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### CLIMATE CHANGE PERCEPTIONS AND ADAPTATION STRATEGIES AMONG MARKET GARDENING CROP PRODUCTION FARMERS IN KUDAN LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA

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#### ARTICLE INFO

#### ABSTRACT

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*This study assesses climate change perceptions and adaptation strategies among market gardening crop production farmers in Kudan Local Government Area of Kaduna State. Temperature and rainfall data for 30 years (1987-2016) were analyzed in order to compare people's perceptions of climate change and observed data. A total of 384 questionnaires were administered to farmers in eight selected communities of the area. Linear trend lines equation was used to determine the changes in both the temperature and rainfall data. Descriptive statistics was used in analyzing the socioeconomic characteristics of the respondents and their perceptions on climate change. A five-point Likert scale was then used to analyze the respondents' perceived impacts of climate change as well as their adaptation strategies. The result revealed that temperature and rainfall have been increasing in the study area in recent years. The result also revealed that majority of the farmers have a good knowledge of climate change in terms of increasing temperature and rainfall. Findings also showed that sins of mankind, habitat destruction, combustion of fossil fuel and pollution were the major causes of climate change as perceived by the respondents. The most significant impacts of climate change as*

*perceived by the farmers were decrease in crops with a mean score ( $\bar{x}$ )*

*of 3.72, and increase in flood and drought events with mean score ( $\bar{x}$ ) of 3.65 and 3.62 respectively. The most significant adaptation strategies adopted by the farmers were the application of fertilizer/animal dung on*

*farms to improve crop yield ( $\bar{x} = 3.77$ ) and water harvesting ( $\bar{x} = 3.58$ ) during the rainy season. It is recommended that government should assist in providing fertilizers, improved seeds and technological supports to farmers for a better mitigation of climate change in order to increase their crop production.*

#### INTRODUCTION

Climate change and its observed and projected impacts is one of the greatest socioeconomic and environmental challenges in recent time (Abaje, Sawa and Ati, 2014). Agriculture is one of

the most weather sensitive of all human economic activities. In spite of recent technological and scientific development, weather still remains the most important variable in agricultural production

(Ayoade, 2008). Weather and climate affect agriculture and determine the adequacy of food supplies, and also whether or not a rain-fed agriculture will be possible in a given area (Ayoade, 2004 and 2008).

The nature of crops produced in any area depends mainly on temperature and rainfall. This means that as temperature and rainfall change, nature of crop production also changes. Available data show that air temperature near the earth surface rose by 0.74°C from 1906 to 2005 and scientists believe this could increase in the nearby future (IPCC, 2007). The report of Dasgupta *et al* (2014) in the Fifth Assessment Report of the IPCC for rural areas revealed that changes in temperature has caused a reduction in global yields of maize and wheat by 3.8 and 5.5% respectively from 1980 to 2008.

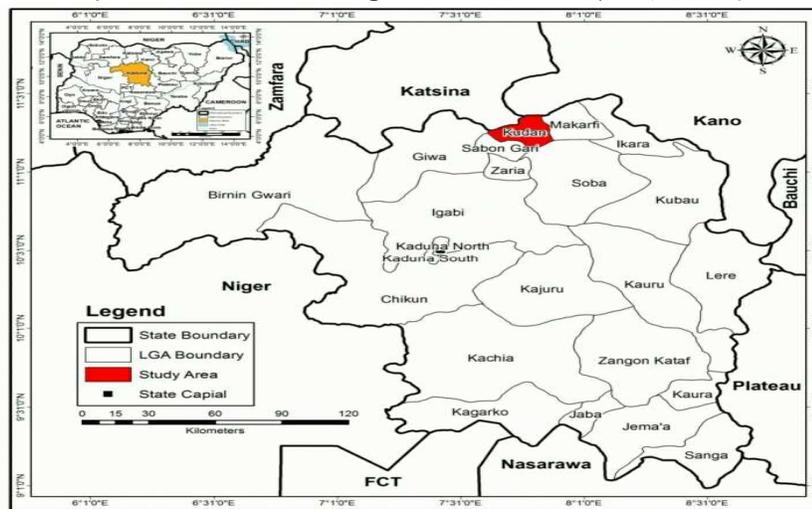
Nigerian climate has been exposed to considerable temporal and spatial alterations in its nature and variability since the late 1960s and early 1970s (Nigerian Meteorological Agency (NIMET) 2015). Flood, drought, and ocean surges among others have become more rampant in the country. Floods have become more of annual occurrences especially in the northern parts of the country with increasing intensity each year, leaving vast losses and serious injuries (NIMET, 2015; Abaje, Yusha’u and Jeje, 2015). Other impacts of climate change in

