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FOOD SECURITY: A DOCUMENTATION OF EFFECT OF CLIMATE CHANGE, CROP PRODUCTION AND FARMERS' INCOME IN KOGI STATE, NIGERIA

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Abstract
Long-term shifts in temperatures and weather patterns mainly due to human activities across the globe have left devastating effects on agricultural landscape, particularly in the Northern part of Nigeria. Accordingly, this study *documented the effects of climate change on crop production and farmers' income in Lokoja, Kogi State, Nigeria. Guided by an objective to examine the effects of climate change on crop production and farmers' income, two research questions were raised and two null hypotheses were postulated. The study utilized responses from 45 registered farmers who experienced effects of climate change from 2012 to 2022. The primary data elicited with a research instrument known as CCFSQ were used to address the research questions and test for the tenability of the hypotheses. Percentage, mean, standard deviation, Chi-square and Pseudo R^2 logistic regression methods were used. The result of the analysis revealed that climate change associated negatively with crop production as well as farmer's income; and the observed and expected responses of farmers on the effects of climate change on crop production and farmers' income do not significantly associate in Lokoja, Kogi State, Nigeria. The study concluded that climate change had adverse effects on crop production and farmers' income within the period of the study. It is therefore recommended that governments should build more water-containing-walls around confluence point of Rivers Benue and Niger in order to reduce level of the water overflow.*

Keywords: Food, Climate Change, Crop, Production, Income, Logistic Regression
JEL Codes: C82, C93, O13, Q4, Q14, Q18, Q54

1.Introduction

One of the purposes of having incremental annual budgetary provision to the real sector of the Nigerian economy is to ensure that there is a state of affair that guarantees a reliable access to a sufficient quantity of affordable and nutritious food for people of any class, gender or religion. A situation that promises all people, at all times, physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Kurukulasuriya and Mendelsohn (2011) note that availability; access, utilization and stability of food are critical focus for food security that reinforces efforts of any country to eradicate hunger and malnutrition. Social security guaranteed by food is critically important because it directly affects individual well-being, societal stability, and economic development (Amfo & Ali, 2020). This goes to suggest that food security is the dream of any economy because it has lots of implications for health and nutrition, economic productivity, social stability, environmental sustainability, global development goals and resilience to crises. No wonder efforts in difference manner are made to address food insecurity which is essential for achieving broader goals of health, equity, and economic development.

However, the dream is not near to realization in Africa. Ojo and Baiyegunhi (2021) assessing food security among young farmers in Kenya, Nigeria, and Uganda report that food insecurity remains a serious challenge for many households – a situation that affects the young people more than any other segment of the population as a result of their activeness in

the production processes of goods and services. In fact, a recent report by FAO (2021) indicates that about 21% of the African population faced severe hunger in 2020, doubling the proportion reported by other regions in the World.

Also, over 50% of the population faces moderate to severe food insecurity (Gebre, 2021), representing one-third (799 million) of the estimated 2.37 billion people facing moderate to severe food insecurity in the World (FAO 2021). Compared to other regions, the prevalence of food insecurity is much higher in West and East Africa, where over 68% and 65%, respectively experience moderate to severe food insecurity (FAO, 2021). Food insecurity is a circumstance that has attracted the United Nations' (UN) Sustainable Development Goals (SDGs) quest to end hunger and ensure food accessibility by all people by 2030. While there have been several national and international efforts to achieve this goal, food insecurity remains a major livelihood challenge in many developing countries, particularly in Africa. The food insecurity situation in Nigeria is getting worse as the country ranked 107th out of 113 countries on the Global Food Security Index (GFSI) in 2022. This position of Nigeria on the GFSI further revealed that the there is a decline of -0.9 in food production from the position the country was as at the year 2012.

A nation that used to be a net exporter of food has continued to experience decline in food production. Niger, Togo, Cameroon, Angola, Zambia, Chad, Sudan, Congo (Democratic Republic), Uganda, Rwanda, Senegal, Mali and Ghana performed better in terms of the production of food than Nigeria as evidenced by the Global Food Security Index (GFSI) in 2022 where Nigeria scored 42.0 on a scale of 100.0 in terms of adequate food production across the globe. Food prices are on the rise despite government's efforts over the years through various agricultural programmes poised to make food available for the masses (Apata, 2011). The problem of food insecurity in Nigeria is compounded by the adverse effect of climate change in terms of flood (Lele, 2019).

More worrying situation is that Nigeria loses and wastes 40 per cent of its total food production each year on the account of flood (Amfo & Ali, 2020). This loss accounts for 31 per cent of the country's total land use and accounts for 5 per cent of its greenhouse gas emissions. Of much concern is that food insecurity incidence is highest at 0.48 and lowest at 0.33 for the traders and unemployed respectively in Kogi State – which increases with increase in household size. This ranges between 0.27 and 1.00 for those households made up of 1- 4 and greater than 12 members respectively. This is a concerned that has generated debates and attracted research attention (Eregha, Babatolu &Akinnubi, 2014; Eshete, Mulatu &Gatiso, 2020; FAO 2021). However, the body of existing literature is yet to receive contribution as per the effect of climate change on food security with particular emphasis on how flood affected crop production and farmer's income, Kogi State, Nigeria. Consequently, this study is guided by the objective to examine the effects of climate change on crop production and farmers' income in Kogi State, Nigeria through the lens of descriptive survey. Accordingly, the study raised this question; what has been the association between climate change and crop production and farmers' income in Lokoja, Kogi State, Nigeria. Based on this, it is postulated that the observed and expected responses of farmers on the effects of climate change on crop production and farmers' income do not significantly associate. The rest of the paper addresses, in section 2, 3, 4 and 5, issues bordering on literature review, methodology, data presentation and results and concluding remarks.

