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INFLUENCE OF CLIMATE CHANGE ON ADOPTION OF AGRICULTURAL TECHNOLOGIES BY FARMERS IN KATSINA STATE, NIGERIA

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Abstract

The aim of this study is to examine the influence of climate change on the adoption of agricultural technologies by farmers in Katsina State. Three hundred and sixty-one copies of a questionnaire were administered to Climate Change Adaptation and Agribusiness Strategies Programme participating crop production farmers, but only 315 were returned and used for the analysis. Focus Group Discussions and Key Informant interviews were also conducted. Temperature and rainfall data (1990 – 2019) were used for the analysis. Descriptive statistics were used to analyze the perception of the farmers. Linear regression and polynomial curve fitting were used to analyze the trends of temperature and rainfall, while regression analysis was used to determine the influence of the adoption of climate change-related agricultural technologies on crop yield. The trends of temperature indicated that the minimum, maximum, and average temperatures were increasing at the rate of 0.006 °C, 0.004 °C and 0.035 °C per annum, respectively. The annual rainfall also revealed an increasing trend of about 11.28 mm/annum. The second-order polynomial curve fitting also showed a growing trend in both the temperature and annual rainfall. The finding on the relationship between adoption of agricultural technologies and crop yield was positive (p-value=0.000).. The coefficient of determination was 0.126, meaning that the adoption of agricultural technologies was responsible for 12.6% of the variation in yield. The study recommended that sustainable adaptation strategies and Climate Smart Agriculture need to be encouraged among farmers in order to mitigate the risk associated with climate change.

Keywords: Climate change, Crop yield, Farmers, Rainfall, Temperature.

Introduction

Climate change is a global phenomenon that is virtually impacting all aspects of human life ranging from agriculture, health, politics, and economy, among others. However, the worst affected is agriculture. Recent statistics have indicated that recurrent droughts, desertification, and floods are seriously threatening the livelihood of over 1.2 billion people who depend on agriculture and its related activities for most of their needs (Prasada, 2008). Also, empirical evidence indicated that extreme weather events such as an increase in temperatures, changes in precipitation patterns, and reduction in water availability may result in reduced agricultural productivity (Dickson, 2010).

In Nigeria, extreme weather and climate events may be gradual, but their destruction of lives and properties has a negative impact on the economy. According to Tanko (2010), the northern part of Nigeria, with its high population and high vulnerability to climate shocks due to its dependency on agriculture for livelihoods, is being threatened by the impact of climate change. The immediate impacts of climate change, as experienced by the rural dwellers who are predominantly farmers, include a reduction in agricultural yield, early cessation of rainfall, and drying up of watering points after the rainy season, among others (Ahmad, 2016).

Agriculture is one of the major economic activities in northern Nigeria, particularly in the extreme northern States of the country, including Katsina. Several studies on climate change in Katsina State (for example, Abaje *et al.*., 2009; Abaje *et al.*., 2016;

El-ladan, 2017) concentrated more on farmers' perception and adaptation strategies, but little is known about how these farmers respond to these adaptation and mitigation strategies, specifically concerning the adoption of agricultural technologies as a coping strategy on crop production. It is believed that farmers in Katsina State and Nigeria at large are susceptible to the adverse impacts of climate change on their livelihoods. It is on this basis that several organizations have brought agricultural-related technologies for farmers to adopt. One of these organizations is International Fund for Agricultural Development (IFAD). Thus, the need to know how these farmers respond to these technologies, specifically the adoption of agricultural technologies as a coping/adaptation strategy on crop production.

Based on the aforementioned, this study aims to examine the influence of climate change with respect to the response made by farmers on the adoption of agricultural technologies as coping and mitigating measures against climate change in Katsina State.

Study Area

The study area comprised three Local Government Areas (LGAs) of Katsina State, namely, Batsari, Jibia and Kaita, located in the Northwestern part of the State. Geographically, the area lies between Latitudes 12° 54′ and 13° 10′ N and Longitudes 7° 03′ and 7° 34' E (Figure 1).

The climate of the study area is the tropical wet and dry type, classified by Köppen as Aw climate. The wet season occurs between May and September, with a peak in August, while the dry season extends from November of one calendar year to April of the subsequent year. Rainfall is between 550 mm-700 mm per annum. Seasonal variation in rainfall is directly influenced by the interaction of two air masses that modulate weather in the study area: the relatively warm and moist tropical maritime (mT) air mass and the relatively cool, dry and stable tropical continental (cT) air mass. The boundary zone between these two air masses is called the Inter-Tropical Discontinuity (ITD) (Abaje and Ogoh, 2018).

Figure 1: Study Area

Source: Adapted from the Office of the Surveyor General, Katsina State (2019)

The highest air temperature is between 38 °C and 40 °C, which normally occurs in April/May, while the lowest temperature of about 21 °C to 23 °C occurs in December through February of the subsequent year. Evapotranspiration is generally high throughout the year. However, the highest amount of evaporation occurs during the dry season (Abaje *et al..*, 2017). The area is characterized by four seasons, namely: dry and cool season (*rani*), which lasts from mid-November to the end of February of the subsequent year; the dry and hot season (*bazara*), which begins from March to mid-May; the wet and warm season (*damina*) which lasts from May through September, over 90% of the annual rainfall is recorded during this season; and, the dry and warm season (*kaka*) which starts at the end of the rains to mid-November with the onset of the harmattan (Abaje *et al.*, 2016).

