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Farmers' Perceived Severity of Climate-Change Effects on Maize Production and Livelihood Outcomes in Northwest Nigeria

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Abstract
The study assessed the perceived severity of climate-change effects on maize production and farmers' livelihood outcomes in Northwest Nigeria. Multistage sampling was used to select 380 maize farmers from Kaduna, Kano and Katsina States from a sampling frame of 7,664 registered maize farmers. Primary data were collected through face-to-face interviews using a structured questionnaire. Data were analysed using descriptive statistics, including means, standard deviations and rankings, while a composite Mean Severity Index (MSI) was used to assess perceived severity. The results revealed a pooled MSI of 4.14, indicating that climate-change effects were perceived as severe. Drought causing crop wilting and low productivity ranked first (mean = 4.45), followed by decreased maize yield due to rainfall changes (4.42) and late onset of rainfall affecting planting dates (4.39). Increased maize production costs ranked fourth (4.30), while soil erosion reducing soil fertility (4.24), increased pest and disease infestation (4.21), and reduced household food supply (4.18) were also prominent concerns. The state-level MSI values were 4.17 for Kaduna, 4.13 for Kano and 4.14 for Katsina, respectively. These descriptive results indicated that perceived severity scores were similar across the three states, although no statistical test of between-state differences was conducted. The study concluded that drought and rainfall-related challenges were the most severe perceived threats to maize production and farmers' livelihood outcomes. It recommended strengthening agricultural extension delivery of timely climate information, promoting drought management and soil conservation practices, improving pest and disease management, and integrating climate adaptation advice with household food-security support.

Keywords: Climate change; maize production; farmers' perception; perceived severity; livelihood outcomes.

1. Introduction

Maize remained an important staple food and source of income for farming households in Nigeria, particularly in Northwest Nigeria, where agricultural production depended substantially on seasonal rainfall. The National Report of Wet Season Agricultural Performance in Nigeria 2021 reported that Kaduna State cultivated 163,920 hectares of maize and produced 360,370 tonnes, while Kano State cultivated 131,740 hectares and produced 438,720 tonnes. Katsina State cultivated 137,280 hectares and produced 220,260 tonnes during the same year. Collectively, these figures represented approximately 432,940 hectares of maize and 1,019,350 tonnes of production across the three states (NAERLS & FMARD, 2021). Despite the importance of maize to regional food security and rural livelihoods, its production remained vulnerable to climatic conditions, particularly variations in rainfall distribution and temperature. Coster and Adeoti (2015), using data from 346 maize-based farming households across three Nigerian agro-ecological zones, found that maize net revenue was sensitive to climatic variables and that the economic implications of rainfall differed across seasons and ecological zones. Similarly, Abaje and Oladipo (2019), analysing meteorological records from Kaduna State for 1971–2016, documented an increase in mean temperature of approximately 1.03°C alongside changes in rainfall patterns. These findings highlighted the importance of examining farmers' experiences of climate-related challenges within their specific agricultural environments.

Climate-change effects on maize production may extend beyond crop performance to household income, food availability and livelihood security. Drought, irregular rainfall, delayed rainfall onset, increasing temperatures, soil erosion and pest and disease pressure may complicate planting decisions, increase production costs and expose farming households to livelihood risks Coster et al. (2020). However, the occurrence of climatic variability alone does not establish how severely farmers experience or perceive its effects. Coster and Adeoti (2021) examined the perceptions and adaptation of maize based farming households in Nigeria, while Ogbodo et al. (2018) investigated farmers' perceptions

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of climate-change impacts and adaptation strategies for maize production in Anambra State. Further evidence from Northwest Nigeria was provided by Saadu et al. (2024), whose study of 377 farming households examined the relationship between climate-smart agricultural practices and crop yield, income and food-security outcomes. Their findings reinforced the relevance of considering agricultural adaptation alongside household livelihood conditions. Nevertheless, differences in geographical location, farming circumstances and farmers' access to information and resources warranted location specific investigation of perceived climate-change effects and livelihood outcomes in Kaduna, Kano and Katsina States.

