ASSESSMENT OF CLIMATE CHANGE ADAPTATION STRATEGIES OF MAIZE AND RICE FARMERS IN KUDAN LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA

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Abstract: The study aimed at assessing climate change adaptation strategies among maize and rice farmers in Kudan Local Government Area of Kaduna State. A total of 384 questionnaires were given to respondents in eight communities of the area. The Krejcie and Morgan sampling table was utilized in arriving at this number. In analyzing the socioeconomic characteristics of the respondents, descriptive statistics were used while to analyze the respondents' adaptation strategies, a five-point Likert scale was used. The results revealed that the application of fertilizer/animal dung on farms to improve crop yield was the most significant adaptation strategy followed by water harvesting during the rainy season. It is recommended that farmers should be enlightened and assisted financially and technologically by the government for better mitigation of climate change impacts.

Keywords: Adaptation, Agriculture, Change, Climate.

1. INTRODUCTION

In agriculture, climate is a key factor which determines what and when to plant. This determines the adequacy of food supply in any region. Climatic factors affect all stages of the agricultural production chain from land preparation to transport and marketing. (Ayode, 2008).

Climate change is a key contemporary issue that cannot be overlooked due to its immense significance (IPCC, 2007b). The mean temperature of the globe has gone up from 0.6^{o}C to 0.98^{o}C over the past 3 decades, and the precipitation pattern has been changing as well (Krishna, Keshab, Mohan and Bishal, 2009). Nigerian climate has been exposed to alterations between the late 1960s and early 1970s. Floods, drought, ocean surges, etc have become more rampant in the country. (Abaje & Giwa, 2010).

Climate change in Nigeria is one of the most serious threats to poverty reduction and sustainable development. This is because a large proportion of Nigerians are farmers. (Ishaya and Abaje, 2008).

Climate change impacts in Nigeria can be seen in the increase of hazardous weather conditions like floods, droughts and even sandstorms. (Ishaya and Abaje, 2008).

In many cases, agricultural development projects fail due to the wrong adaptation methods of farmers. This results in to decline in food production (yield) per annum. According to The World Food Program (2008), nearly a billion people today are not getting enough food to eat. If climate change continues, there is a high likelihood of absolute food supply shortage in the country and this will result in serious problems.

Maize and rice farming in Kudan LGA of Kaduna State contributes to a large extent to

development in not only the region but to the state as a whole. It is a major source of sustenance making it significant to the people in the area. However, observed variability in climate poses a serious threat to this fact. According to Amawa et al (2015), the relationship between climatic variations and changes in crop outputs is strong. The inability of farmers to devise mitigation measures has led to a major setback in maize and rice farming.

The research will add knowledge to existing literature concerning farmer's perceptions and adaptation to climate change. It will be of great help to small- and large-scale farmers by providing a cheap source of information about climate change to improve production. Furthermore, it will be of great help to agricultural development projects currently operating with or without proper climatological data and will help in tending to agricultural projects in planning, implementation and managing for optimum operation.

The research aim is to evaluate the adaptation strategies of maize farmers to the changing climate in Kudan LGA of Kaduna State. The objectives are to provide empirical evidence of climate change and rank the adaptation strategies of the farmers in order of significance.

2 CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 Conceptual Framework

2.1.1 The concept of climate change

Climate change is a change of climate caused directly or indirectly by anthropogenic factors that alter the nature of the global atmosphere and is in addition to natural climate variability observed over comparable periods (Richard, 2004). Climate change is a global issue that impacts every living thing on earth. It refers to any significant change in the measures of weather elements such as temperature, rainfall, and wind patterns lasting for an extended period (Nigerian Meteorological Agency (NiMet), 2017). Generally, climate change encompasses all forms of climatic inconsistency (that is, any differences between the "long-term" statistics of the meteorological elements calculated for different periods but relating to the same area); regardless of their statistical nature or physical cause.

According to the Intergovernmental Panel on Climate Change (IPCC), climate change is a change in the state of the climate which may be identified by changes in the mean and/or the variability of its properties and which prevails for decades or longer (IPCC, 2007a).