The landforms are sandy plain, but it is common to find deposits of sand dunes of varying degrees, especially when one moves northward around Daddara and Dankama in Jibia and Kaita LGAs, respectively. These sand dunes are formed from the deposition of erosive materials carried along by strong winds across the Sahara desert, especially during harmattan (Abaje *et al.*, 2017). The soils are coarse deposits influenced by Aeolian process. These soils are well suited for the production of millet (*Pennisetum typhoidium*), groundnut (*Arachis hypogeal*), sorghum (*Sorghum bicolar*), cowpea (*Vigna unguiculata*), and sweet potatoes (*Ipeoma batatas*) (Abaje *et al.*, 2017).

Material and Methods

Data Collection

The target population for the study were climate change adaptation and agribusiness support programme participating farmers in Batsari, Jibia, and Kaita LGAs of Katsina State with a total population of 3,249. These participating farmers were drawn from the three communities in each of the participating LGAs. The LGAs and their participating communities include Batsari (Kasai, Ruma and Yauyau), Jabia (Daga, Farfaru and Zandam), and Kaita (Abdallawa, Ba'awa and Yanhoho). Based on the total number of participating farmers in each community, Bartlett *et al.* (2001) method was used to determine the sample size. The method is computed as follows:

$$n_0 = \frac{(t)^2 \times (p)(q)}{(d)^2} \text{ --------------------eq.1}$$

for sample size of not more than 5%.

Therefore, the required sample size for the population (*N*) of the study area is calculated as:

$$n_1 = \frac{n_o}{1 + {n_o}/{N}} \text{ ------------------------- eq.2}$$

and

$$n_2 = n_0 \Big/ \left(\frac{r}{100}\right) \text{----------------------- eq.3}$$

for the adjusted sample size for a response rate

where: t = value for a selected alpha level of 0.025 in each tail, which is 1.96

(p)(q) = estimate of variance, which is 0.25

d = acceptable margin of error for the proportion being estimated which is 0.05

$_0n$ = sample size of not more than 5%

n_1 = required return sample size

n_2 = sample size adjusted for response rate

N = population size

r = anticipated response rate assumed to be 95%

Based on this method, a total of 361 questionnaires with an anticipated response rate of 95% were administered to a group of purposively-selected registered climate change farmers who are into crop production in the selected LGAs (Table 1).

Table 1: Sampled Local Government Areas and Number of Respondents in Each Community

LGA	Communities	Coordinates	Number of farmers	Sample size
Batsari	Ruma	12° 15' 28"N, 7° 15' 10" E	399	44
	Yauyau	12° 58' 44"N, 7° 16' 53" E	364	41
	Kasai	12° 41' 22"N, 7° 08' 27" E	387	43
Jibia	Daga	13° 05' 05"N, 7° 30' 50" E	189	21
	Zandam	13° 03' 31"N, 7° 14' 57" E	588	65
	Farfaru	13° 04' 02"N, 7° 12' 05" E	368	41
Kaita	Ba'awa	13° 07' 04"N, 7° 52' 10" E	405	45
	Yanhoho	13° 05' 09"N, 7° 41' 10" E	316	35
	Abdallawa	13° 07' 50"N, 7° 46' 52" E	233	26
Total			**3,249**	**361**

Source: Field Survey, 2020

Climate data (rainfall and temperature) were also obtained from the archive of the Nigeria Meteorological Agency (NiMet) Abuja. The data collected ranged from 1990-2019.

Questionnaire administration

Trained climate change officers that understood the local language (Hausa) conducted the interview with regular supervision from the authors. Information on the socio-economic characteristics of the farmers (size, age, level of education, farming experience, among others), perception of farmers on climate change, and their responses to the adoption of climate change-related agricultural technologies on crop yield were collected. In addition, Focus Group Discussion (FGD) and Key Informant interviews (KII) were also conducted to obtain in-depth knowledge on climate change and agriculture in the study area.

Data analysis

Descriptive statistics were used to analyze and present the data on the socio-economic characteristics of the farmers, their perception of climate change, and responses to the adoption of climate change-related agricultural technologies on crop yield. However, regression analysis was used to test whether a significant relationship exists between adopting agricultural technologies and crop yield.

The standardized coefficients of Skewness (Z_1) and Kurtosis (Z_2) statistics, as defined by Brazel and Balling (1986), were used to test for the normality in the temperature and rainfall series for the study area. The standardized coefficient of Skewness (Z_1) was calculated as:

and the standardized coefficient of Kurtosis (Z_2) was determined as:

$$Z_1 = \left[\left(\sum_{i=1}^{N} (x_i - \bar{x})^3 / N \right) \Big/ \left(\sum_{i=1}^{N} (x_i - \bar{x})^2 / N \right)^{3/2} \right] \Big/ \left(6/N \right)^{1/2} \quad \text{… eq. 4}$$

and the standardized coefficient of Kurtosis (Z_2) was determined as:

$$Z_2 = \left[\left(\sum_{i=1}^{N} (x_i - \bar{x})^4 / N \right) \Big/ \left(\sum_{i=1}^{N} (x_i - \bar{x})^2 / N \right)^{2} \right] - 3 \Big/ \left(24/N \right)^{1/2} \quad \text{… eq. 5}$$

where x is the long-term mean of $_ix$ values, and N is the number of years in the sample. If the absolute value of Z_1 or Z_2 is greater than 1.96, a significant deviation from the normal curve is indicated at the 95% confidence level.