Nigeria include increased infestation of crop by pests and diseases, decline in forest resources, increased health risks and the spread of infectious disease among others (Ishaya and Abaje, 2008).

Market gardening crop production contributes heavily to the economy of the entire country (Amawa *et al.* 2015). In northern Nigeria, market gardening is practiced throughout the year. It entails the cultivation of highly perishable crops which are consumed or transformed within a relatively short period of time (Amawa *et al.* 2015). The principal crops include green beans, carrots, lettuce, cucumber, cabbage, spices and vegetables under ample precipitation conditions. It is a common practice in Kudan Local Government Area (LGA) of Kaduna State. The aim of this study is to compare climate data of 30 years and farmers’ perception of climate change as well as the adaptation strategies.

**STUDY AREA**

Kudan LGA (Figure 1) is located on a plateau at a height of 732m above sea level in the center of northern Nigeria. It falls within the tropical wet and dry type of climate classified by Koppen as Aw. The raining season starts from April/May to mid-October, and the dry season is from mid-October of one calendar year to April of the next year. The average annual rainfall is about 1032 mm (Abaje, Ishaya and Abashiya, 2016).



**Figure 1:** Kaduna State Showing the Study Area  
**Source:** Adapted from Kaduna State Ministry of Lands and Survey

The area is surrounded by hill features with the prominent one called “Dutsen-Hunkuyi”. The relief generally consists of upland which gently slopes into low lying streams and marshes called *fadama* (Ladan, 2003). The *fadama* is of special importance as they are rich in nutrients and have a good water supply during the dry season for irrigation farming. The main rivers draining the area are Galma, Kinkiba and Kubanni Rivers. The soil in the study area is classified as leached ferruginous tropical soil which consists of upland soils that have the tendency to form a hardpan. The vegetation is the northern Guinea Savanna which consists of short grasses and scattered strands of shrubby plants of about 1.2m height.

**MATERIALS AND METHODS**

**Data Collection**

The 1991 census population of the area of 94,585 was used to determine 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 2016 for the purpose of this study using the method of Mehta (2004). The projected population of the study area for the year 2016 is 188,647 people. The basis for using the 1991 census instead of 2006 was due to the fact that this study is focused on localities and the 2006 population census’ document has no locality population. Krejcie and Morgan (1970) method of determining sample size of a given population 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:

$$s = \frac{X^2 NP (1 - P)}{d^2 (N - 1) + X^2 P(1 - P)} \dots\dots\dots \text{eq. 1}$$

where: *s* = sample size.

*X*<sup>2</sup> = 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 0.50 since this would provide the maximum sample size.

*d* = the degree of accuracy expressed as a proportion (0.05)

Data on perception and adaptation strategies adopted by the market gardening farmers were collected through the administration of structured questionnaires. However, only eight

(8) communities were selected from the 109 communities for this study using simple random sampling (Table 1).

**Table 1:** Sampled Communities and Number of Respondents

Selected Communities	Population (1991)	Projected Pop. (2016)	No. of Respondents
Ung. Damaski	1,020	2,034	73
Dantsoho	755	1,506	54
Ung. Dutse	662	1,320	47
Ung. Waziri	818	1,632	59
Makoyi	555	1,107	40
Sabon-Layi	940	1,875	67
Tashar-Likoro	322	642	23
Marke	291	580	21
<b>Total</b>	<b>5,363</b>	<b>10,697</b>	<b>384</b>

Source: Field Survey (2016)

The questionnaires were only administered purposively to household heads who are 42 years and above, and must have been residing in the community for at least 30 years. This was done in order to gather information from respondents who have had experiences with their environment over the years. In addition, a Focus Group Discussion (FGD) of nine people (one representative from each of the 8 communities and the chairman of the farmers' association) was also held in December 2016 at Hunkuyi, the LGA headquarters, in order to obtain in-depth information on the subject matter.