2.1.2 Adaptation

Adaptation to the changing climate deals with efforts that will reduce the harm of climate change as well as taking advantage of beneficial opportunities that may be derived therein (IPCC, 2001). The methods of adaptation in agriculture include crop diversification, mixed cropping, livestock farming systems and altering planting dates among others (Udeh, 2014). According to Mitchell and Tanner (2006), adaptation is the adjustment of natural or human systems to a new or changing environment. This adjustment is crucial in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Societies have a long record of managing the impacts of weather and climate-related events. A wide array of adaptation options are available, although better adaptation strategies are required to reduce vulnerability in the future. Adaptation is necessary in the short and longer term to address impacts resulting from the warming that would occur even for the lowest stabilization scenarios.

2.2 Literature Review

The amount of literature that exists on climate change and agriculture is overwhelming. For instance, Lordemann and Salas (2009) claim that agriculture is vulnerable to climate change since it has a significant impact on economic growth when production reduces and prices increase. Furthermore, evidence shows that climate change leaves sequels in the agricultural production function. Therefore, it is inevitable that any change in climatic parameters on a global scale impacts local agriculture, and hence affects the food supply in general (Rosenzweig & Hillel, 1995).

Studies have been conducted to determine how agricultural activities are affected by climatic variations. The accuracy of recent projections on the future impacts of climatic variations on agriculture has been marred by a lot of uncertainties such as the degree of temperature increase and its geographic distribution as well as changes likely to occur in precipitation patterns. The changing trend of climate may present agricultural activities with prospects for both benefits and risks. It is important to estimate the losses that could result from the effects of such changes and to enlighten farmers on how to manage this increasing unpredictability (Rosenzweig & Hillel, 1995).

3. METHODOLOGY

3.1. Study Area

Kudan LGA (Fig 1) is located on a plateau at a height of 732m above sea level in the centre of northern Nigeria. Precisely, the area lies between Latitudes 10025' N and 11031' N of the equator and Longitudes 7006' E and 8035' E of the Greenwich Meridian. Kudan is bounded in the north by Katsina and Kano States, in the south-west by Sabon-Gari LGA, in the south-east by Soba LGA and on the eastern side by Makarfi LGA (Works Department, Kudan LGA, 2013). It is situated on a plateau 732m above sea level in the centre of northern Nigeria. It falls within the tropical wet and dry type of climate classified by Koppen as Aw. The area experiences two distinct seasons- a rainy season which extends from April/May to October, and a dry season between November and April. The average annual rainfall is about 1032mm (Abaje, Ishaya and Abashiya, 2016).

The relief is characterized by an open rolling country consisting of upland which gently slopes into low-lying streams and marshes called fadama. The area is surrounded by hill features with the prominent one called “Dutsen-Hunkuyi” (Ladan, 2003). The main rivers draining the area of study are the Galma in the centre, the Kinkiba in the south, and Kubanni in the north. These rivers flow mostly during the rainy season and water may occur in discontinuous pools with a large part totally on the surface in the dry season. The drainage pattern is mostly dendritic, especially in deeply weathered areas which implies that the water courses are not structurally controlled. However, river Galma follows some structural trends in some places. A prominent right-angled turn is observed between Nasarawa and Kwasallo where the river flows along a fault trend almost north for approximately 1.5 km before branching off in the south-west direction (Shehu, 2014).

The Galma River which is the major river in the study area flows slowly along gentle slopes. There is a slow rate of erosion. There is also a small dam in the area although it does not sustain enough water. Both relief and drainage do not seem to act as significant barriers to the movement of people and goods (Kudan LG Manual, 2011).

The soil in the study area is classified as leached ferruginous tropical soil which consists of upland soil which tends to form a

hardpan. This pan can be seen outcropping in many parts of the study area. It is very hard and vesicular in appearance. Sometimes quartz is embedded in the hardpan. This usually impairs drainage and the general level of fertility is low. Floodplain soils called the "fadama" are found there. The Fadama is of special importance as they are fairly rich in nutrients and have a good to excessive water supply which persists during the dry season (Survey dept. Kudan LG council, 2013).

