877.9	4	1	0

Table 5 shows the exact number of dry years in which the first decade (1989-1998) has the highest number of dry years, five 5 moderately dry years, one 1 severe dry years and one 1 extremely dry years, followed by the third decade (2009-2018) with four 4 moderately dry years, and one severe dry year. And then the second decade (1999-2008) with only three 3 moderately dry years.

Table 6: Frequency of Wetness of the Study Area, 1989-2018

Decades	Mean	Slightly Wet	Moderately Wet	Considerably Wet	Extremely Wet
1989-1998	807.9	5	0	0	0
1999-2008	936.7	3	1	1	1
2009-2018	877.9	4	2	1	0

Table 6 indicates the number of wet years in Dadinkowa, where the third decade (2009-2018) has the highest number of wet years with four 4 slightly wet years, two 2 moderately wet years, and one 1 considerably wet year. Followed by the second decade (2009-2018) which is relatively wet with three 3 slightly wet years, one moderately wet year, one 1 considerably wet and one extremely wet year. And the first decade (1989-1998) with only five 5 slightly wet years. It is clear that the last two decades (1999-2008 and 2009-2018) were found to be wet while the first decade was dry.

Characteristics of Temperature in Dadinkowa General Area

Table 7: General characteristics of temperature (Maximum) in Dadinkowa

Years	1989-1998	1999-2008	2009-2018
Mean	39.3	41.4	38.7
Standard deviation	2.31	1.34	2.11
Coefficient of variation	17.01	30.89	18.34
Least temperature	35	38	36
Highest temperature	43	43	42

This finding is in conformity with the work of Odjugo (2013) who reported that the rainfall amount is increasing in the Niger delta region and Farmers get farming information more from the cooperatives and friends.

Table 8: Temperature Variability test

Statistic	Rain	Tmax	Tmin	Tmean
Mean	122.914	34.692	21.328	28.010
Variance	525.011	1.269	1.674	0.933
Standard deviation	22.913	1.127	1.294	0.966
Variation coefficient	0.186	0.032	0.061	0.034

Note: Tmax: Maximum Temperature, Tmin: Minimum Temperature, Tmean: Annual Mean Temperature

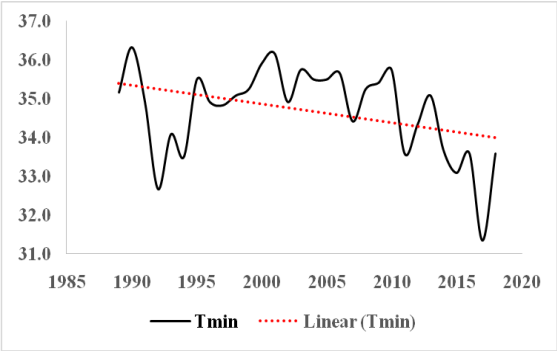

Figure 5: Annual Maximum Temperature Distribution in Dadinkowa (1989-2018).

Figure 5 shows a temporal distribution of annual maximum temperature in Dadinkowa. The result revealed that the region experienced fluctuations. There was a massive fall in maximum temperature in 1990 up to 1992 and rise from 1992 to 1995 then there was a repeated similar pattern (rise and fall) until 2013 where the region started experiencing lower temperature. It indicates a downward linear slope in the region, which showed a negative trend. That is the tendency of decreasing temperature in the near future.

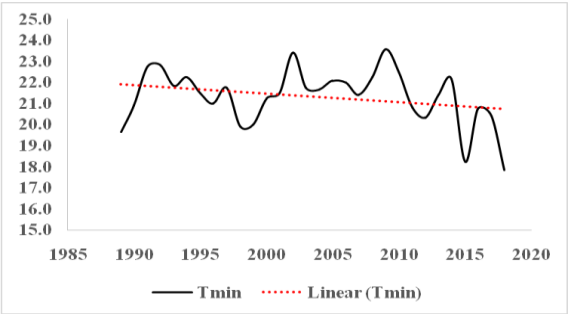

Figure 6: Annual Minimum Temperature Distribution in Dadinkowa (1989-2018)

Figure 6 showed a temporal distribution of annual minimum temperature (Tmin) in Dadinkowa. The result revealed that the region experienced an increase in temperature from 1989 up to 1992 where it started experiencing a decrease up to 1999. It then started increasing till 2003. The region started experiencing a falling pattern till the end of the study period. The analysis indicates a downward linear trend in the region, which shows a negative trend. That is the tendency of decreasing temperature in the near future.

Conclusion

Findings of the present study revealed that there is significant variability of rainfall and temperature as experienced by the farmers in the areas of study over the years, which also corroborated with findings of rainfall and temperature data collected from UBRBDA on the number of rainy days and mean amounts of rainfall for different time series and the spatial and temporal trends of rainfall and temperature variability. Conclusively, there is climate variability in the area, as the values of standard deviation and coefficient of variation clearly indicate the variability in annual distributions of rainfall in the study area.

Recommendations

I. It has been observed that there is inadequate meteorological station hence the date becomes difficult to obtain. To avoid that, accurate weather forecasting devices are recommended as well as establishment of more meteorological stations especially in rural areas to ensure capturing of weather data. This data should be made available to farmers and the general populace to guide effective adaptation strategies for agricultural activities.

II. Further studies should be carried out to broaden the scope of this study so as to encompass other climatic elements such as wind and dry spell and their interaction with other environmental variables such as nutrient availability and soil type.

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