Simple linear regression was used to detect the trend of rainfall and temperature and make a discernible decision concerning the increase or decrease (change) in their distribution within the study period. The linear regression equation is expressed as follows:

$y = a + bx$ ………… eq. 6

where: y = rainfall (mm)/temperature (°C)

a = the intercept of the regression line on the y-axis

b = the level of the slope of the regression model

x = time in years

Furthermore, second-order polynomial curve fitting was used to determine the non-linear trends of both rainfall and temperature. The equation is given as:

$y = a + b_1 x + b_2 x_2 + bkx^k$ ………eq. 7

In equation (5) all the terms have the same meaning as described in equation (4). By analyzing the data, y is replaced by the annual value of rainfall and temperature which are the dependent variables. While x is the time in a year and was used as the independent variable.

In order to determine whether there is a significant relationship between climate change awareness and the adoption of agricultural technologies and crop yield in the study area, regression analysis was employed. The dependent variables are the yield and income of the farmers in the study area, while the independent variable is the adoption of agricultural technologies. The dependent variables were obtained by summing up the total income obtained from the realistic monetary values of the farmers' yield in the study area. It is explicitly explained as follows:

$Y = f\,(a + b_1x_1 + b_2X_2 + b_3X_3 \ldots\ldots\ldots\ldots + U_1$ -------eq. 8

where: Y = Summed up income, yield in monetary value.

X_1 = Use of drought-resistant crop varieties

X_2 = Use of early maturing crop varieties

X_3 = Use of good and sustainable soil management practices

X_4 = Use of pests and diseases resistant crop varieties

X_5 = Early plating

a = Constant term

U_1 = Error term

$b_1 - b_5$ = Regression coefficient of $X_1 - X_5$

Results and Discussion

Respondents' socio-economic characteristics

The result in Table 2 revealed that the majority (80.6%) of the respondents were male. This may not be unconnected with the culture and religion of the people in the study area that confined women in their matrimonial homes (purdah), thus not actively involved in agricultural activities beyond threshing and food processing in their respective homes. The finding agrees with Udeh (2014) who reported that religion discriminates against certain social activities in some areas. The result also corresponded with the findings of Tarfa *et al.* (2019) that male-headed households are more predominantly involved in agricultural activities than female-headed households. They further believed that men have more access to agricultural resources than women, thus adopting more readily to climate change than females.

Table 2 further revealed that 4.1%, 22.9%, 37.8%, 34.9% and 0.3% of the respondents were aged between 20 -29, 30 – 39, 40 – 49, 50 – 59 and above 60 years, respectively, while the average age of the farmers pegged at 45 years. This implies that middle age and elderly people are more involved in farming. This study agrees with Banmeke and Fapojuwo's (2011) findings that farming occupation is mainly dominated by the elderly and is common in rural areas of Nigeria. The finding also indicated that youth are not actively involved in farming, and if the trend continues, there will be a decline in food crop production in the study area. The results matched with Otitoju (2016) findings, which suggested that food crop production is not witnessing the injection of able body youths. Concerning marital status, the finding shows that most of the respondents (80.6%) are married. About 8.3% were single, while 10.2% and 1.0% were widowed and divorced, respectively. This indicates that most of the participating farmers

Table 2: Socio-economic Characteristics of the Respondents

Household Characteristics	Frequency	Percentage	Mean
Gender			
Male	254	80.6	
Female	61	19.4	
Age			
20-29 years	13	4.1	
30-39 years	72	22.9	
40-49 years	119	37.8	45
50 and 59 years	110	34.9	
Above 60 years	1	0.3	
Marital Status			
Single	26	8.2	
Married	254	80.6	
Widowed	32	10.2	
Divorced	3	1.0	
Number of Dependents			
1-5	74	23.5	
6-10	156	49.5	
11-15	58	18.4	9
16-20	17	5.4	
21 and above	10	3.2	
Educational Background			
Primary education	68	21.6	
Secondary education	65	20.6	
Religious education	127	40.3	
Tertiary education	41	13.0	
No formal education	14	4.5	
Farm Size			
Less than one hectare	31	9.8	
1 to 2 hectares	155	49.2	2
3 to 4 hectares	101	32.1	
5 hectares and above	28	8.9	

Source: Field Survey, 2020

are in their adulthood stage. The findings are also in line with Ajayi (2015), who believed that marriage is an important aspect of adulthood in African societies, thus, individuals who attain marriageable age are independent and have to fend for themselves outside the comfort of their parent's home. The majority of the respondents (49.5%) have a household size of 6 – 10. Large household size is believed to provide cheap labour that will assist in practices that would minimize the impacts of climate change (Abaje *et al.*, 2014).

Regarding educational background, 40.3% of the respondents have obtained religious education. The study further revealed that 21.6%, 20.6% and 13.0% attended primary, secondary and tertiary education, respectively. A negligible number of the respondents (4.4%) have no formal education, meaning they have never attended school. Education is believed to increase one's ability to receive, decode and understand information relevant to making innovative decisions. Also, literacy and numeracy levels are vital factors that may determine the understanding and perception of risk associated with climate change (Ajayi, 2015). The majority (49.2%) of the respondents have a farm size of 1 -2 hectares. Only 9.8% and 8.9% of the respondents have less than one hectare and 5 hectares and above, respectively, as depicted in Table 2. About 32.1% have farm size ranging between 3 – 4 hectares. Farm size depends on respondents' socio-economic status (Umar, 2014).

Perception of climate changes (temperature and rainfall) in the last 30 years

Perceived temperature changes

Table 3 shows the perceived temperature changes in the last 30 years. The majority (87.3%) of the respondents observed an increase in temperature in the study area during the previous 30 years. 8.9% perceived a decrease in temperature in the last 30 years, while 1.6% perceived no change in temperature. The result is in tandem with Abirham and Zebene (2019), whose finding indicated that temperature has increased from time to time in the last three decades. These findings also corresponded with the works of Abaje et al. (2014); Idoma and Yakubu (2020), whose study agreed that temperature has increased over the last 30 years. According to Oladipo (2011), Nigeria has been experiencing an increase in temperature of about 0.2°C -0.3°C per decade in all its ecological zones. One of the participating farmers from Jibia during the FGD said that "climate change is a change in weather such as high temperature and decrease in rainfall that affect agricultural activities".