The natural vegetation of the study area is the Sudan savanna. Economic trees like silk cotton, Shea-butter, baobab, locust beans and edible fruit trees are found in the area. The dominant wooded trees in the area include *Isoberlina doka*, *Tomentosa spp* and *Uapasatogoensis* etc. Well-developed grass species in the area are *hyparuthenia*, *Androprogon* and *mocymbium ceresiiforro* (Ladan, 2003).

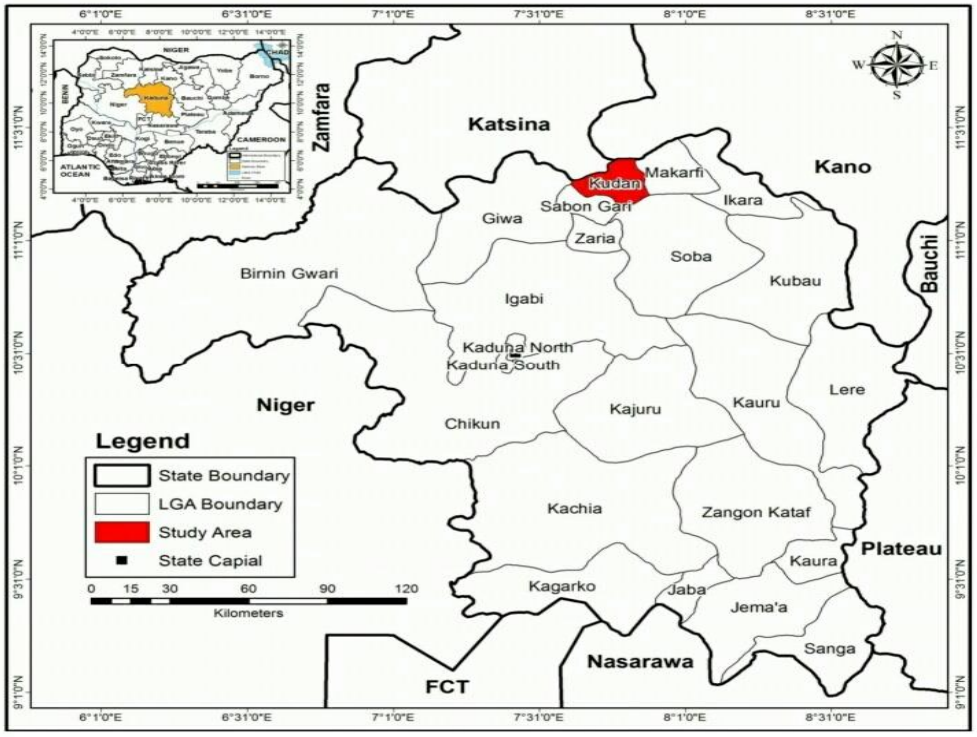

Figure 1: Study Area

Source: Adapted from Kaduna State Ministry of Lands and Survey (2022)

3.2. Population and Sample Size

The population of the area based on the 1991 census (94,585) was used in deriving the sample size of the population. The study area with 109 communities and an annual growth rate of 2.8% (NPC, 1991), was projected to the year 2022 for this research using the method of Mehta (2004) and the derived value is 249,704. The reason for using the 1991 population instead of the 2006 population [(138,956) (NPC, 2006)] was because the 2006 census had no locality population. When determining the sample size required for the questionnaire survey, Krejcie and Morgan's (1970) method was

adopted. Using both the table of Krejcie and Morgan (1970) and the formula, the sample size used for this study was 384. The formula is given as:

$s = X^2 NP (1- P) \div d^2 (N -1) + X^2 P (1- P)$ ……..(Eq. 1)

where: s = sample size.

X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841).

N = the population size.

P = the population proportion (assumed to be .50 since this would provide the maximum

sample size).

d = the degree of accuracy expressed as a proportion (.05).