Also, 30 years (1987-2016) data of temperature and rainfall were collected from NIMET, Zaria. The climatic data for Zaria were used for the analysis due to: 1) the absence of a well-equipped synoptic station in the study area; and 2) the study area (Kudan) and where the data were collected (Zaria Synoptic Station) are very close and have the same climatic characteristics.

**Data Analysis**

The analysis of the collected primary data was based on descriptive statistics and Likert Scale (LS). Simple descriptive statistics was used to describe the socio-economic characteristics of the respondents. Impacts of climate change were determined using a five point LS. Each

respondent was required to respond by ticking any of the options namely: 'strongly agreed', 'agreed', 'undecided', 'disagreed' and 'strongly disagreed'. Values assigned to these options were 5, 4, 3, 2 and 1 respectively. The mean score of the respondents based on the five point LS is 3. Climate change factors with mean score less than 3.0 were taken as those which experience less impact while those with mean score equal or above 3.0 were taken as having greater impacts. Adaptation strategies to climate change were equally examined using a five point LS. Factors with mean score less than 3.0 were taken as not significant adaptation strategies while those with mean score equal or above 3.0 were taken as significant adaptation strategies to the impacts of climate change.

Trend analysis of the secondary data (temperature and rainfall) was carried out in order to compare people's perception of climate change and the observed change. To examine the nature of the trends, linear regression was used to determine the linear trends of the temperature and rainfall data using Microsoft Excel Tool (2013). 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:

$$y = a + bx \dots\dots\dots \text{eq. 2}$$

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:

$$a = \frac{\sum y - b(\sum x)}{n} \dots\dots\dots \text{eq. 3}$$

$$b = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2} \dots\dots\dots \text{eq. 4}$$

**RESULTS AND DISCUSSION**

**Socioeconomic Characteristics of the Respondents**

Out of the 384 copies of the questionnaire administered, 84% of the respondents were male while the remaining 16% were female. Majority of the respondents (59.0%) attended Islamiyya (Islamic education), 9.4% of attended only primary school, 18.9% attended secondary

school education, and 7.8% attended tertiary institutions whereas only 4.9% had no formal education at all. Out of the 384 respondents, 46.3% fall within the age of 40-45 years, 35.2% fall within the age of 46-50 years, 12.3% were within the age of 51-60 while the remaining 6.2% were at the age range of 61 and above. 90.9% of the respondents were married, 1.0% were single, and 3.0% were divorced whereas 5.1% were widows.

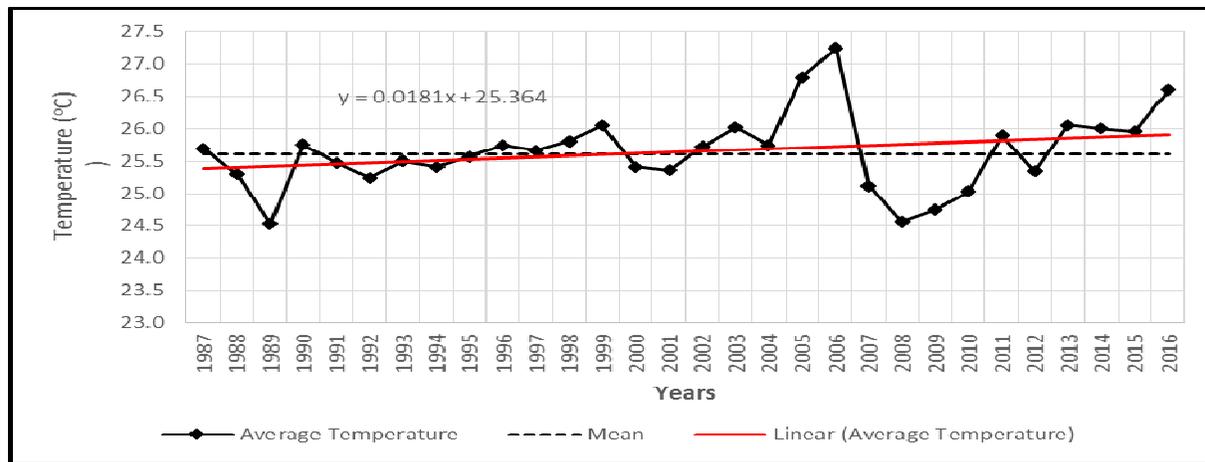
Majority of the respondents (52.3%) have children at the frequency range of 1-6, 32.9% at the frequency range of 7-12, 9% at the frequency range of 13-18, and 2.3% at the frequency range of 19-24 while the remaining 3.6% at the frequency range of 25-30. Furthermore, 44.4% of the respondents have approximate annual income (in Naira) of 10,000 and below, 22.4% have the estimated range of annual income of ₦10,000-₦100,000, and 29.6% have estimated annual income of ₦100,000- ₦1,000,000 while only 3.6% have approximated annual income of ₦1,000,000 and above.