Table 3: Perceived Temperature Changes in the Last 30 Years by the Respondents

Trends/ characteristics	Frequency	Percentage
Increasing	275	87.3
Decreasing	28	8.9
No change	5	1.6
Undecided	7	2.2
Total	**315**	**100.0**

Source: Field Survey, 2020

Perceived rainfall changes

Table 4 shows that the majority (67.3%) of the farmers agreed that rainfall has decreased in the last 30 years. 29.2%, 1.3% and 2.2% assessed rainfall trend over the previous 30 years as increasing, no change and undecided, respectively. The decrease in rainfall as perceived by the respondents agrees with some of the earlier conclusions drawn by Oladipo (1993) and Sawa (2002) on the rainfall trends of northern Nigeria but in contrast with other recent related studies in the area. For example Abaje *et al.* (2013), Udeh (2014), Abaje and Ogoh (2018), Abaje and Oladipo (2019), and Ati *et al.* (2022) using observed rainfall data found that the northern part of the country, especially the sudano-sahelian ecological zone is now experiencing wetter conditions in recent years. The decreased in rainfall in the study area as perceived by the respondents may not be unconnected with the shrinking in the length of rainy season. Based on their perception, it is believed that as the length of rainy days decreases, the total (annual) rainfall is also affected negatively.

Majority of the respondents (67.3%) agreed that the intensity of rainfall is decreasing. The result is similar to the work of Akpan *et al.* (2018) and Idoma and Yakubu (2020) whose findings revealed decrease in rainfall intensity with an increase in duration for a given period of time. The frequency of the rainfall as indicated in Table 4, shows that the majority (70.2%) of the respondents agreed that rainfall frequency is decreasing, 27.0% and 2.9% believe that the frequency of rainfall is increasing, and no change respectively. The result on the intensity and frequency of rainfall in the study area is contrary to Westra, *et al.* (2014) findings, which revealed that rainfall intensity is increasing and is likely to occur in short-duration storms, leading to an increase in the magnitude and frequency of flash floods. Regarding onset and cessation of rainfall, the result shows that 69.2% of the respondents agreed that the onset of rainfall in the study area is always late.

Table 4: Farmers' Perceived Rainfall Changes in the Study Area

Rainfall Characteristics	Frequency	Percentage
Annual rainfall		
Increasing	92	29.2
Decreasing	212	67.3
No change	4	1.3
Undecided	7	2.2
Intensity		
Increasing	90	28.6
Decreasing	212	67.3
No change	13	4.1
Frequency		
Increasing	85	27.0
Decreasing	221	70.2
No change	9	2.9
Onset		
Early	72	22.9
Late	218	69.2
Normal	25	7.9
Cessation		
Early	209	66.3
Late	77	24.4
Normal	29	9.2

Source: Field Survey, 2020

On the other hand, the result obtained from the respondents on the cessation of rainfall in the study area depicts that the majority (66.3%) assessed it as early. The delay in the onset dates of rains and early cessation dates of rains is in agreement with the findings of Adebayo *et al.* (2012) in Adamawa State and Amadou *et al.* (2015) in the Upper East Region of Ghana. One of the participants of the FGD held in Kaita revealed that: "I noticed late onset of rainfall and early cessation of rainfall which is affecting our agricultural productivity and is subsequently reducing our income to the extent that we cannot take care of some of our family needs".

Observed climate changes (temperature and rainfall) in the last 30 years

Observed Temperature Changes

The result of the descriptive statistics of temperature in the study area is shown in Table 5. The mean minimum, maximum and average temperatures are 19.80°C, 33.92°C and 26.87°C respectively. The result further revealed the minimum, maximum and average temperature standard deviation to be 1.02, 0.49 and 0.61 respectively. The Kurtosis and Skewness are both normal at 95% confidence level.

Figure 2(a-c) is the graphical presentation of the study area's annual minimum, maximum, and average temperature in the last 30 years (1990 – 2019). A closer look at the results revealed that the temperature has been increasing throughout the study period.

The linear trend line indicates an increase of about 1.98°C in the last 30 years at a rate of 0.066 per annum (Figure 2(a)). The result of the second-order polynomial curve fitting shows an increasing trend within the study period (1990 – 2019). The linear trend lines of the annual maximum and average temperature also indicate an increase. There is an increase of about 0.132°C in the last 30 years at a rate of 0.004 per annum for the annual maximum temperature (Figure 2(b)), and an increase of 1.05°C at the rate of 0.035 per annum for the average temperature (Figure 2(c)). Just like the annual minimum temperature, the second-order polynomial curve fitting shows an increasing trend in both the annual maximum and average temperature within the study period (1990 – 2019). This clearly indicates climate change in the area leading to global warming.

Table 5: Descriptive Statistics of Temperature

Variables	Annual Min. Temp. (°C)	Annual Max. Temp. (°C)	Average Annual Temp. (°C)
Mean	19.83	33.92	26.87
Standard Deviation	1.02	0.49	0.61
Kurtosis	-0.04	0.29	-0.61
Skewness	-0.64	-0.05	-0.36
Range	4.21	2.26	2.25
Minimum	17.38	32.78	25.75
Maximum	21.59	35.03	27.99
Trend (^{0}C/annum)	0.066	0.004	0.035
Total Change (^{0}C/30 years)	1.98	0.132	1.05

Source: Authors' Computation, 2020.