Data on the adaptation strategies of the farmers were collected through the administration of structured questionnaires. A total of 109 communities were recorded in Kudan LGA with 8 wards (NPC, 1991). However, a single community was sampled in each ward due to time factors and financial constraints (Table 1).

Table 1: Sampled communities and Number of Respondents

Ward	Community Sampled	Projected Population (2022)	No. of Respondents
Kudan	Damaski	2,693	73
Sabongari	Ang. Dan-Tsoho	1,993	54
Doka	Sabon-Garin Doka	1,307	47
Kauran Wali North	Ang. Wali	12,543	59
Kauran Wali South	Taban Sani	11,877	40
Garu	Sabon-Layi Garu	2,482	67
Likoro	Likoro	4,348	23
Zabi	Sabon Gida	4,015	21
TOTAL		41,258	384

Source: Field Survey (2022)

3.3 Data Collection

A systematic/purposive sampling technique was adopted in the research. This involved careful selection of respondents based on their involvement in maize farming. Eight assistant researchers were trained to conduct the interview. The questionnaires were administered to maize and rice farmers purposively who are 40 years and above. The reason was to generate information from respondents who have lived long enough to have experienced changes in the environment caused by the changing climate. The respondents selected were maize and rice farming. Furthermore, a Focus Group Discussion (FGD) of eight participants representing eight communities was also held in May 2022 at Kudan ward. Monthly temperature and rainfall data for thirty years (1986-2015) were obtained from the archive of the Nigerian Meteorological Agency (NIMET) Zaria. The Zaria data was used for the analysis because there is no synoptic station in Kudan.

3.4 Data Analysis

The collected data was analyzed using descriptive statistics and Likert Scale (LS). Simple descriptive statistics were used to describe the socio-economic characteristics of the respondents while the assessment of adaptation strategies was based on a five-point LS. Each respondent was asked to choose any option among “strongly agreed”, “agreed”, “undecided”, “disagreed” and “strongly disagreed”. Values assigned to these

options are 5, 4, 3, 2, and 1 respectively. Responses with an average value less than 3.0 will be considered as insignificant adaptation strategies while options with a mean score equal to or above 3.0 will be regarded as being useful and important adaptation strategies in reducing the impacts of climate change by the farmers.

The linear trends of temperature and rainfall data were determined using Linear regression using Microsoft Excel Tool (2013). Second-order polynomial curve fitting was also used to determine the non-linear trends of the temperature and rainfall. Changes in temperature and rainfall per year and for the whole study period were then calculated using Microsoft Excel Tool (2013) and SPSS version 21. The formula for the linear regression is given as:

$$Y = a + bx \quad \text{(Eq. 3)}$$

where a is the intercept of the regression line on the y-axis; b is the slope of the regression line. The values of a and b can be obtained from the following equations:

$$a = \frac{\sum y - b(\sum x)}{n} \quad \text{(Eq. 4)}$$

$$b = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2} \quad \text{(Eq. 5)}$$

4. RESULTS AND DISCUSSION

4.1. Socioeconomic Characteristics of the Respondents

Out of the 384 questionnaires that were administered, 74% of the respondents were male while the remaining 26% were female. This is mainly because males are more numerous when it comes to agricultural practices. 43.3% fall within the age of 40-45 years, 37.2% fall within the age of 46-50 years, 13.3% are within the age of 51-60 while the remaining 6.2% are at the age range of 61 and above. 84.9% of the respondents were married, 7.0% were single, 3.0% were divorced and 5.1% were widowed. 9.4% of the respondents attended only primary school while 18.9% attended secondary school education. 59.0% of the respondents gained only Islamic education (Islamiyya), 7.8% attended tertiary institutions whereas only 4.9% gained no formal education at all. 42.4% of the respondents have an approximate annual income of 10,000 and below, 24.4% have an estimated range of annual income of 10,000-100,000, and 29.6% have an estimated annual income of 100,000-1,000,000 while only 3.6% have approximated annual income of 1,000,000 and above.

