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Evidence of Climate Change and the Perceived Changes in Climate Parameters by Smallholder Farmers in Gombe State, Nigeria

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Abstract:-We know the global climate is changing. This study presents study findings on the evidence of Climate Change and the perceived changes by smallholder farmers in GombeState,Nigeria. The objectives are to empirically examine changes in temperature, and the trends of change in rainfall totals, the number of rain days and rainfall normality; to determine the awareness of changes in climate by smallholder farmers in the state and to elucidate smallholder farmers' observed changes in temperature, rainfall, the onset and cessation of rainfall, and number of rain days. Both primary and secondary data were used. Rainfall and temperature data were obtained from the Upper Benue River Basin Development Authority (UBRBDA) for the period 1984-2014. The primary data were collected through interview schedules with 249 farmers from across Gombe state. Time series, descriptive and inferential statistics were used for the analysis. The findings reveal an increasing trend in temperature at 0.058^0C per/year, a decreasing trend in rainfall at -0.012 mm/year, and changes in the number of rain days.

Key words: *Climate Change, Temperature, Rainfall, Perceived impact, Gombe State*

I. INTRODUCTION

The world's climate is changing due to various factors from within and outside the climate system (United Nation Framework Convention on Climate Change, UNFCCC, 2007). Climate change is any significant variation in the measure of climate parameters such as temperature, rainfall, wind, and relative humidity over a long period of time ranging from three to six decades, (Pender, 2008). Climate change is a consequence of global warming caused by both natural processes and human activities that have caused an accumulation of heat-trapping (UNFCCC, 2007).There are evidences of climate change on all continents with increasing trend in warming temperature, varying rainfall patterns, more frequent extreme weather events such as wind storm, high rainfall intensity, flood, drought, heat waves, sea level rise along coastal regions and melting glaciers in polar and mountainous regions (UNFCCC, 2007 and ONCHR, 2009). The impacts of climate change are being experienced on every continent on agriculture, water resources, human health, terrestrial ecosystems and biodiversity and coastal zones (UNFCCC, 2007). Widespread incidences of higher than normal temperatures/heat waves, heavy rainfall, floods, extreme winters, heavy snow blizzards, droughts, bush fires, more frequent and severe extreme weather/climate events, changes in average weather parameters linked to climate change are common occurrences that have so far characterised the 21st century (Lavell*et al*, 2012; Nokkala, 2012; Rummukainen, 2012; Vardoulakis and Heaviside, 2012; Hughes and Fenwick, 2015; Steffen and Fenwick, 2016). Evidently "each of the last three decades has been successively warmer than any preceding decades since 1950" (Vergano, 2013).Developing countries in general and poor rural African smallholder/subsistence farmers, are in particular the most vulnerable to climate change due to their predominant dependence on rain-fed agriculture and the subsequent exposure to the vagaries of weather (Zinyowera*et al,* 1998; Whitmarsh, 2007; AMCEN, 2011; Overseas Development Institute and Climate & Development Knowledge Network, 2014). The developing countries in addition have fewer resources to adapt due to widespread poverty that limits their adaptation capabilities (Whitmarsh, 2007; UNFCCC, 2007). Changes in precipitation and evaporation have direct effect on crop and water use. Changes in precipitation also affect both rain-fed agriculture and irrigation due to effects on water supply and changes in river flow regimes. Warmer temperature also increases the water holding capacity of the atmosphere and increase evapotranspiration with consequences on crop production (Trenberth, *et al* 2007). It is projected that climate change will cause a decrease in rain fed crop yields by up to 50% by year 2020 which has already started (IPCC, 2007).There are however uncertainties of how climate change will continue to influence weather and climate in terms of definite local settings around the world (Lavell*et al,* 2012 and Otto, 2015). The latest (5th) IPCC report also reveals that the impacts of climate change are more urgent, intense and devastating than previously projected by the earlier reports (Howard, 2014; IPCC, 2014). Nigeria is concerned with climate change as

diverse ecological problems linked to climate change are being experienced. Evidences in rainfall irregularities in the southern parts and increasing temperatures in the Guinea savannah in the north; crop failures and increased hunger, poverty, malnutrition, diseases and the abandonment of farming are some of the reported impacts experienced in some parts of Nigeria (Bello *et al*, (2012).Adaptation by various sectors especially agriculture by smallholder farmers is of paramount importance as they supply most of the food consumed in Nigeria. The questions that require answers in specific localities are. One is there evidence of climate change in particular locations in Nigeria? Two, are smallholder farmers aware of climate change? What are the observed locality specific changes in climate being experienced by smallholder farmers? This paper presents study findings on Evidence of Climate Change and the perceived changes in climate parameters by smallholder farmers in Gombe State, Nigeria.