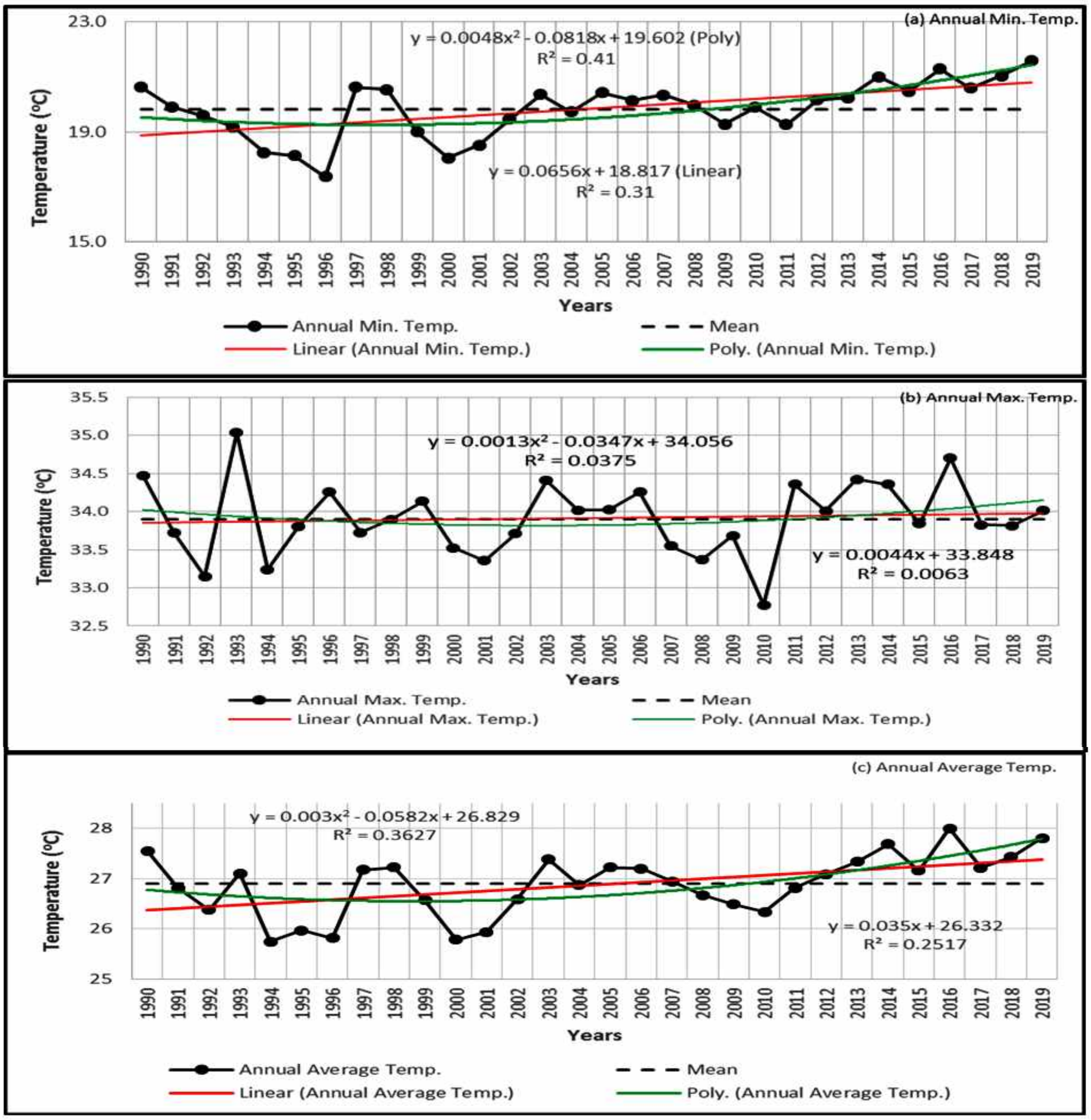

Figure 2: Annual Temperature Trends of the Study Area (1990 – 2019) for: (a) Annual Minimum Temperature, (b) Annual Maximum Temperature, and (c) Average Temperature

Observed Rainfall Changes

A careful observation of the result of descriptive rainfall statistics in the study area indicates the mean annual rainfall as 576.13 mm, while the standard deviation is 171.6. The minimum and maximum values of rainfall for the period under study were found to be 262 (1993) and 956 (2010), respectively. The rainfall distribution is normal at 95% confidence level as indicated by the Kurtosis and Skewness.

Figure 3 is the graphical representation of annual rainfall in the study area for the period under study (1990 – 2019). The linear trend line shows an increase in the annual rainfall of about 338.40 mm in the last 30 years at the rate of 11.28 mm per annum. The second-order polynomial curve fitting shows an increasing rainfall trend from the beginning of the study period to the end (1990 – 2019).

Table 6: Descriptive Statistics of Rainfall

Variables	**Statistics**
	Annual Rainfall (mm)
Mean	576.13
Standard Deviation	171.5922
Kurtosis	-0.51557
Skewness	-0.18103
Range	693.7
Minimum	262
Maximum	955.7
Trend (mm/Annum)	11.28
Total Change (mm/30 years)	338.40

Source: Authors' Computation, 2020.