2. Literature Review: Review of Theoretical Literature

This section undertakes review of literature in relation to the effect of climate change on crop production and farmers' income. This is done under the sub-heading of theoretical and

empirical reviews. Theoretical review considers climate sensitivity, and sustainability and development theories.

Theoretical Review

Climate Sensitivity Theory

This theory refers to the degree to which the Earth's climate responds to changes in greenhouse gas concentrations. Climate sensitivity is typically measured as the change in global average temperature resulting from a doubling of atmospheric CO2. Understanding climate sensitivity helps predict the potential impacts of different levels of greenhouse gas emissions on temperature and climate patterns, which in turn affect agricultural productivity and food availability. This theory is a key measure of the longer-term climate response to external forcing and impacting objects. In principle, it represents the equilibrium change in mean surface temperature to a doubling of atmospheric CO2 concentration from preindustrial levels and its resultant effect on the environment in both short-and-long-terms.

Nicholas (2023) argues that the theory is normally estimated using some approximate measure, often derived from disequilibrium changes cause by climate variation. Charney (2019) argues that climate change offers changes to how convective precipitation was natural modeled. This varied climate sensitivity is informed largely by human activities; and it in turn the fortune of human beings. Changing the order in which the various parameterized atmospheric modules were naturally updated in of creation remains sensitive to the future of all human affairs (Amfo & Ali, 2020).

Loehle (2014) is of the thought that climate sensitivity summarizes the net effect of a change in forcing on earth's surface temperature – which asserts lots of unpleasant implications on farming and other economic activities. This theory refers to the concept used to understand how the climate system responds to changes in greenhouse gas concentrations and causes negative effects on agricultural and other economic activities. It essentially measures how sensitive the earth's climate is to changes in atmospheric CO2 and other greenhouse gases that impact on farming activities. There are different ways to quantify and interpret climate sensitivity, but the core idea revolves around estimating how much the average global temperature will increase in response to a given increase in greenhouse gas concentrations. Understanding climate sensitivity helps in assessing risks and planning for climate impacts. Higher sensitivity implies a greater potential for warming and associated impacts, which influences policy decisions and adaptation strategies.

Sustainability and Development Theory

Sustainability and development theory was developed through practice and the study of sustainable development issues and tackling environmental issues to deal with the global climate issues. Based on the study of the evolution of sustainable development thoughts and the formation of sustainable development theory (Lele, 2019) posits that issues relating to human-environment are of great concern to the survival of the society in present and future. Thus, food security is a by-product of human environment that requires attention in order to ensure the survival of bother present and future generation. Sustainable development theory emphasizes balancing environmental, economic, and social goals to ensure long-term well-being. It incorporates climate change mitigation and adaptation into development planning. Its core interest is the integrating sustainability principles into agricultural practices and food systems helps address the challenges posed by climate change and ensures that food security is maintained over the long term.

Sustainability of food security is an essential part of facing current and future global challenges, not only those related to the climate change. This theory emphasizes the need for sustainable development practices that balance environmental, economic, and social dimensions to ensure long-term food security. It focuses on integrating climate adaptation and mitigation into development planning. Sustainable development relates to the principle of meeting human development goals while at the same time sustaining the ability of natural systems to provide the natural resources and ecosystem services upon which the economy and society depend (Gebre, 2021). It therefore follows that sustainable development practices can help build resilience to climate change by promoting sustainable agriculture, reducing food waste, and improving resource management.

Sustainable development theory (SD) has become a fundamental strategy to guide the world's social and economic transformation. However, in the process of practice, there are still misinterpretations in regards to the theory. Such misinterpretations are highlighted in the struggle between strong and weak sustainable development paths, the confusion of the concept of intra-generational, inter-generational justice and extent of impact of climate change. Sustainable development is the idea that human societies must live and meet their needs without compromising the ability of future generations to meet their own needs.

The theory explores the intersection between economic development and sustainable management of natural resources. This theory is grounded in the recognition that food security must be pursued in ways that do not deplete or degrade the environment, ensuring that future generations can meet their own needs. In summary, theories of climate change and food security provide frameworks for understanding the complex interactions between climate impacts and food systems. These theories help in identifying vulnerabilities, assessing risks, and developing strategies to enhance food security in the face of a changing climate. The theoretical framework linking climate change and food security encompasses various interrelated theories and concepts that explain how climate change impacts food systems and, consequently, food security. This framework integrates insights from environmental science, economics, agriculture, and social sciences. Climate change theory focuses on how variations in climate variables (temperature, precipitation, extreme weather) influence environmental conditions. Key aspects include global warming, changes in precipitation patterns, and increasing frequency of extreme weather events.

These changes can directly affect agricultural productivity, water availability, soil health, and biodiversity – which are crucial for food production. Thus, this study anchors on climate sensitivity theory and sustainability and development theory which argues that climate change can bring atmospheric variability that affect agricultural activities. While climate change threatens development, sustainability, through food security, provides the tools and strategies needed to achieve long-term economic and environmental balance. Moving towards sustainable development is essential to combat climate change while ensuring food security, economic progress and social well-being.