The highest percentage of males' respondents in the study area may not be unconnected with the culture and religion of the people where women are restricted from some certain social activities. The religion of the people, Islam, has an influence on the household size as it allows the marrying of a maximum of four wives. This might have led to the multiplication of children in the study area. The large household size is believed to provide cheap labor that will assist in adaptation practices that will mitigate the impacts of climate change. Age and level of education are important factors in terms of climate change perception and adaptation strategies in the study area. This is because the younger ones that did not attend any formal education but very active and agile commit more of their energy in crop production, whereas the older and uneducated ones have had experiences in climate change over the years and some of the traditional/local coping and adaptation strategies to be adopted in combating climate change impacts. The educated ones on the other hand are more aware of the modern coping/adaptation strategies to climate change. This is very important because the knowledge will be used to enlighten the people about activities that are sensitive to climate. The assumption herein is that an educated person is more able to process information and use it to inform decisions, in addition to enabling the individual to perform tasks more efficiently, whereas lower education

constrains the ability to understand warning information and access to recovery information (Cutter *et al*, 2003). The low level of income per annum implies that most of the respondents are peasant farmers.

### Observed Climate Changes

The observed average temperature trend of the study area from the analyzed data is shown in Figure 2, 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 (Trentberth *et al*, 2007). The minimum temperature of 24.5°C was recorded in 1989. From the linear trend line equation, estimation of changes in average temperature expressed in °C for the period of study (1987-2016) showed an increase of 0.54°C for the 30 years period of study at the rate of 0.018°C year<sup>-1</sup>. When compared with the long-term mean, it means the average temperature has been increasing at the rate of 0.07% year<sup>-1</sup> (see Table 2). This is a clear indication that the study area (earth's atmosphere) is getting warmer in recent years. This increase is in line with the findings Oladipo (2011) that the country has been experiencing temperature increase of about 0.2°C - 0.3°C per decade in all its ecological zones. The warming trend is also in agreement with the reports of other researches that the average surface temperatures have increased by 0.5°C or more during the last 50-100 years over most parts of Africa with minimum temperatures warming more rapidly than maximum temperatures (Trentberth *et al*, 2007); while over West Africa and the Sahel, surface temperatures have increased between 0.5-0.8°C between 1970 and 2010 (Niang, *et al*, 2014). The increase in temperatures is majorly as a result of increase in GHGs due to human activities as a result of increasing technological development and subsequent high level industrialization.



**Figure 2:** Observed Average Temperature Trend (1987–2016).

**Source:** Field Survey (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 high amount of rainfall in the same

year. This high rainfall amount resulted to incidences of flood across the country, especially the northern States (NIMET, 2015). The lowest amount of rainfall of 786.4 mm was recorded in 1989. This coincided with the drought of the late 1980s.