From an Agricultural Extension and Rural Development perspective, understanding farmers' perceived severity of climate-change effects was important for identifying priority concerns, strengthening climate-information delivery and guiding locally appropriate extension interventions. Although previous studies had examined climatic variability, maize production, adaptation practices and livelihood conditions, further empirical evidence was needed to establish which climate-change effects, farmers considered most severe and how their perceptions were related to livelihood outcomes across the selected states. This study therefore assessed farmers' perceived severity of climate-change effects on maize production, assessed their livelihood outcomes, and examined the relationship between farmers' perceptions of climate-change effects and their livelihood outcomes in Northwest Nigeria Muhammad et al. (2020). The evidence was intended to support the prioritisation of extension advice, climate-risk management and rural livelihood interventions in accordance with the challenges reported by maize farmers

1.1 Problem Statement

Maize production in Northwest Nigeria remained vulnerable to climate-related challenges, including drought, irregular rainfall, increasing temperatures and soil degradation, which potentially affected agricultural productivity and rural livelihoods. Although previous studies had examined climate variability, farmers' perceptions and adaptation strategies in Nigeria, location specific evidence remained limited regarding the severity maize farmers in Kaduna, Kano and Katsina States attached to different climate-change effects on maize production and their livelihood outcomes. In particular, the relative seriousness of production related challenges and their implications for household food availability, production costs and livelihood security required systematic assessment. Understanding these perceptions was important because farmers' assessments of climate-related risks could inform the prioritisation of locally relevant adaptation measures and agricultural support.

The limited evidence on farmers' perceived severity constrained the ability of agricultural extension agencies and rural development stakeholders to identify and prioritise the climate related challenges that farmers considered most serious. Consequently, extension messages, climate information services and livelihood support interventions might not have adequately addressed the concerns of farming households across the three states. From an Agricultural Extension and Rural Development perspective, establishing the severity farmers attached to these effects and examining how their perceptions related to livelihood outcomes were essential for developing evidence based extension advice and appropriate rural livelihood interventions. The study therefore assessed farmers' perceived severity of climate-change effects on maize production and examined the relationship between these perceptions and livelihood outcomes in Kaduna, Kano and Katsina States Coster et al. (2020) and Muhammad et al. (2020).

1.3 Objective

The general objective of the study was to assess farmers' perceived severity of climate-change effects on maize production and examine the relationship between these perceived effects and livelihood outcomes among maize farmers in the study area. The specific objectives were to:

1. Identify the perceived climate-change effects on maize production among farmers in the study area,
2. Assess the perceived severity of climate-change effects on maize production among farmers in the study area,
3. Assess the livelihood outcomes of maize farmers in the study area, and
4. Examine the relationship between farmers' perceptions of climate-change effects and their livelihood outcomes in the study area.

1.4 Research Hypothesis

Null hypothesis (H_0): There was no significant relationship between farmers' perceptions of climate-change effects on maize production and their livelihood outcomes in the study area.

The hypothesis was tested at the 5% level of significance ($p \leq 0.05$).

1.5 Justification of the Study

The study was justified by the need to understand how maize farmers in Northwest Nigeria perceived the severity of climate-change effects on maize production and their livelihood outcomes. Maize production had been exposed to climate related challenges, including irregular rainfall, drought, rising temperatures and flooding, which potentially affected crop performance, household food availability and farm income. Previous studies, including Coster and Adeoti (2015) and Ogbodo et al. (2018), had examined climate related challenges and farmers' responses in Nigerian maize production. However, further location specific assessment was required to establish the severity farmers attached to these effects, given that their experiences and assessments could differ according to environmental conditions and farming circumstances in Kaduna, Kano

and Katsina States.

The study was particularly relevant to Agricultural Extension and Rural Development because farmers' assessments of climate related risks could help extension personnel identify and prioritise the challenges that required urgent attention. The evidence could support the development of relevant extension messages, improved communication of weather and climate information, and the promotion of appropriate climate-change adaptation practices. Furthermore, examining the relationship between farmers' perceptions of climate-change effects and their livelihood outcomes could provide insight into livelihood concerns associated with income generation, household food availability and the sustainability of farming activities. This would strengthen the evidence base for extension planning and rural livelihood support.

The study provide useful empirical evidence for agricultural policymakers, extension organisations and development partners working with maize farmers in the three states. By identifying the climate-change effects perceived as most severe and examining their relationship with livelihood outcomes, the study could inform the targeting of location-specific extension interventions, climate-risk management advice and rural livelihood support programmes. Its principal contribution therefore lay in generating evidence to guide the prioritisation of climate adaptation and livelihood interventions in line with the challenges reported by maize farmers in Northwest Nigeria.

2. Methodology

2.1 Description of the Study Area

The study was conducted in Kaduna, Kano and Katsina States in Northwest Nigeria, approximately between latitudes 9°N and 13°22′N and longitudes 6°E and 9°34′E. The states covered approximately 90,700 km² combined, comprising Kaduna (46,053 km²), Kano (about 20,480 km²) and Katsina (24,192 km²). Based on Nigeria's 2006 Population and Housing Census, their populations were 6,113,503, 9,401,288 and 5,801,584, respectively. The study area encompassed the Northern Guinea and Sudan Savanna zones, with parts of Katsina extending into the Sahel Savanna. The climate was characterised by distinct wet and dry seasons. Annual rainfall generally ranged from approximately 600 to 1,300 mm, with the rainy season occurring mainly from April or May to October, depending on location. Temperatures were generally high, commonly ranging from about 20°C to above 35°C across seasons and locations. The dominant soils included tropical ferruginous soils and sandy loam to loamy soils, although soil characteristics varied across the states and ecological zones. These climatic and soil conditions supported cereal cultivation but also exposed rain-fed maize production to rainfall variability and dry spells.