Empirical Review

Extant body of empirical literature has documented diverse effects of climate change on agricultural activities. Ayo, Omosebi and Sulieman (2014) report that the effect of climate change on food security is found to include decline in agriculture productivity, changes in the quality of land suitable for crop production, changes in precipitation patterns, and increase in temperature (that could lead to longer growing seasons), decreased arability, more pest, risk to fisheries, under nutrition. In a similar thought, Gregory, Ingram and Brklacich (2005) assert that the effect of climate change on food security differs in much way which includes

direct effects on crop production. That is, variations in rainfall result to drought or flooding, or warmer or cooler temperatures leading to changes in the length of growing season. This will automatically result to variation in markets, food prices and supply chain infrastructure.

Devereux and Edwards (2024) are of the opinion that the main effect of climate change on food security is evident in food production. Eregha, Babatolu and Akinnubi (2014) in their study argue that climate change exerts strong effect on food output, and the effects of climatic change variables on food security varies from one food to another, and also depends on the life span of the crop. Apata (2011) reports that hunger-related deaths will most likely rise if grain is produced in the same proportion with the growth rate experienced under a condition of unfavourable climatic environment. The work of Ahmed, Yusuf and Shamaki (2016) investigate the influence of climatic change on food security in Taraba State from 1983 to 2012 and document that change exhibits a strong influence on the production of Cassava in the area under studied. Dhakal, Khadka, Park and Escalante (2022) examine climate change and its effect on farm income and argue that climate change adaptation exerts favourably influence on crop revenue and revenue risk reduction. The result of the Ricardian model adopted by Ojo and Baiyegunhi (2021) reveals that the income of the farmers is affected by climate change perspective in addition to their socio-economic characteristics.

Akbari, Alamdarlo and Mosavi (2020) investigate the influence of climate change and groundwater salinity on the income of farmer in Qazvin region. Finding indicates that a rise in climate change and groundwater salinity demonstrate an inverse connection with the income risk and water shadow prices. This implies that climate change will decline farmer's income risk in the study region. The study of Ojo and Baiyegunhi (2020) revealed that the mean net income of each individual rice farm of those farmers that employed the strategies of adaptation was evidently larger than that of farmers who did not. In a similar study, Amfo and Ali (2020) document that climate change threatens the yield and income of farmers in the study areas. Alam, Taufique and Sayal (2017) report that climatic changes exerts different effect on agricultural output, profitability, income equality, employment, farmer's health, and government subsidy policy. Shrimp farmers are often threatened with shrimp income decline in the study areas in recent time as a result climate change prevalence (Quach, Murray & Morrison-Saunders, 2017).

Bobojonov and Aw-Hassan, (2014) in a study divulge that climate change exerts strong positive influence on income of large-scale commercial farms in the northern regions of Kazakhstan, while for the small-scale farms in arid zones of Tajikistan, the outcome is found to be negative. Abid, Schneider and Scheffran (2016) examine the relationship between adaptation to climate change and its impacts on performance of food output and crop income. The result reveals that the adaptation of wheat crops to climate change strongly favoured wheat productivity and net crop income and thereby indirectly promoting the welfare of the farmers and local food security. Alamgir, Furuya, Kobayashi, Binte and Salam (2018) report that high level of differences in agricultural income among regions is facilitated by the gross income from rice production.

Studies by Dhakal, Khadka, Park and Escalante (2022) and Gibson (2012) have reported mixed resultant effects of climate change on agricultural product, while (Apata, 2011; Lele, 2019; Charney, 2019) have argued that climate change assert negative effect on agricultural produce. However, Ojo, and Baiyegunhi, (2021); Amfo and Ali, (2020) reported otherwise. It is evident that the debate on the effect of climate change on agriculture as an aspect of real sector of the world economy is inconclusive and the field has not been sufficiently researched or addressed in the existing body of literature - suggesting the existence of gap in the body of

extent literature. In view of this, it becomes crucial to extend food security literature by documenting the effects of climate change on crop production and farmers' income in Kogi State, Nigeria.

3. Method of Study

This study adopts descriptive survey research design on the basis that it would allow the use of quantitative approach to describe the events and discover inferences in investigating the effects of climate change on crop production and farmers' income in Kogi State, Nigeria. The population of the study comprises the 45 farmers who are affected by flood from 2012 to 2022 and are active and registered members of the Kogi State Farmers' Association, Lokoja Branch, Kogi State. The study adopts homogeneous sampling as an aspect of purposive sampling method within the orientation of non-probability sampling. On this basis therefore, the population will serve as the sample size.

The study utilizes data primarily sourced with the use of a research instrument known as CCFSQ which represent climate change food security questionnaire. This instrument is utilized to elicit information on issues raised with the aim of achieving the objectives of the study and test the tenability of the hull hypotheses. The instrument is self-constructed and consists of two parts; part A consists questionnaire items of demographic variables while part B consists of questionnaire statements aimed at eliciting responses from the 45 farmers. Both validity and reliability of the instrument were confirmed to have high validity index (0.863) and internal consistency. This was confirmed in a pilot study using 5 farmers in different location within the Kogi State using Cronbach's Alpha correlation statistical tool; and it was administered using through the services of three research assistants.Responses from the research instrument are analyzed using statistical tools of percentage, mean, standard deviation, bar chart for the research questions, while the tenability of the null hypothesis was confirmed using Chi-square and Pseudo R^2 logistic regression methods at 0.05 alpha level.