The increasing trends in rainfall from the observed data are at variance with the general perceptions of

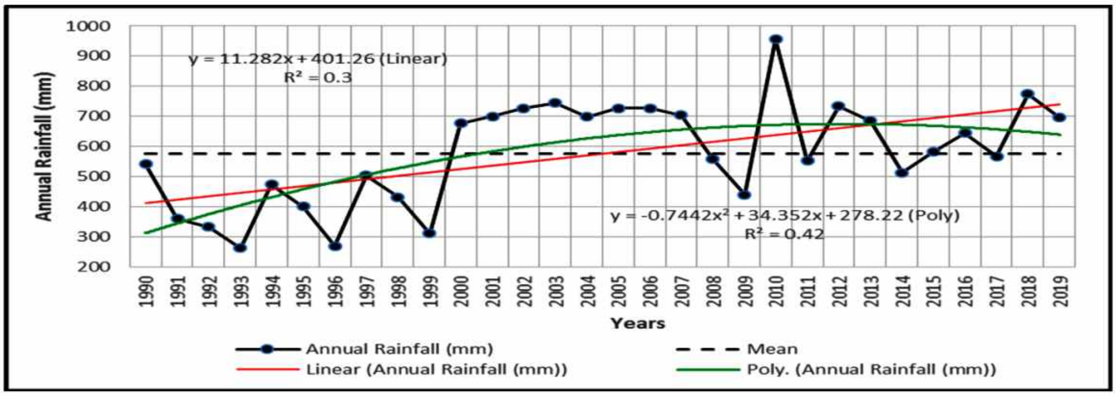

Figure 3: Annual rainfall trend of the study area (1990 – 2019).

the farmers that rainfall has been decreasing. This indicates that the farmers are unaware that even though the length of the rainy season has reduced, the observed rainfall amount is still high in recent years.

Influence of the adoption of agricultural technologies on crop yields as perceived by the respondents

At the individual level, Table 7 shows that the use of drought-resistant crop varieties (with a positive coefficient of 576.692) significantly increases the cropyield since the p-value (0.037) of the t-statistic (2.098) is smaller than the level of significance (α=0.05) which indicates that the null hypothesis is rejected. Similarly, the use of early maturing crop varieties, though with a negative coefficient of -1204.710 but can significantly increase crop yield since the p-value (0.000) of its t-statistic (-4.302) is far less than the level of significance (α=0.05) thus, the hypothesis is also rejected. However, the use of pests and diseases resistant crop varieties has a positive coefficient of 152.043 with a p-value (0.619) of the t-statistic (0.497) is greater than the alpha level of significance (0.05), the null hypothesis is accepted, and it deduced that there is no relationship between the variable (use of pests and drought resistant varieties) and crop yield. Finally, the use of good and sustainable soil management practices had a negative co-efficient of -97.355 and a p-value (0.730) of the test statistic (-0.346) is greater than the alpha level of significance (0.05); thus, the null hypothesis which state that "there is no relationship between the use of good and sustainable soil management practices and crop yield is accepted in the study area".

The above result indicates individual assessment of each of the adoption of agricultural technology. However, the combined influence of adoption of agricultural technologies can be assessed with the use of F-statistic. From Table 7, since the p-value (0.000) of the F-statistic (10.855) is smaller than the alpha level of significance (0.05), it, therefore, means that the null hypothesis, which states that "there is no significant relationship between adoption of agricultural technologies and crop yield in the study area" is rejected. It is therefore concluded that "there is a significant relationship between adoption of agricultural technologies and crop yield in the study area". This means that the adoption of agricultural technologies gives better crop yields. The R-square, which is the coefficient of determination, that is, the percentage of the total variation accounted for by all the variables, is 12.6%, meaning that overall, the influence of agricultural technologies on crops yield is low, however, the overall p-value (0.000) of the F-statistics (10.855) is smaller than the level of significant (α=0.05) suggesting a weak relationship between the yields and technologies adopted.

Table 7: Regression Coefficient of the Relationship between the Adoption of Agricultural Technologies and Crop Yield

Variable	Coefficient	Standard error	t-value	Sign-value
Constant	2642.413	276.530	9.556	0.000
Use of drought-resistant crop varieties	576.692	274.848	2.098	0.037
Use of early maturing crop varieties	-1204.710	280.027	-4.302	0.000
Use of good and sustainable soil management practices	-97.355	281.518	-0.346	0.730
Use of pests and diseases resistant crop varieties	152.043	305.707	0.497	0.619
R-squared	*0.126*			
Adjusted R-Squared	*0.115*			
Standard error of the estimate	*1958.11016*			
F-statistics (p-value)	***10.855(0.000)***			

Source: Authors' Computation, 2020.

Climate change and adoption of agricultural technology as observed by the respondents

Table 8 indicated that 96.5% of the respondents had encountered climate-related disaster on their farms. Only 3.5% of the respondents did not encounter climate-related disasters on their farms. Out of the respondents that encountered climate-related disasters 11.9%, 46.2%, 5.1%, 23.7%, and 13.1% have respectively experienced floods, drought, long dry spells, pests and diseases and soil erosion.