The objectives of the paper are:

i. To empirically determine changes in temperature, and the trends of change in rainfall totals, the number of rain days and rainfall normality in Gombe state
ii. To determine the awareness of changes in climate by smallholder farmers in the State and
iii. To elucidate smallholder farmers' observed changes in temperature, rainfall, the onset and cessation of rainfall, and number of rain days by smallholder farmers in Gombe state

II. MATERIALS AND METHOD

Both secondary and primary sources provided data for the study. The secondary data consists of the available daily temperature and rainfall, the onset and cessation dates of rainfall and the number of rain days was obtained from the Upper Benue River Development Authority (UBRBDA) station at DadinKowa for the determination of trends in rainfall, temperature and number of rain days for the period 1984-2014.To determine farmers' awareness of climate change and their observed changes in temperature and rainfall, a list of Village Extension Areas (VEAs) was obtained from the Gombe State Agricultural Development Program (GSADP) from which three LGAs were randomly selected namely: Billiri, Kwami and Nafada. Two VEAs were randomly selected from each of the selected LGAs. Thereafter based on a list of registered farmers with the GSADP 2% of household heads were selected based on a stratified random sampling with the aim of purposively studying farmers with farming experience of at least 30 years (Table 1). A total of 249 smallholder household heads were selected. Structured interviews were conducted with the 249 smallholder famers for determining the awareness of climate change and the observed changes in temperature and rainfall. The 30 years' experience is based on the *a priori* assumption that they have experienced more variability in weather elements.

Table 1: Sample Population

LGA	Selected VEA	Number of Registered Farmers	Study Population
Billiri	Sansani	1069	21
	Todi	1807	36
Kwami	Malleri	2074	41
	Kwami	3621	72
Nafada	Jigawa	2422	48
	Nafada	1561	31
Total		12554	249

The interviews sought to determine the farmers' awareness of climate change and the changes in climatic parameters that they have observed in terms of temperature and rainfall. The changes in temperature were in terms or increases or decreases. The changes in rainfall were for determining their perceived changes in terms of decrease or increase, changes in the onset and cessation of rainfall dates and the number of rain days. The study also sought to determine farmers observed impacts of climate change on their farming activities.

Both qualitative and quantitative techniques were used to analyse the data obtained. Time series analysis was used to determine the trend of temperature and rainfall for the period 1984-2013. Least square criterion was used to determine the line of best fit.

The equation is:

$$Y_t = a + bt + e_t \quad \text{.....(1)}$$

Where $Y_{t=}$ the amount of rainfall or temperature

a = intercept

b= slope, which measures the rate of change in rainfall or temperature with time t

$e_{t=}$ random error component

Simple correlation coefficient (r) was used to determine whether the trend in the time series analysis is upward or downward. Positive (r) indicates an upward trend and negative (r) indicates a down ward trend in the time

series.Farmers' awareness, observed changes in temperature, rainfall, onset and cessation of rain days and observed impacts of climate change were analysed using cross tabulations and percentages.

III. RESULT AND DISCUSSION

Changes in Temperature

Temperature is changing in Gombe State. Time series analysis of temperature in Gombe state for the period 1984 – 2013 (Figure 1 and Table 2) shows an increasing trend. The highest mean temperature of 36.30 ^{0}C was recorded in 1990 and the lowest mean temperature of 19.1^{0}C was recorded in 1986. The mean temperature is 32.1 ^{0}C with 5.09 ^{0}C standard deviation. The trend in increase per year is 0.058. There is an increasing trend of temperature at 0.092^{0}Cper/year.This finding is in agreement with the scenarios reported by BNRCC (2011) which showed an increasing trend of temperature in northern Nigeria. This means that there is a real and significant rise in temperature. The implication of the upward trend in temperature will be the wilting of crops, delay in the growth of crops, high evapotranspiration and heat stress in the study area.