4. Presentation of Results of Tests of Descriptive Statistics and Hypotheses

Research Question One

Table 4.1: Transformed Data and Result of Descriptive Statistical Test for Research Question One

S/N	AC	Questionnaire Items	SA (%)	A (%)	D (%)	SD (%)	N	Sum	Mean	SD	Variance
1.	A	Changes in average temperature affect crop growth, development, and yield.	28 (62.2)	8 (17.8)	4 (8.9)	9 (11.1)	45	149	3.31	1.04	1.08
2.	B	Increased variability in rainfall, including more frequent or intense droughts and floods, affects crop growth.	29 (64.4)	8 (15.6)	4 (6.7)	4 (13.3)	45	149	3.31	1.08	1.17
3.	C	Flooding can damage crops and harvest schedules.	31 (68.9)	5 (8.9)	3 (6.7)	6 (15.6)	45	149	3.31	1.14	1.31
4.	D	Elevated CO2 levels can affect crop growth differently.	10 (22.2)	19 (42.2)	6 (13.3)	10 (22.2)	45	119	2.64	1.07	1.14

5.	E	Persistent decreases in crop yields can be directly linked to adverse climate conditions, such as increased temperatures, reduced precipitation, or extreme weather events.	22 (48.9)	15 (33.3)	3 (6.7)	5 (11.1)	45	144	3.20	.99	0.98
6.	F	Crop Size and Shape: Changes in temperature and water availability can affect the size, shape, and overall quality of crops, impacting their market value and nutritional quality.	22 (48.9)	14 (31.1)	4 (8.9)	5 (11.1)	45	143	3.18	1.01	1.01
7.	G	Changes in the length and timing of the growing season, due to altered temperature and precipitation patterns, can affect planting and harvesting schedules and overall crop productivity.	24 (53.3)	12 (26.7)	2 (4.4)	7 (15.6)	45	143	3.18	1.09	1.20
8.	H	Warmer temperatures and changing precipitation patterns can lead to an increase in pest populations and their range, affecting crop health and yields.	22 (48.9)	14 (31.1)	5 (11.1)	4 (8.9)	45	144	3.20	.97	0.94
9.	I	Increased rainfall intensity leads to higher rates of soil erosion, reducing soil fertility and affecting crop production.	17 (37.8)	20 (44.4)	4 (8.9)	4 (8.9)	45	140	3.11	.91	0.83
10.	J	Changes in climate can lead to soil degradation, reducing the availability of essential nutrients for crops.	26 (57.8)	11 (24.4)	4 (8.9)	4 (8.9)	45	149	3.31	.97	0.95
Average Values			**23.4**	**12.6**	**7.5**	**5.8**	**45**	**142.9**	**3.18**	**1.03**	**1.06**

AC = Analytical Codes. SD = Standard Deviation. SA = Strongly Agree, A = Agree, D = Disagree, SD = Strongly Disagree.
Source: Extract from SPSS Result Output, 2025.

Table 4.1 presents ten (10) questionnaire items used to assess the impact of climate change on crop production in Kogi State, Nigeria. From the responses, it is evident that questionnaire

item 1 has 28, 8, 4 and 9 responses for SA, A, D and SD respectively. This gives rise to total 45 responses and 149 response-sum, with the mean value of 3.31, standard deviation of 1.04 and 1.08 variance. By the mean value, it is instructive to point out that the item is accepted in favour of the research question. The low values of standard deviation (1.04) and variance (1.08) support this claim by revealing that the data point of responses of the 45 sampled farmers do not differ. Responses on the second questionnaire item of the study show that out of the 45 responses from the sampled farmers, SA, A, D, SD have 29, 8, 4 and 4 responses respectively.

The item has a mean score of 3.31, standard deviation and variance values of 1.08 and 1.17 respectively. From the analysis, it is obvious that the item is accepted in favour of the research question. This acceptance is supported by the low values of standard deviation and variance. Responses to item C of the questionnaire has 31, 5, 3 and 6 for SA, A, D and SD respectively. With a response-sum of 149, the mean score is 3.31, standard deviation is 1.14 and variance stands at 1.31. This shows that item is accepted in favour of the research question. With respect to item D, the responses of the 45 sampled farmers are 10, 19, 6 and 10 for SA, A, D and SD respectively. This gives rise to 119 response-sum, mean value of 2.64, standard deviation value of 1.07 and 1.14 for variance. For questionnaire item E, the responses are 22 for SA, 15 for A, 3 for D and 5 for SD, a response-sum of 144, and the values of mean, standard deviation and variance stand at 3.20, 0.99 and 0.98 respectively. Questionnaire item F has respective responses to SA, A, D, and SD as 22, 14, 4 and 5, giving rise to 143 response-sum, 3.18, 1.01 and 1.01 values for mean, standard deviation and variance. Questionnaire item G of the study has 24 responses for SA, 12 for A, D has 2 and SD gets 7. These responses from 45 sampled farmers give rise to 143 response-sum, 3.18 mean score, standard deviation of 1.09 and 1.20 variance score.