The table further revealed that the majority (99.4%) of the respondents' crops were affected by climate change, and only 0.6% that was not affected by climate change. Similarly, out of the respondents whose crops were affected by climate change 27.3%, 17.5%, 44.3%, 10.9% have respectively experienced increase in plants pest and disease incidences, decrease in soil fertility, wilting due to drought or dry spell and submerged of farmland by floods. Furthermore, when asked about coping strategies, the majority (41.9%) of the respondents used early

Table 8: Influence of Adoption of Agricultural Technology on Crop Yield by the Respondents

Responses	Frequency	Percentage
Do you experience any climate-related disasters on the farm?		
Yes	304	96.5
No	11	3.5
Type of disaster encountered		
Floods	49	11.9
Drought	191	46.2
Long dry spell	21	5.1
Pest and disease	98	23.7
Soil erosion	54	13.1
Does climate change influence crop production?		
Yes	313	99.4
No	2	0.6
How does climate change influence crop		
Increase in plants and disease incidence	108	27.3
Decrease soil fertility	69	17.
Wilting due to drought or dry spell	175	44.3
Submerge of farmland by flood	43	10.9
Coping strategies		
Planting of drought resistance crop variety	82	20.6
Planting of early maturing crop variety	167	41.9
Planting of pests and diseases resistance crop variety	69	17.3
Improve and sustainable soil management practice	81	20.3
Do you adopt agricultural-related technologies as a result of climate change?		
Yes	272	86.3
No	43	13.7
Reason for adoption		
Drought	155	43.8
Floods	49	13.8
Soil erosion	69	19.5
Prevalence of pests and diseases	61	17.2
Long dry spell	20	5.6
Effectiveness of the technology		
Excellent	46	14.6
Good	243	77.1
Fair	26	8.3
Is there any impact of adopting agricultural technology		
Yes	299	94.9
No	16	5.1
Nature of Impact		
Reduction in the incidence of pests and diseases of crop	59	16.3
Increase in soil fertility	61	16.9
Withstanding harsh weather conditions by crops	170	47.1
Reduction in soil erosion/flood	71	19.7

Source: Field Survey, 2020

maturing crop varieties to cope with climate change-related disasters. Others, 20.6%, 17.3%, and 20.3%, coped with climate-related disasters by planting drought-resistant crop varieties, planting of pests and diseases resistance varieties, and improving a sustainable soil management practices, respectively. According to one of the Key Informants interviewed, he stated that: "we assist farmers to cope with climate-related disasters through sensitization, awareness creation and demonstration on adaptation and mitigation measures".

Most of the respondents (86.3%) adopted agricultural technologies as a result of climate change, but only 13.7% adopted agricultural technology, not as a result of climate change (Table 8). The result further indicates that 43.6%, 13.8%, 19.5%, 17.2% and 5.6% of the respondents decided to adopt agricultural technologies due to drought, floods, soil erosion, the prevalence of pests and diseases and long dry spell, respectively.

Concerning the effectiveness of the technology used by the respondents, the majority (77.1%) of the respondents regarded the adopted agricultural technology as effective, 14.6%, and 8.3% as excellent and fair, respectively. None of the respondents indicated the effectiveness of technology as poor. In relation to the impact of the technology adopted, 94.9% and 5.1% of the respondents observed a positive impact and no positive impact, respectively. Consequently, out of the respondents that observed a positive impact from the technology adopted, 16.3%, 16.9%, 47.1%, and 19.7% had a reduction in the incidence of pests and diseases of crops, increase in soil fertility, withstanding harsh weather condition by crops and reduction in soil erosion/floods respectively.

Conclusion and Recommendations

Based on the findings, the result shows that farmers in the study area are aware of climate change, impacting agricultural production negatively. However, climate change awareness does not influence agricultural technology adoption among farmers in the study area, but the adoption of agricultural technologies paves the way for better agricultural productivity. Therefore, the creation of awareness to adopt technology among farmers, especially those dwelling in a rural area whose majority are poor, needs to be encouraged as technology boosts agricultural productivity hitherto improves income generation among the poor farming family, which may subsequently have a multiplier effect in the broader economy. Other recommendations for ensuring climate change resilience among farmers include incorporating climatologists into agricultural sectors to educate and enlighten farmers on the dangers of climate change on agricultural activities to encourage farmers to adopt Climate Smart Agriculture (CSA); promoting extension services thereby sensitizing and educating farmers on the impact of climate change on agricultural productivity.

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References

Abaje, I.B. & Ogoh, A.O. (2018). Rainfall Trends and Occurrence of Floods in Katsina State: Implications for Infrastructural Development. *Osun Geographical Review,* 1: 78-89.

Abaje, I.B. & Oladipo, E.O. (2019). Recent Changes in the Temperature and Rainfall Conditions Over Kaduna State, Nigeria. *Ghana Journal of Geography,* 11 (2): 127-157.

Abaje, I.B., Abashiya, M., Onu, V. & Masugari, D.Y. (2017). Climate Change Impact and Adaptation: Framework for Rural Communities in Northern Nigeria. *JORIND* 15 (2): 142-149.

Abaje, I.B., Abdullahi, A. & Jeje, O.G. (2009). Farmers' Perception and Adaptation Strategies to Climate Change in Safana LGA of Katsina State, Nigeria. *JORIND,* 14 (2): 50-58.

Abaje, I.B., Ati, O.F., Iguisi, E.O., & Jidauna, G.G. (2013). Droughts in the Sudano-Sahelian Ecological Zone of Nigeria: Implications for Agriculture and Water Resources Development. *Global Journal of Human Social Science (B): Geography, Geo-Sciences & Environmental.* 13 (2): 1-10.

Abaje, I.B., Sawa, B.A., & Ati, O.F. (2014). Climate Variability and Change, Impacts and Adaptation Strategies in Dutsin-Ma Local Government Area of Katsina State, Nigeria, *Journal of Geography and Geology,* 6 (2): 103-112.

Abaje, I.B., Sawa, B.A., Iguisi, E.O. & Ibrahim, A.A.

(2016). Impacts of Climate Change and Adaptation Strategies in Rural Communities of Kaduna State, Nigeria. *Ethiopian Journal of Environmental Studies and Management,* 9 (1): 97 – 108.