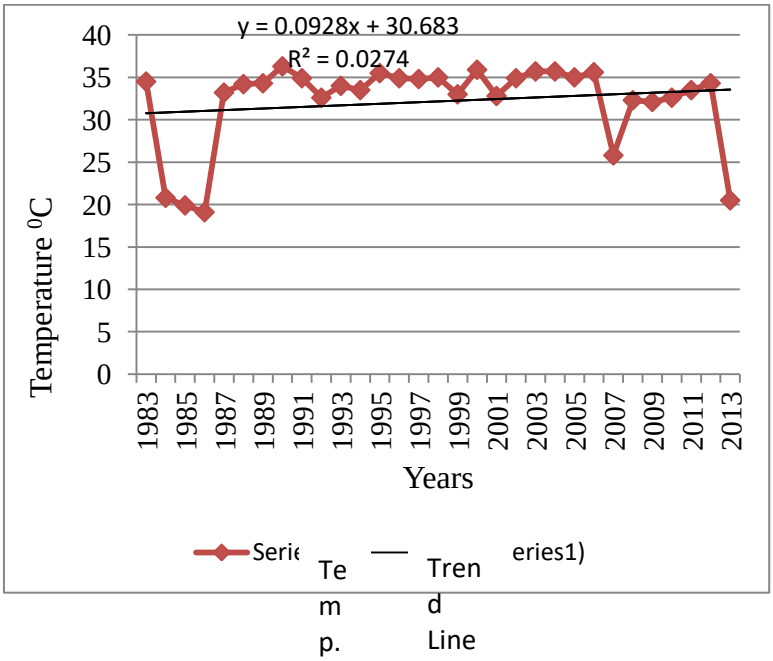

Fig 1: Temperature Trend

Table 2: Analysis of Temperature from 1984-2013

Mean Tem.	**Value**
Mean(^{0}C)	32.10
Standard deviation (^{0}C)	5.097
Maximum Temperature (^{0}C)	36.30
Minimum Temperature (^{0}C)	19.10
Trend (^{0}C/year)	0.058
Correlation	0.062

Changes in Rainfall Totals

Rainfall totals between 1984–2014 shows a decreasing trend as presented on Figure 2 and Table 3. The highest rainfall for the period was 1111.0 mm recorded in 1988 and the lowest value of 508.0 mm was recorded in 1987. The mean and standard deviation values are 842.4 mm and 140.88 mm respectively. The coefficient of the trend is – 1.705 per year. Which indicate a decreasing trend in rainfall totals.This finding is in agreement with BNRCC (2011) report that showed a decreasing trend in rainfall in northern Nigeria. The downward trend in the time series implies reductions in the crop yield.