4.2. Observed Climate Changes

The observed maximum and minimum temperature trends of the study area from the analyzed data are shown in Figures 2 and 3 respectively, while the summary statistics of the average temperature for the study period can be seen in Table 2. The highest average temperature of 27.2°C (Table 2) was recorded in 2006 which is in line with the report of the IPCC that global average temperatures have been increasing from the 1970s to 2006. The minimum temperature of 24.5°C was recorded in 1989. The linear trend line equation for the period 1986-2015 shows an average temperature increase of 0.54°C at the rate of 0.018°C per year. The average temperature has therefore been increasing at the rate of 0.07% annually (see Table 2). This means that the temperature in the study area is increasing in recent years. This increase is in line with the findings of Oladipo (2011) that the country has been experiencing a temperature increase of about 0.2°C - 0.3°C per decade in all its ecological zones.

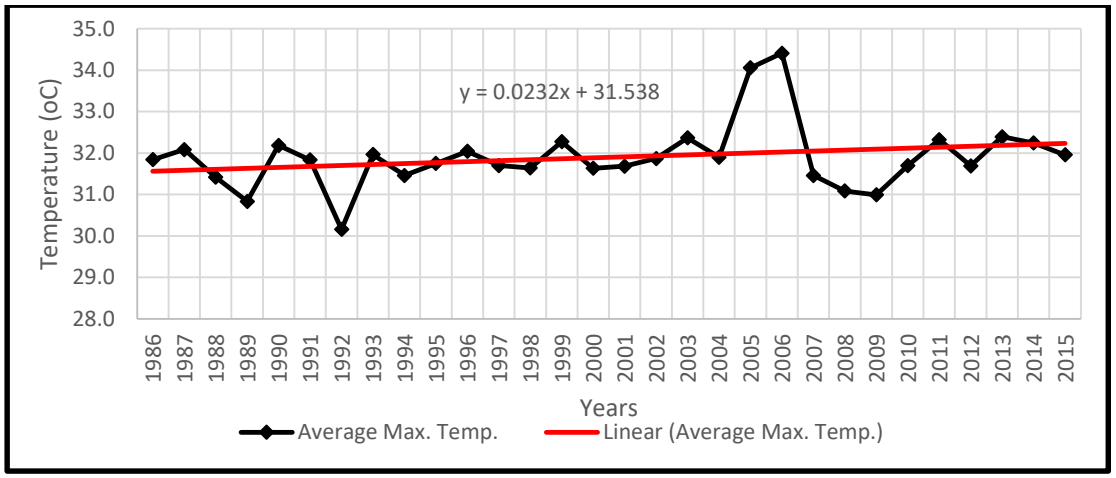

Figure 2: Observed Maximum Temperature Trend (1986 – 2015).
Source: Abaje, Balarabe and Onu (2016)