Questionnaire item H of the study has 22, 14, 5 and 4 responses to SA, A, D and SD respectively; with 144 response-sum, 3.20 mean score, 0.97 standard deviation and 0.94 variance scores. All of these point to the fact the questionnaire item is accept accepted in favour of the research question. Questionnaire option responses, SA, A, D and SD, to questionnaire item ‘I’ have 17, 20, 4 and 4 scores respectively; with response-sum of 140, mean value of 3.11, 0.91 for standard deviation and 0.83 for variance. With the value of the mean, the questionnaire item is accepted in favour of the research question. The responses of the 45 farmers to questionnaire item J are in the distribution of 26, 11, 4 and 4 for SA, A, D and SD respectively. The response-sum stands at 149, mean value is 3.31, standard deviation of 0.97 and variance of 0.83.

The acceptance of the questionnaire items following the values of the mean values is strongly corroborated by the values of standard deviation and variance. For the measurement of how spread out or dispersed the value of the item in a data set is, the value of the standard deviation values imply that the data points are close to the mean (average) of the data set. In other words, they do not vary much from the mean values. The value of the average squared deviation (1.03) from the mean known as the variance is equally low – suggesting that the variance is small. This means that the data points are close to the mean, and there is little spread or variability in the data. It is obvious that all the questionnaire items have mean scores above the criterion mean of 2.50; hence they are all accepted in favour of the research question under consideration. This implies that the impact of climate change on crop production are that changes in average temperature affect crop growth, development, and yield; increased variability in rainfall, including more frequent or intense droughts and floods, affects crop growth and flooding can damage crops and harvest schedules. Also, Elevated CO2 levels affected crop growth differently and persistent decreases in crop yields can be

directly linked to adverse climate conditions, such as increased temperatures, reduced precipitation, or extreme weather events.

Climate change in terms of flooding has made changes in temperature and water availability to affect the size, shape, and overall quality of crops, impacting their market value and nutritional quality. Just like how changes in the length and timing of the growing season, due to altered temperature and precipitation patterns, affected planting and harvesting schedules and overall crop productivity. Similarly, the farmers accepted that warmer temperatures and changing precipitation patterns led to an increase in pest populations and their range, affecting crop health and yields. Increased rainfall intensity led to higher rates of soil erosion, reducing soil fertility and affecting crop production and changes in climate led soil degradation, reducing the availability of essential nutrients for crops. From the analysis, it is instructive to point out that the impact of climate change on crop production is high. This claim earns support from the average statistical values of mean (3.18) – which is greater than the criterion mean score of 2.50, with low values of standard deviation and variance at 1.03 and 1.06 respectively.

Research Question Two

Table 4.2: Transformed Data and Result of Descriptive Statistical Test for Research Question Two

S/N	AC	Questionnaire Items	SA (%)	A (%)	D (%)	SD (%)	N	Sum	Mean	SD	Variance
11	**K**	Extreme weather led to complete crop failure and loss of income for the season.	28 (62.2)	10 (23.2)	4 (8.9)	3 (6.7)	45 (100)	153	3.40	.91	.84
12	**L**	Climate-induced variability in crop production led to fluctuations in market prices and did not benefit farmers.	29 (64.4)	8 (17.8)	5 (11.1)	3 (6.7)	45 (100)	153	3.40	.94	.88
13	**M**	Increased variability in weather patterns made farming more unpredictable leading decrease farmers' income.	24 (53.3)	10 (22.2)	6 (13.3)	5 (11.1)	45 (100)	143	3.18	1.05	1.10
14	**N**	Higher temperatures and changing precipitation patterns affected livestock health and negatively impacted farmers' income.	10 (22.2)	20 (44.4)	5 (11.1)	10 (22.2)	45 (100)	120	2.67	1.07	1.14

15	**O**	Adverse weather conditions increased labour costs and reduced net income of farmers	26 (57.8)	10 (22.2)	6 (13.3)	3 (6.7)	45 (100)	149	3.31	.95	.91
16	**P**	Reduced rainfall and increased evaporation led to water scarcity which increased cost of farming and reduced profitability of farmers.	22 (48.9)	16 (35.6)	4 (8.9)	3 (6.7)	45 (100)	147	3.27	.89	.79
17	**Q**	Climate change affected quality of crops and livestock products, and reduced farmers' income.	25 (55.6)	10 (22.2)	6 (13.3)	4 (8.9)	45 (100)	146	3.24	1.00	1.01
18	**R**	Increase in climate led to higher expenses for farmers.	29 (64.4)	9 (15.6)	4 (8.9)	3 (6.7)	45 (100)	164	3.64	1.32	1.73
19	**S**	Climate change forced farmers to migrate due to loss of livelihoods, leading to loss of agricultural income.	20 (44.4)	14 (31.1)	4 (8.9)	7 (15.6)	45 (100)	137	3.04	1.09	1.18
20	**T**	Climate change made farming riskier and reduced farmers' access to necessary capital and incomes.	24 (53.3)	12 (26.7)	4 (8.9)	5 (11.1)	45 (100)	145	3.22	1.02	1.04
Average Mean Values			**23.7**	**11.9**	**4.8**	**4.6**	**45**	**145.7**	**3.24**	**1.02**	**1.06**

AC = Analytical Codes. SD = Standard Deviation. SA = Strongly Agree, A = Agree, D = Disagree, SD = Strongly Disagree.