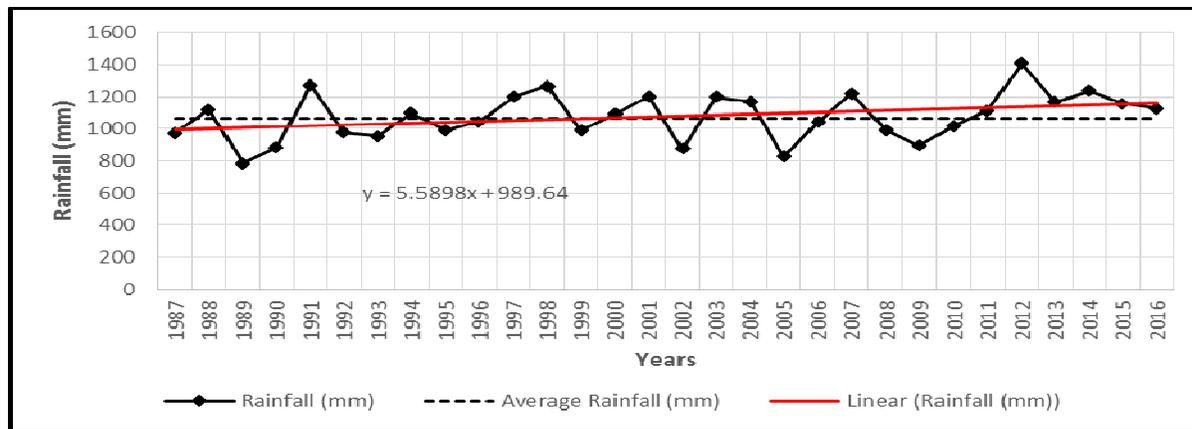
**Table 2:** Summary Statistics of Average Temperature and Annual Rainfall (1987-2016)

Average Temperature (°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/year	0.07	Percentage (%) of Change/year	0.52

**Source:** Field Survey (2016)

From the linear trend line equation, estimation of changes in annual rainfall expressed in mm for the period of study (1987-2016) showed an increase of 167.69 mm for the 30 years period of study at the rate of 5.59 mm year<sup>-1</sup>. When compared with the long-term mean, it mean the annual rainfall has been increasing at the rate of 0.52% year<sup>-1</sup> (see Table 2). The trend is in line with the findings of Odekunle, Andrew and Aremu (2008); Abaje, Ati, Iguisi and Jidauna (2013) and NIMET (2015), that the northern part

of the country has been experiencing wetter conditions in recent years. This is also in agreement with the findings of Trenberth *et al* (2007) that increases in heavy precipitation events have now been observed, even in places where total amounts have decreased and that these changes are associated with increased water vapor in the atmosphere arising from the warming of the world’s oceans, especially at lower latitudes.



**Figure 3:** Observed Annual Rainfall Trend (1987–2016)

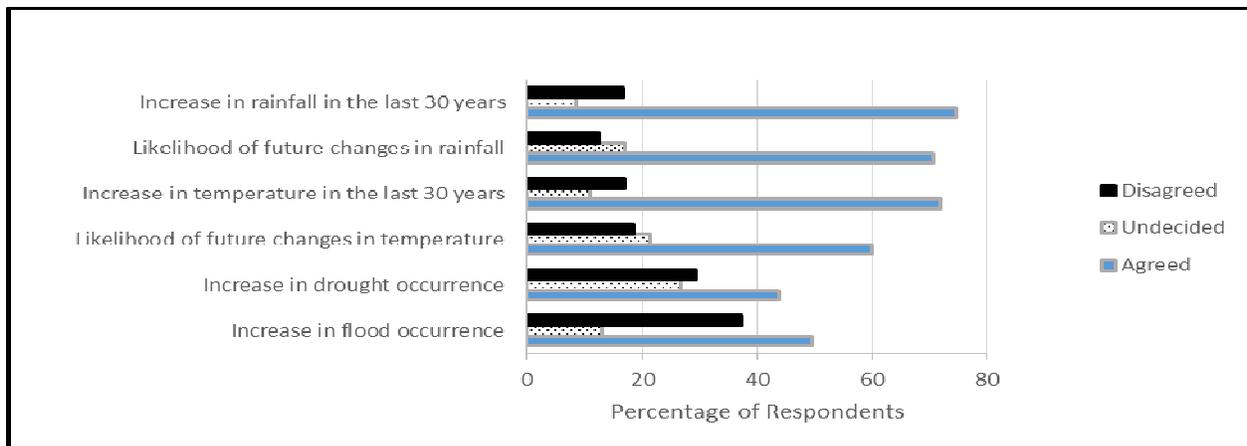
**Source:** Field Survey (2016)