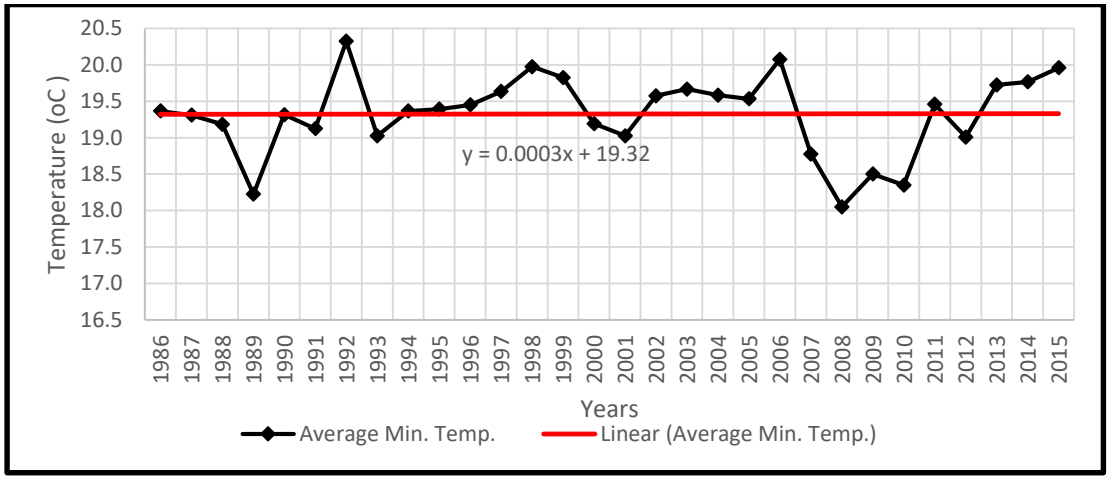

Figure 3: Observed Minimum Temperature Trend (1986 – 2015).
Source: Abaje, Balarabe and Onu (2016)

The observed annual rainfall trend of the area is shown in Figure 3, while Table 2 presents the summary statistics of the annual rainfall for the study period. The highest annual rainfall of 1406.3 mm (Table 2) was recorded in 2012. Other meteorological stations across the country also recorded a high amount of rainfall in the same year. This high rainfall amount resulted in incidences of flood across the country, especially in the northern States (NIMET, 2015). The lowest amount of rainfall 786.4 mm was recorded in 1989. This coincided with the drought of the late 1980s.

Table 2: Summary Statistics of Average Temperature and Annual Rainfall (1986-2015)

Average temperature (^{0}C)		Annual Rainfall (mm)	
Mean	25.6	Mean	1076.3
Standard Deviation	0.59	Standard Deviation	146.6
Range	2.71	Range	619.9
Minimum Value	24.52	Minimum Value	786.4
Maximum Value	27.2	Maximum Value	1406.3
Trend (mm/year)	0.018	Trend (mm/year)	5-59
Total Change (mm/40 years)	0.54	Total Change (mm/40 years)	167.69
Percentage (%) of change per year	0.07	Percentage (%) of Change/year	0.52

Source: Field Survey (2022)

From the linear trend line equation, the estimation of changes in annual rainfall expressed in mm for the period 1986-2015 indicates an increase of 167.69 mm for the study period at the rate of 5.59 mm per year. When compared with the long-term mean, it means the annual rainfall has been increasing at the rate of 0.52% per year (see Table 2). This is in agreement with NIMET (2015), which claimed that the northern part of the country has been experiencing wetter conditions recently.

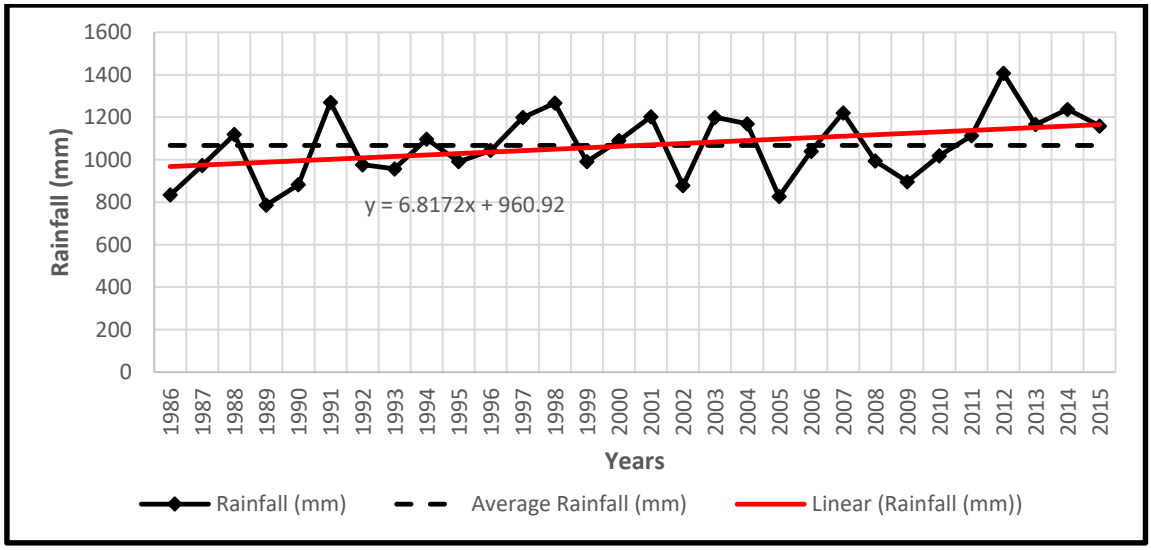

Figure 3: Trend of Rainfall Data (1986 – 2015)
Source: Abaje, Balarabe and Onu (2016)