Source: Extract from SPSS Result Output, 2025.

Table 4.9 presents ten (10) questionnaire items used to assess the impact of climate change on farmers' income in Kogi State, Nigeria. From the responses, it is evident that questionnaire item A has 28, 10, 4 and 3 responses for SA, A, D and SD respectively. This gives rise to total 45 responses and 153 response-sum, with the mean value of 3.40, standard deviation of 0.91 and 0.84 variance. By the mean value, it is instructive to point out that the item is accepted in favour of the research question. The low values of standard deviation (0.91) and variance (0.84) support this claim by revealing that the data point of responses of the 45 sampled farmers do not differ.

Responses on the second questionnaire item with analytical code of B show that out of the 45 responses from the sampled farmers, SA, A, D, SD have 29, 8, 5 and 3 responses respectively.

The item has a mean score of 3.40, standard deviation and variance values of 0.94 and 0.88 respectively. From the analysis, it is obvious that the item is accepted in favour of the research question. This acceptance is supported by the low values of standard deviation and variance. Responses to item C of the questionnaire has 24, 10, 6 and 5 for SA, A, D and SD respectively. With a response-sum of 143, the mean score is 3.18, standard deviation is 1.05 and variance stands at 1.10. This shows that the item is accepted in favour of the research question. With respect to item D, the responses of the 45 sampled farmers are 10, 20, 5 and 10 for SA, A, D and SD respectively. This gives rise to 120 response-sum, mean value of 2.67, standard deviation value of 1.07 and 1.14 for variance.

For questionnaire item E, the responses are 26 for SA, 10 for A, 6 for D and 3 for SD, a response-sum of 149, and the values of mean, standard deviation and variance stand at 3.31, 0.95 and 0.91 respectively. By the mean value the questionnaire item is accepted in relation to the research question. Questionnaire item F has respective responses to SA, A, D, and SD as 22, 16, 4 and 3, giving rise to 147 response-sum, 3.27, 0.89 and 0.79 values for mean, standard deviation and variance respectively. Also, this signifies acceptance of the item in favour of the research question. Questionnaire item G of the study has 25 responses for SA, 10 for A, D has 6 and SD gets 4. These responses from 45 sampled farmers give rise to 146 response-sum, 3.24 mean score, standard deviation of 1.00 and 1.01 variance score.

Questionnaire item H has 29, 9, 4 and 3 responses to SA, A, D and SD respectively; with 164 response-sum, 3.64 mean score, 1.32 standard deviation and 1.73 variance scores. All of these point to the fact the questionnaire item is accept accepted in favour of the research question. Questionnaire option responses, SA, A, D and SD, to questionnaire item 'I' have 20, 14, 4 and 7 scores respectively; with response-sum of 137, mean value of 3.04, 1.09 for standard deviation and 1.18 for variance. With the value of the mean, the questionnaire item is accepted in favour of the research question. The responses of the 45 farmers to questionnaire item J are in the distribution of 24, 12, 4 and 5 for SA, A, D and SD respectively. The response-sum stands at 145, mean value is 3.22, standard deviation of 1.02 and variance of 1.04. The acceptance of the questionnaire items following the values of the mean values is strongly corroborated by the values of standard deviation and variance. For the measurement of how spread or dispersed the value of the item in a data set is, the value of the standard deviation values imply that the data points are close to the mean (average) of the data set. In other words, they do not vary much from the mean values. The value of the average squared deviation (1.02) from the mean known as the variance is equally low – suggesting that the variance is small, it means the data points are close to the mean, and there is little spread or variability in the data.

It is obvious that all the questionnaire items have mean scores above the criterion mean of 2.50; hence they are all accepted in favour of the research question under consideration. This implies that the impact of climate change on farmers' income are that extreme weather led to complete crop failure and loss of income for the season, climate-induced variability in crop production led to fluctuations in market prices and did not benefit farmers, increased variability in weather patterns made farming more unpredictable and led to decrease farmers' income, higher temperatures and changing precipitation patterns affected livestock health and negatively impacted farmers' income, and adverse weather conditions increased labour costs and reduced net income. Further, reduced rainfall and increased evaporation led to water scarcity which affected cost of farming and reduced profitability of farmers. Also, climate

change affected the quality of crops and livestock products, and reduced farmers' income; and increase in climate led to higher expenses for farmers. Climate change forced farmers to migrate due to loss of livelihoods, leading to loss of agricultural income and it made farming riskier and reduced farmers' access to necessary capital and incomes. From the analysis, it is instructive to point out that the impact of climate change on farmers' income is high. This claim earns support from the average statistical values of mean (3.24) – which is greater than the criterion mean score of 2.50, with low values of standard deviation and variance at 1.02 and 1.06 respectively.

Table 4.3: Result of Test of Hypothesis on Model Fitting Information
H_{01}: The observed and expected responses of farmers on the effect of climate change on crop production do not significant associate.