### Perception of Climate Changes

Respondents' perception of climate change in the study area is shown in Figure 4. Rainfall according to 74.6% of the respondents is increasing significantly in the study area. Only 16.8% of the respondents are of the opinion that there is decrease in rainfall while 8.6% remained neutral. Respondents' perceived increased in rainfall is in line with the observed data. The perception of some of the respondents that rainfall is decreasing in the study area may be as a result of the shrinking in length of the rainy season. Based on that perception, they now believed that as the length of the rainy days decreases, the total rainfall amount is also affected negatively. About 70.6% of the respondents believed that there is likelihood of future changes in rainfall supply. Majority of the respondents (71.9%) believed that temperature has increased over the last three decades, and that there is likelihood of future changes in temperature in our lifetime as agreed by 60.0% of the respondents. Respondents' perception on increasing temperature is in line with the observed data in which temperature has been increasing in recent years.

In terms of extreme events, 43.8% responded that there is increase in the rate of drought

occurrence in the study area, while 29.4% said that there is reduction in the number of drought occurrence in the area. 26.8% of the respondents were not certain of either increasing or decreasing in drought occurrences in the area. The drought occurrence as perceived by the community dwellers is mostly as a result of irregularity in the onset or cessation of rainfall. However, the findings of Abaje *et al*, (2013) revealed that the Sudano-sahelian ecological zone has experienced a severe drought in the 1970s and 1980s but in the late 1990s and 2000s, there have been decrease in the occurrence of drought in the zone. Flood occurrence according to 49.5% of the respondents is increasing. The occurrence of floods as perceived by the respondents is not only as a result of increase in rainfall intensity and high inter-annual variability of the rainfall; but it was also observed that improper physical planning, deforestation and the erection of structures in areas of high risk were also factors that causes flooding in the area. The increasing number of flood occurrence is in line with the findings of Abaje *et al* (2013 and 2015) that flooding is becoming an annual occurrence in the northern parts of the country leading to loss of lives and property worth millions of Naira.



**Figure 4:** Respondents Perceived Changes in Climate  
**Source:** Field Survey (2016)

**Perceived Causes of Climate Change**

Most of the respondents are aware of the scientific proven causes of climate change. These include the release of harmful gases to the atmosphere through industrial activities, combustion of fossil fuel, human interference with the natural set-up of vegetation (deforestation), and natural factors such as changes in volcanic activity and solar output among others as some of the causes of climate change (Manyatsi, Mhazo and Masarirambi, 2010; Odjugo, 2010).

The respondents are aware of human interference with the natural set-up of vegetation which is mainly through the destruction of natural habitat informs of deforestation, overgrazing and bush burning (Abaje et al, 2014). This may be as a result of their dependent on the vegetation as a source of fuel wood and fodder for livestock.

A significant percentage of the respondents (81.6%) agreed that sins of mankind lead to climate change which induces weather hazards. This result is in good agreement with the findings of Farauta, Egbule, Idrisa and Agu (2011), Manyatsi et al (2010) and that of Abaje et al (2014) in which community disobeying God was one of the major causes of climate variability and change by rural communities. The strong religion belief of the people in the study area (mostly Muslims) seems to have influenced their response to believe that sins of mankind is a factor that is causing climate change. Climate

change and its impacts are seen as a punishment from God (*Allah*), not as a result of physical (natural) or anthropogenic factors. With such a strong religion belief, it may be very difficult for the respondents to adopt some adaptation measures that will reduce the impacts of climate change on their environment. This belief is also in line with the findings of Odjugo (2011) in which one basic reason given by the rural communities of the Niger Delta Region was that climate change impacts are divine punishment from God being meted out due to the numerous sins that the entire communities and the world have committed against the environment and God who created it.