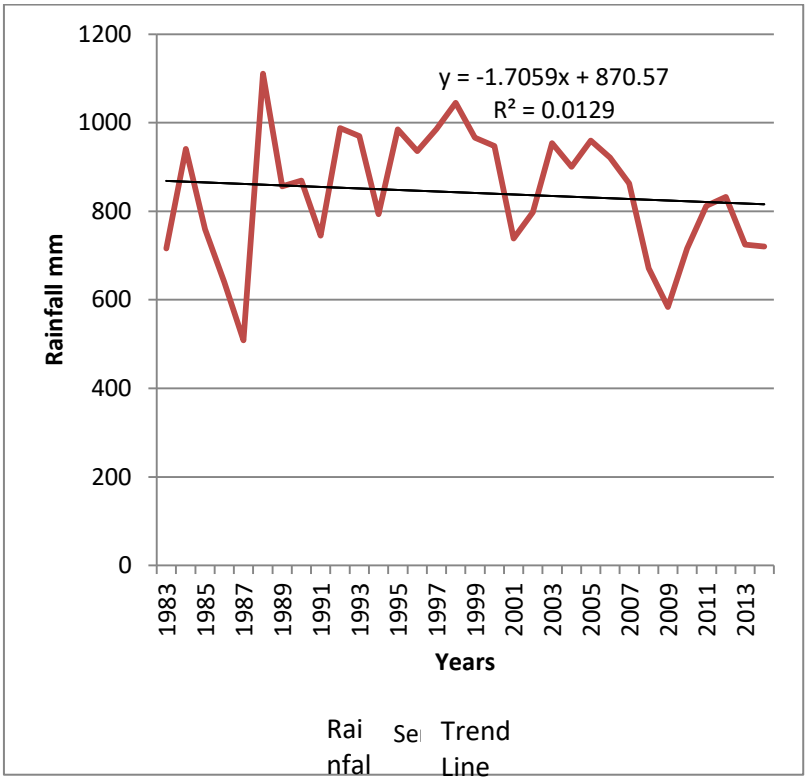

Fig 2: Rainfall Trend

Table 3: Analysis of Rainfall from 1983-2014

Rainfall in Millimetres (mm)	
Highest	1111.0
Lowest	508.0
Mean	842.42
Standard deviation	140.88
Trend (mm/year)	-0.012
Correlation	0.137

Change in the Number of Rain days

Time series analysis of the number of rain days presented on Figure 3 and Table 4 reveals a downward trend in the number of rain days per annum which indicate that the number of rain days is reducing in Gombe State. The implication of the reducing trend in total rainfall and the reducing trend in the number of rain days on crops is most probably through reductions in crop yield. When the number of rain days is concentrated in a few months, crops that have longer cycles are disadvantaged. Also long rain day intervals of seven to fourteen days, will affect the growth of the crops and their yields.

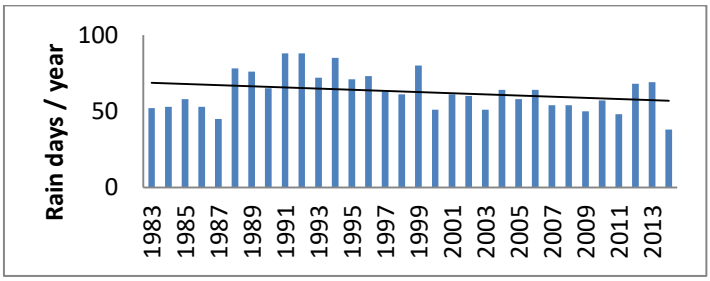

Fig 3: Number of Rain Days showing a Decreasing Trend

Table 4: Analysis of Rain days from 1983-2014

Number of Rain Days	Value
Mean	63
Standard deviation (days)	13
Maximum Rain day	88
Minimum Rain day	38

Rainfall Normality

The distribution of rainfall between 1983 and 2014 showed a deviation from the mean line which implies that rainfall is not normally distributed as shown in Figure 4. The mean number of rain days is 63 days; the highest (maximum) number of rain days is 88 which occurred in 1991 and 1992; the lowest (minimum) number of rain days is 38 days which was in 2014; the standard deviation is 13 days. The deviation from the mean rain day and the standard deviation is high; this implied that the rain days in the study area was not normally distributed.

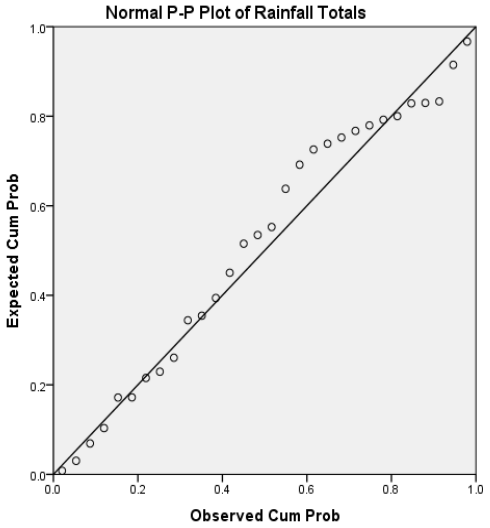

Fig. 4: Normal Probability Distribution Plot of Rainfall

All the changes have implications on biodiversity. Observed Changes in Africa's biodiversity was reported by the World Wide Fund for Nature (WWF) and African Development Bank (AfDB) (2012).