Abirham, C. & Zenebe, M. (2019). Comparing Farmers' Perception of Climate Change and Variability with Historical Climate Data: The Case of Ensaro District, Ethiopia. *International Journal of Environmental Sciences and Natural Resources,* 17 (4): 1-7.

Adebayo, A.A., Onu, J.I., Adebayo, E.F. & Anyanwu, S.O. (2012). Farmers Awareness, Vulnerability and Adaptation to Climate Change in Adamawa State, Nigeria. *British Journal of Arts and Social Sciences,* 9 (2): 104-115

Ahmad, A. (2016). An Assessment of Farmers' Adaptation Strategies to Climate Change in Parts of Yobe State, Nigeria. M.Sc Thesis, Ahmadu Bello University, Zaria.

Ajayi, N.O. (2015). Analysis of Perception and Adaptation Strategies of Farmers to Climate Change in Ikara LGA of Kaduna State, Nigeria. Ph.D Thesis, Ahmadu Bello University, Zaria.

Akpan, G.D., Aho, M.I. & Musa, A.A. (2018). Rainfall Intensity Duration-Frequency Models for Lokoja Metropolis, Nigeria. *Global Journal of Pure & Applied Sciences,* 24: 81-90.

Amadou, M.L., Villamor, G.B., Attua, E.M. & Traore, S.B. (2015). Comparing Farmers' Perception to Climate Change & Variability with Historical Climate Data in the Upper East Region of Ghana. *Ghana Journal of Geography,* 7 (1): 47-74.

Ati, O.F., Aremu, K., Olatunde, A.F., Abaje, I.B. & Oladipo, E.O. (2022). Meteorological Drought and Temperature in Sudano-Sahelian Region of Nigeria under Increasing Global Warming. In: Harris S (ed) *The Nature, Causes, Effects and Mitigation of Climate Change on the Environment,* IntechOpen Book Series, London.

Banmeke, T.O.A. & Fapojuwo, O.E. (2011). Awareness and Adoption of Nigeria Institute for Oil Palm Research (NIFOR) Technologies by Farmers in Owan-West LGA, Edo State, Nigeria. *Global Journal of Agricultural Sciences; Calabar***,** 10 (1): 19-25.

Bartlett, J.E., Kotrlik, J.W. & Higgins, C.C. (2001). Organizational Research: Determining Appropriate Sample Size in Survey Research. *Information Technology, Learning, and Performance Journal*, 19 (1): 43-50.

Brazel, S.W. & Balling, R.C. (1986). Temporal analysis of long-term atmospheric moisture levels in Phoenix, Arizona. *Journal of Climate and Applied Meteorology.* 25: 112-117.

Dickson, A.O. (2010). *Global Climate Change "Cause, Effect, Impact, Mitigation" A Theoretical and Practical Perspective*. Alphabet Nigeria Publishers.

El-Ladan, I.Y. (2017). Peasant Farmers' Adaptation Strategies to Coping with Climate Change in Jibia, Northwest Katsina, Nigeria. *British Journal of Applied Science and Technology,* 20 (2): 1-10.

Idoma, K. & Yakubu, D. (2020). Analysis of Pastoralists' Perception of and Responses to Climate Variability in Malumfashi LGA of Katsina State, Nigeria. *EC Agriculture* 6 (8): 33-44.

Oladipo, E. (2011). The Challenge of Climate Change for Nigeria: An Overview. In: Iguisi EO, Ati OF, Yusuf RO and Ubogu AE (eds), *Climate Change Impacts: Risks and Opportunities,* **(**pp. 22-44). Proceedings of the International Conference of the Nigerian Meteorological Society held at NAERLS Conference Hall, Ahmadu Bello University, Zaria-Nigeria, 13th to 17th November, 2011.

Oladipo, E.O. (1993). Some aspects of the spatial characteristics of drought in Northern Nigeria. *Natural Hazards*, 8: 171-188.

Otitoju, M.A. (2016). The Effects of Climate Change Adaptation Strategies on Food Crop Production Efficiency in South Western Nigeria. Ph.D Thesis, University of Nigeria, Nsuka.

Prasada, R. (2008). *Agricultural Meteorology.* Prentice Hall of India Private Limited, New Delhi.

Sawa, B.A. (2002). Trend in the temporal variability of occurrence of wet and dry spells north of latitude 10^{0}n in Nigeria. In: Iguisi EO (ed), *The Zaria Geographer*, 15 (1): 34-41.

Tanko, A.I. (2010). Climate Change and Agriculture: Impact and Adaptations in Northern Nigeria. A Paper Presented at the Desertification and Environmental Summit Organized by Katsina State Government, July 22, 2010

Tarfa, P.Y., Ayuba, H.K., Onyeneke, R.U., Idris, N., Nwajiuba, C.A. & Igberi, C.O. (2019). Climate Change Perception and Adaptation in Nigeria's Guinea Savanna: Empirical Evidence from Farmers in Nasarawa State, Nigeria. *Applied Ecology and Environmental Research* 17 (3): 7085-7112.

Udeh, L.E. (2014). Assessment of Farmers' Perception and Adaptation Strategies to Climate Change in Kano State, Nigeria. Ph.D Thesis, Ahmadu Bello University, Zaria.

Umar, B.S. (2014). Farmers Adaptation Strategies to Drought in Katsina and Its Environs. M.Sc Thesis, Ahmadu Bello University, Zaria.

Westra, S., Fowler, H.J., Evans, J.P., Alexander, L.V., Berg, P., Johnson, F., … & Roberts, N.M. (2014). Future Changes to the intensity and frequency of short-duration extreme rainfall. *American Geophysical Union* (522 – 555).