**Impacts of Climate Change**

The impacts of climate change as perceived by the respondents are presented in Table 2. The most significant impact of climate change as perceived by the farmers in the study area is decrease in output of market gardening crops

(ranked 1) with a mean score ( $\bar{x}$ ) of 3.72. This statement was found to be significant in all the communities. The result is in agreement with the study of Abaje et al (2014) in which decline in crop yields as perceived by the respondents was significant. All the participants of the FGDs in the study area also complained of decreasing output of market gardening crops in recent years.

The significant impact of climate change on decline in market gardening crops as perceived by the respondents cannot be unconnected with other impacts of climate change such as increased in temperature as observed from the trend analysis of temperature, increase in rainfall and the shortening of the length of the growing season as also observed from the rainfall analysis, and incidence of flood occurrences. All these events always result to low crop yields.

Incidences of drought affecting market gardening crop production was the next most significant impact of climate change as perceived by the respondents in the study area.

This was ranked 2<sup>nd</sup> with a mean score ( $\bar{x}$ ) of 3.65. The view of respondents concerning incidences of flood leading to destruction of

market gardening crop farms and reduction of income generated from market gardening crop production were also significant with mean

scores ( $\bar{x}$ ) of 3.62 and 3.58 respectively. Another significant impact of climate change as perceived by the farmers was the fact that climate change leads to crop infestation and disease which is ranked 5<sup>th</sup> with a mean score

( $\bar{x}$ ) of 3.36. This is also in agreement with the results of Abaje *et al* (2014).

On the other hand, reduction in crop quality, increase in cost of producing market gardening crops, the yearly rains not supporting the crops as before, and fluctuation in cultivation period were not perceived by the respondents as significant impacts of climate change.

**Table 2:** Respondents' Perceived Impacts of Climate Change

Statements	Mean Scores of Selected Communities									Rank
	Ung. Damaski	Dantsoho	Ung. Dutse	Ung. Waziri	Makoyi	Sabon-Layi	Tashar Likoro	Marke	Average	
There is a decrease in output of market gardening crops over the years	3.52*	3.66*	4.19*	3.84*	3.20*	4.00*	3.67*	3.69*	3.72*	1
Incidences of drought affect market gardening crop production	3.78*	3.21*	4.17*	3.91*	3.22*	3.30*	4.45*	3.19*	3.65*	2
Incidences of flood lead to destruction of market gardening crop farms	3.69*	3.92*	4.13*	3.20*	3.77*	4.00*	3.17*	3.04*	3.62*	3
Income generated from market gardening crop production has reduced	3.28*	3.79*	3.24*	4.14*	3.72*	3.09*	3.91*	3.47*	3.58*	4
Climate change has led to crop infestation and disease	3.13*	2.97	3.44*	3.78*	2.54	3.90*	3.63*	3.55*	3.36*	5
The quality of the crops has reduced	3.15*	2.46	3.00*	2.91	2.88	2.46	2.97	3.26*	2.89	6
Cost of producing market gardening of crops is increasing because of climate change	2.91	3.28*	3.48*	2.76	2.34	2.64	2.78	2.82	2.87	7
The yearly rains are not supporting the crops as before	2.82	2.71	3.12*	2.88	2.63	2.96	2.77	3.00*	2.86	8
The period of cultivation fluctuates	2.72	2.99	3.12*	2.14	2.91	2.73	3.60*	2.41	2.82	9

\*Significant impacts

Source: Field Survey (2016)

**Adaptation Strategies to Climate Change in Producing Market Gardening Crops**

Adaptation strategies adopted by the farmers in combating the impacts of climate change on market gardening crop production in the various communities is presented in Table 3. The most significant adaptation strategies adopted by the farmers in the study area are application of fertilizer/animal dung on the farms to improve crop yield ( $\bar{x}$  = 3.77) and water harvesting during the rainy season ( $\bar{x}$  = 3.58). These two strategies were found to be significant in all the communities. This is in agreement with the findings of Abaje *et al* (2015) 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 in Kaduna State to hurdle the negative impacts of climate change on their farms.