Smallholder Farmers Perceived Changes in Climate Parameters

Interview with smallholder farmers revealed the following findings on their observed or experienced changes in temperature in terms of increase, decrease or no change; changes in rainfall in terms of increase, decrease or no change; changes in the number of rain days; and changes in the onset and cessation of rainfall.

Perceived Changes in Temperature

The findings on the observed changes in temperature presented on Table 5 shows that the majority of farmers (180) who constituted 71.29% of the study population perceived an increase in temperature; 43 (17.3%) perceived a decrease; 9 (3.6%) did not perceive any change and 6.8% were not sure of change. It can thus be stated that temperature has increased in Gombe state.

Table 5: Perceived Change in Temperature

Increase	Decrease	No Change	Not Sure
180 (72.29)*	43 (17.27)	9 (3.61)	17 (6.83)

*Figures in brackets are percentages

Perceived Changes in Amounts of Rainfall

Farmers perceived decreases in rainfall totals in Gombe state as presented on Table 6. As many as 176 (70.68%) perceived a decrease in the amount of rainfall in Gombe state. Almost 20% perceived an increase; 6.83% did no perceive any change and 2.81% were not sure of changes.

Table 6: Perceived Changes in Amounts of Rainfall

Decrease	Increase	No Change	Not Sure
176 (70.68)*	49 (19.68)	17 (6.83)	7 (2.81)

*Figures in brackets are percentages

Perceived Changes in the Onset and Cessation of Rainfall

Farmers' perceived changes in the onset of rainfall presented on Table 7 reveals the following. One, a higher proportion of the farmers who constitute 54.62% of them perceived delays in the onset of the rains. Two, about 21% perceived earlier delays. Three, 14.46% and 10.04% perceived no change and were not sure respectively.

Table 7: Perceived Changes in the Onset of Rainfall

Delay	Early	No Change	Not Sure
136 (54.62)*	52 (20.88)	36 (14.46)	25 (10.04)

*Figures in brackets are percentages

As many as 148 (59.44%) farmers perceived an earlier than normal cessation of rainfall in Gombe state. 21.29% of the respondents did not observe changes in the cessation of rain. Only 14.46% and 4.82% of the farmers observed delays in the cessation of rain or were not sure of changes in cessation of rains respectively.

Table 8: Change in the Cessation of Rainfall

Delay	Earlier	No Change	Not Sure
36 (14.46)	148 (59.44)	53 (21.29)	12 (4.82)

*Figures in brackets are percentages

The perceived change in temperature, rainfall totals, and changes in the onset and the cessation of rainfall are important in crop production cycles as they which have direct impacts on the livelihood of the respondents. This is so as farmers' perception will affect how they cope with real changes. Changes in climatic parameters affect crop yields which require adaption by farmers. The implication of the perception of changes can also result in the immaturity of crops when planted late or the spoilage of crops when planted early as it gets ripened earlier than the end of the rainfall.

IV. CONCLUSION AND RECOMMENDATIONS

Based on both the time series and interviews with farmers it can be concluded that there in an increasing trend of temperature and a decreasing trend in rainfall in Gombe state. There is an increasing trend in temperature at 0.092^{0c} per/year, a decreasing trend of rainfall at -1.705mm per/year and a decreasing trend of rainy days. The rainfall is also not normally distributed. Smallholder farmers in the state have also observed increases in temperature, decreases in rainfall totals, and changes in the onset and cessation of the rains which are in line with the analysis of data albeit for just 31 years. The consequences of the changing climate on livelihoods can be inferred since smallholder farmers depend on harvest solely based on from rain fed cropping with no irrigation as of now.

The following recommendations are made

1. There should be more studies on locality specific coping/adaptations strategies to climate change in Gombe and other states in Nigeria
2. Stakeholders should be encouraged to assist farmers in adopting new crops as a climate change coping strategies
3. Farmers should be enlightened and encouraged to adopt irrigation farming where feasible as a way of coping with water stress indiced by climate change

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