4.3. Adaptation Strategies to Climate Change

The adaptation strategies of the farmers in curtailing the impacts of climate change on maize and rice production in the various communities are shown in Table 3. Application of fertilizer/animal dung on the farms to improve crop yield (3.77) is the most significant adaptation strategy followed by water harvesting during the rainy season (3.58). These are significant in almost all the LGAs. This agrees with the findings of Abaje et al. (2016) which showed that application of fertilizer/animal dung on farms and water harvesting during the rainy season are the most significant adaptation strategies adopted by farmers to hurdle the

negative impacts of climate change on their farms. This is followed by Praying for God's intervention (3.47). Irrigation farming along flood plains during the dry season and utilization of herbicides to control weeds on farms were also significant adaptation strategies with mean scores of 3.34 and 3.06 respectively. These are in agreement with the results obtained by Abaje et al. (2014).

Every other adaptation strategy was not considered significant based on the respondents' response pattern.

As for praying for divine intervention as an adaptation strategy, a Muslim participant in the Damaski community during the FGD said: "Whenever there is late onset of the rainy season or in events of drought or other weather anomalies, people gather for a special prayer because they believe these are signs of God's displeasure with the people".

Table 3: Adaptation Strategies Against Climate Change

*Significant adaptation strategies

S/No	Adaptation strategies	Mean scores of selected communities									
		Damaski	Ang. Dan-Tsoho	Sabon - Garin Doka	Ang. Wali	Taban Sani	Sabon -Layi Garu	Likoro	Sabon Gida	Average	Rank
1	Applying fertilizer/animal dung on the farms	4.41*	4.19*	3.87*	3.68*	4.18*	3.64*	2.44	3.71*	3.77*	1
2	Water harvesting during the rainy season	3.70*	3.09*	3.29*	3.79*	3.25*	4.14*	3.91*	3.47*	3.58*	2
3	Praying for God's intervention	2.34	3.89*	3.45*	3.71*	3.85*	3.37*	4.11*	3.00*	3.47*	3
4	Irrigation farming	4.17*	3.36*	3.17*	3.53*	3.81*	2.64	3.05*	2.97	3.34*	4
5	Use of herbicides for weed control	3.07*	2.98	3.17*	2.55	3.12*	3.49*	3.37*	2.74	3.06*	5
6	Utilization of modern storage facilities	2.14	2.73	2.77	2.93	3.47*	3.17*	2.72	3.90*	2.98	6
7	Attending climate change enlightenment programs	2.64	2.33	3.11*	2.89	3.56*	2.97	2.44	3.10*	2.88	7
8	Participation in community and individual savings	2.69	2.44	2.18	3.12*	3.11*	2.93	3.00*	2.77	2.78	8
9	Planting of economic trees to augment crop production	2.77	2.80	2.19	3.15*	2.93	2.00	3.45*	2.72	2.75	9

10	Access to loans	2.31	2.54	3.19*	2.75	3.44*	2.22	2.65	2.74	2.73	10

5. CONCLUSION AND RECOMMENDATIONS

From the findings of the study, it is concluded that maize and rice farmers in the Kudan Local Government Area of Kaduna State are moderately adapting to climate change. This is because of the ten strategies provided, five are significant.

The provision of modern storage facilities, loans, enlightenment programs and other modern adaptation strategies should be facilitated by the government to improve the farmers' adaptation to climate change.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization, methodology and analysis
Author 2: Validation and supervision
Author 3: Funding acquisition
Author 4: Review and editing

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