Likelihood Ratio Tests						
Effect	**Model Fitting Criteria**	**Likelihood Ratio Test**			**Pseudo R-Square**	
	-2 Log Likelihood of Reduced Model	**Chi-Square**	**df**	**Sig**		
Intercept	1.623[a]	.000	0	.	Cox and Snell	.870
I	1.623[b]	.000	3	1.000	Nagelkerke	.988
J	2.808[b]	1.185	3	.757	McFadden	.960
B	1.623[b]	.000	3	1.000		
C	1.623[b]	.000	3	1.000	Model	Model Fitting Criteria
D	1.623[b]	.000	3	1.000		-2 Log Likelihood
E	1.623[b]	.000	3	1.000	Intercept	86.109
F	1.623[a]	.000	0	.		
G	1.623[b]	.000	3	1.000	Final	1.426
H	1.623[b]	.000	3	1.000		
Summary of Likelihood Ratio Tests		74.209	48	0.000		

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0. (a). This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom. (b). Unexpected singularities in the Hessian matrix are encountered. This indicates that either some predictor variables should be excluded or some categories should be merged.

Source: An Extract from Result Output Analyzes With SPSS, 2025.

Table 4.3 presents the likelihood ratio result of test of hypothesis on whether or not observed and expected responses of farmers on the effects of climate change on crop production significantly differ. The test was done using model fitting criteria of -2 log likelihood of reduced model. The opinions of the sampled 45 farmers in Lokoja, Kogi State, Nigeria on the ten questionnaire items ranging from A to J were used in the analysis. The analysis used the **-2 Log Likelihood** in the context of **model fitting**, for logistic regression – which measures how well a model fits the data with a rule of thumb suggests that lower values generally

indicate a better fit. From the result, it is evident that the items used as analytical codes (AC) have respective values of -2 log likelihood of reduced model. Analytical codes from A to I have 1.623 as the value of -2 likelihood of reduced model, while analytical code of J has 2.808.

The **-2 Log Likelihood (LL)** is a measure of the "badness of fit" – it is derived from the likelihood of observing the data under the model. The lower the value, the better the model fits the data. The result of **1.623** suggests that the model fit is associated with this value of the log-likelihood and it typically means that the model fits the data better. In this case, **1.623** might seem quite low in absolute terms, but the context really depends on the **-2 Log Likelihood** of the other models you are comparing it to. However, the value of J is considered high because it is greater than 2. Following this result it becomes instructive to point out that the questionnaire items raised to address the research questions have reason goodness-of-fit and suitable in examining the subject matter.

In furtherance of the test of hypothesis, the pseudo regression square test was conducted. The result of the test revealed that **Cox and Snell value is $R^2 = 0.870$.** This statistic is used to measure how well a model fits the data, similar to the R^2 value in ordinary least squares (OLS) regression. The Cox and Snell R^2 value of **0.870** suggests that the model explains about **87%** of the variance in crop production, which is considered a very good fit as it explains most of the variability in the outcome variable. However, the result does not represent the proportion of variance explained in a strict sense. It provides an indication of model fit but should be interpreted alongside other metrics, such as the **Nagelkerke R^2** (which adjusts the Cox and Snell R^2 to ensure it has a maximum value of 1.

In order to ensure the robustness of the result, a **Nagelkerke test was conducted and R^2 of 0.988** is produced as an adjusted Cox and Snell R^2 used to address some of the limitations of statistic. This **pseudo-R^2** value assesses the fit of a logistic regression model (or other generalized linear models). The value of Nagelkerke (0.988) is closer to 1 indicating a better fit of the model to the data. It goes further to suggest that the model explains about **98.8%** of the variance in crop production and implies that your model is very well suited to the data, well-calibrated and quite accurate in predicting outcomes. However, it is always a good idea to check for potential overfitting or ensure you're using cross-validation techniques to validate the model's performance. This is done and reported using McFadden R^2. The test of McFadden test produces a value of **$R^2 = 0.960$** – which is another **pseudo-R^2** value used in the context of logistic regression and other generalized linear models. The value of the result means that the model explains **96%**of the improvement in the likelihood of observing the outcome compared to a null model (which only predicts based on the overall mean of the dependent variable). In simpler terms, it suggests that the model is explaining almost all of the variability in the data beyond what would be expected by chance or by using a very basic model. This suggests that the model is highly effective in explaining the variability of the outcome variable.

The table further reveal a chi-square value of 74.209 – which is used to determine whether there is a significant difference between expected and observed frequencies in categorical data with a de**gree of freedom (df) of 48. From the result the p-value is very small (0.000, being less than 0.05)**. This intuitively suggests that the null hypothesis cannot be accepted, suggesting there is a significant difference between the observed and expected values. Hence the null hypothesis of no association between the two categorical variables is dropped. This means that there is enough statistical evidence to conclude that the observed data significantly deviates from what was expected under the null hypothesis; thus, there is a significant relationship between the two categorical variables. This further suggests that the differences in the observed data are unlikely to be due to random chance alone, meaning that some underlying factor is likely influencing the data. However, it does not indicate causation, only association.

Table 4.4: Result of Test of Hypothesis on Model Fitting Information

H_{02}: The observed and expected responses of farmers on the effect of climate change on farmers' income do not significant associate.

Likelihood Ratio Tests						
Effect	**Model Fitting Criteria**	**Likelihood Ratio Test**			**Pseudo R-Square**	
	-2 Log Likelihood of Reduced Model	**Chi-Square**	**Df**	**Sig**		
Intercept	1.664[a]	.000	0	.	Cox and Snell	.860
L	1.664[b]	.	3	.	Nagelkerke	.987
M	1.664[a]	.000	0	.	McFadden	.958
N	1.664[b]	.	3	.		
O	1.664[b]	.	6	.	Model	Model Fitting Criteria
P	1.664[b]	.	6	.		-2 Log Likelihood
Q	2.343[b]	.679	3	.878	Intercept	90.07
R	1.664[b]	.000	3	1.000		
S	1.664[b]	.	6	.	Final	1.66
T	1.664[a]	.000	0	.		
Summary of Likelihood Ratio Tests		88.40	48	0.000		

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0. (a). This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom. (b). Unexpected singularities in the Hessian matrix are encountered. This indicates that either some predictor variables should be excluded or some categories should be merged.