This is followed by praying for God's intervention ( $\bar{x}$  = 3.47) in which all the communities were significant with the only exception of Ung. Damaski. Irrigation farming along flood plains during dry season and utilization of herbicides to control weeds on farm were the other significant adaptation strategies adopted by the farmers in the study area, with mean scores ( $\bar{x}$ ) of 3.34 and 3.06 respectively.

**Table 3:** Adaptation Strategies Adopted in Minimizing the Impacts of Climate Change

Statements	Mean Scores of Selected Communities								Average	Rank
	Ung. Damaski	Dantsoho	Ung. Dutse	Ung. Waziri	Makoyi	Sabon-Layi	Tashar Likoro	Marke		
Application of fertilizer/animal dung on the farms to improve crop yield	4.43*	4.17*	3.89*	3.66*	4.19*	3.63*	2.45	3.70*	3.77*	1
Water harvesting during the rainy season	3.72*	3.09*	3.28*	3.79*	3.24*	4.14*	3.91*	3.47*	3.58*	2
Praying for God's intervention	2.34	3.89*	3.45*	3.71*	3.85*	3.37*	4.11*	3.00*	3.47*	3
Irrigation farming along flood plains during dry season	4.19*	3.34*	3.17*	3.53*	3.81*	2.64	3.05*	2.97	3.34*	4
Using herbicides to control weeds on farm	3.07*	2.98	3.17*	2.55	3.12*	3.49*	3.37*	2.74	3.06*	5
Utilization of modern storage facilities	2.15	2.72	2.77	2.93	3.47*	3.17*	2.72	3.90*	2.98	6
Attending enlightenment programs on climate change	2.65	2.32	3.11*	2.89	3.56*	2.97	2.44	3.10*	2.88	7
Involvement in community and individual level savings	2.69	2.44	2.18	3.12*	3.11*	2.93	3.00*	2.77	2.78	8
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
Access to formal and informal credit community-based loaning institution in your community	2.31	2.54	3.19*	2.75	3.44*	2.22	2.65	2.74	2.73	10

\*Significant adaptation strategies

**Source:** Field Survey (2016)

Utilization of modern storage facilities was not a significant adaptation strategy for the study area but it was found to be significant among the communities of Makoyi, Sabon-Layi, and Marke communities. In terms of enlightenment on the use of modern storage facilities, it was significant only for Ung. Dutse, Makoyi, and Marke communities. Other insignificant strategies according to the respondents in the various communities are: involvement in community and individual level savings, planting of economic trees to augment crop production, and

access to formal and informal credit community-based loaning institution in the various communities. This is in agreement with the study of Abaje *et al* (2015).

In terms of praying for God to intervene as an adaptation strategy, a Muslim participant in Tashar-Likoro community during the FGD said that: “whenever there is late onset of the rainy season or any other weather anomalies, people do gather for a special prayer because they believe these are signs of God displeasure with the people”. He claimed that it always work.

#### **CONCLUSION AND POLICY RECOMMENDATIONS**

Agriculture as the mainstay of the economy in developing countries suffers a lot from erratic weather patterns such as longer dry seasons, heat stress and fluctuating rainfall patterns. Unfavorable weather conditions affect crop production and ultimately leading to food insecurity, hunger and shorter life expectancies. Great losses have already been recorded in the agricultural sector due to climate change, especially market gardening crops which are

very sensitive to changes in weather and climatic conditions.

This study recommends livelihoods diversification and moving away from the existing over reliance on natural and physical resources that are climate-sensitive; provision of irrigation facilities by government to encourage irrigation farming in order not to depend solely on rainfall; farm inputs such as fertilizers, herbicides and pesticides should be made available by the government at affordable price; and lastly, information dissemination, enlightenment and training programs on climate change should be strengthened. This can be done through radio and television programs, issuance of newsletter, booklets, reports and videos containing information on climate change and advice on sustainable adaptation strategies to be adopted.

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