Source: An Extract from Result Output Analyzes With SPSS, 2025.

From the result in table 4.4, it is evident that the items used as analytical codes (AC) have respective values of -2 log likelihood of reduced model. Analytical codes from K, M, N, O, P, R, S and T have 1.664 as the value of -2 likelihood of reduced model, while analytical code of Q has 2.343. the reveals that the lower the value, the better the model fits the data. The result of **1.664** suggests that the model fit is associated with this value of the log-likelihood and it typically means that the model fits the data better. In this case, **1.664** might seem quite low in absolute terms, but the context really depends on the **-2 Log Likelihood** of the other models you are comparing it to. However, the value of Q is considered high because it is greater than 2. Following this result it becomes instructive to point out that the questionnaire items raised to address the research questions have a reason goodness-of-fit and suitable in examining the impact of climate change on farmer's income in Kogi State, Nigeria.

In furtherance of the test of hypothesis, the pseudo regression square test was conducted. The result of the test revealed that **Cox and Snell value is R^2 = 0.860. This test is** typically a statistic used in the context of logistic regression or other types of generalized linear models (GLMs). This statistic is used to measure how well a model fits the data, similar to the R^2 value in ordinary least squares (OLS) regression. The Cox and Snell R^2 value of **0.860**

suggests that the model explains about **86%** of the variance in the farmer's income, which is considered a very good fit as it explains most of the variability in the outcome variable. However, the result does not represent the proportion of variance explained in a strict sense. It provides an indication of model fit but should be interpreted alongside other metrics, such as the **Nagelkerke R²** (which adjusts the Cox and Snell R² to ensure it has a maximum value of 1.

In order to ensure the robustness of the result, a **Nagelkerke test was conducted and R² of 0.987** is produced as an adjusted Cox and Snell R^2 used to address some of the limitations of statistic. This **pseudo-R²** value assesses the fit of a logistic regression model (or other generalized linear models). The value of Nagelkerke (0.987) is closer to 1 indicating a better fit of the model to the data. It goes further to suggest that the model explains about **98.7%** of the variance in farmer's income and implies that your model is very well suited to the data, well-calibrated and quite accurate in predicting outcomes. However, it is always a good idea to check for potential overfitting or ensure you're using cross-validation techniques to validate the model's performance. This is done and reported using McFadden R^2. The test of McFadden test produces a value of **R² = 0.956** – which is another **pseudo-R²** value used in the context of logistic regression and other generalized linear models. The value of the result means that the model explains **95%** of the improvement in the likelihood of observing the outcome compared to a null model (which only predicts based on the overall mean of the dependent variable). In simpler terms, it suggests that the model is explaining almost all of the variability in the data beyond what would be expected by chance or by using a very basic model. This suggests that the model is highly effective in explaining the variability of the outcome variable.

The table further reveal a chi-square value of 88.40 – which is used to determine whether there is a significant difference between expected and observed frequencies in categorical data with a d**egree of freedom (df) of 48. From the result the p-value is very small (0.000, being less than 0.05)**. This intuitively suggests that the null hypothesis cannot be accepted, suggesting there is a significant difference between the observed and expected values. Hence the null hypothesis of no association between the two categorical variables is dropped. This means that there is enough statistical evidence to conclude that the observed data significantly deviates from what was expected under the null hypothesis; thus, there is a significant relationship between the two categorical variables. This further suggests that the differences in the observed data are unlikely to be due to random chance alone, meaning that some underlying factor is likely influencing the data. However, it does not indicate causation, only association.

5. Concluding Remarks

The state in which all people, at all times, have **physical, social, and economic access** to **sufficient, safe, and nutritious food** that meets their dietary needs and food preferences for an active and healthy life. This state relies on four pillars which are availability, access, utilization, and stability – which have been argued to be threatened by c**limate change** (droughts, floods, extreme weather)**. Accordingly, this study was carried out to unravel the effects of** climate change on crop production and farmers' income in Lokoja, Kogi State, Nigeria by relying on the opinions of 45 affected farmers from 2012 to 2022 using an instrument known as CCFSQ. The responses were analyzed using statistical tools of percentage, mean, standard deviation, bar chart for the research questions, while the tenability of the null hypothesis was confirmed using Chi-square and Pseudo R^2 logistic regression methods at 0.05 alpha level. The result of the analysis revealed that climate change associated negatively with crop production as well as farmer's income; and the observed and expected responses of farmers on the effects of climate change on crop production and farmers' income do not significantly associate in Lokoja, Kogi State, Nigeria. The concluded that climate

change had adverse effects on crop production and farmers' income within the period of the study.

It is therefore recommended that governments should build more water-containing-walls around confluence point of Rivers Benue and Niger in order to reduce level of the water overflow. Further there should be constant maintenance of water plane by the government, and the farmers should be educated and abreast with the implications of hydrological information on annual basis.

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