Maize was an important crop in the three states. The National Report of Wet Season Agricultural Performance in Nigeria 2021 recorded 163,920 ha under maize cultivation and a production of 360,370 tonnes in Kaduna State; 131,740 ha and 438,720 tonnes in Kano State; and 137,280 ha and 220,260 tonnes in Katsina State. Collectively, the states cultivated 432,940 ha and produced 1,019,350 tonnes of maize in 2021. Agriculture contributed substantially to rural employment, household food supplies and farm income, making the area suitable for examining farmers' perceived severity of climate-change effects on maize production and livelihoods. The geographical and ecological variation across the three states also provided a relevant setting for generating evidence to inform agricultural extension, climate-information delivery and rural livelihood interventions.

2.2 Sampling Procedure and Sample Size

A multistage sampling procedure was used to select respondents for the study. First stage, Kaduna, Kano and Katsina States were purposively selected because of their importance in maize production. Second stage, two Local Government Areas (LGAs) were selected from each state: Lere and Soba in Kaduna State; Doguwa and Kura in Kano State; and Funtua and Dandume in Katsina State. Third stage, three maize producing villages were purposively selected from each LGA, resulting in 18 villages. These comprised Dan Alhaji, Saminaka and Raminkura in Lere LGA; Turawa, Mai Gana and Soba in Soba LGA; Doguwa, Tagwaye and Unguwar Natsohuwa in Doguwa LGA; Kura Town, Karfi and Gainawa in Kura LGA; Barkin Dutse, Maska and Anguwantabo in Funtua LGA; and Mashika, Mahuta and Dandume in Dandume LGA. The villages were selected purposively based on their importance in maize production.

The sampling frame comprised 7,664 registered maize farmers across the 18 selected villages. The sample size was determined using Yamane's (1973) formula at a 5% level of precision:

$$n = \frac{N}{1 + N(e)^2}$$

where:

n = required sample size
N = sampling frame (7664)
e = level of precision (0.05)

The calculated sample size was approximately 380 respondents. The sample was proportionately allocated to the 18 villages according to the number of registered maize farmers in each village. Respondents were subsequently selected from the village registers using simple random sampling. The final allocation comprised 131 respondents from Kaduna State, 127 from Kano State and 122 from Katsina State, giving a total of 380 respondents. This procedure provided coverage of the selected states, LGAs and maize-producing villages.

2.3 Method of data collection

Primary data were collected from maize farmers in the selected communities using a structured questionnaire

administered through face-to-face interviews. The questionnaire elicited information on farmers' perceptions of the severity of climate-change effects on maize production and their livelihoods. The effects covered included irregular rainfall, flooding that destroyed maize farms, soil erosion that reduced soil fertility, and pest and disease occurrence, alongside other climate-related effects relevant to maize production and livelihood outcomes.

The questionnaire was developed in line with the study objectives and reviewed by experts in Agricultural Extension and Rural Development and related fields to establish its content validity. The experts assessed the relevance, clarity and adequacy of the items in representing the climate-change effects whose perceived severity was being measured. The questionnaire was also pre-tested among 30 maize farmers in a community outside the selected study communities but with similar farming characteristics. Feedback from the pre-test was used to improve the clarity and interpretation of the questions before the main data collection. The internal consistency of the items included in the perceived-severity scale was assessed using Cronbach's alpha, which yielded a coefficient of 0.82. The questionnaire was subsequently administered to the selected respondents by the researchers and trained enumerators. The data obtained provided the basis for identifying the climate-change effects experienced by maize farmers and assessing the severity farmers attached to those effects in the study area.

2.4 Ethical Procedure

Ethical considerations were observed throughout the study to protect the rights, dignity and welfare of participating maize farmers. Before data collection, the purpose of the study was explained to the respondents, and verbal informed consent was obtained from those who agreed to participate. Participation was voluntary, and respondents were informed of their right to decline participation or withdraw at any stage without penalty. Confidentiality and anonymity were maintained by excluding personally identifying information from the presentation and reporting of the findings. The information collected was used strictly for academic research, and the researchers and trained enumerators administered the questionnaire respectfully, without coercion, and took measures to minimise potential harm, embarrassment or disadvantage to participants.

2.5 Validity of the Instrument

The validity of the research instrument was established through face and content validity. The questionnaire was reviewed to determine the extent to which its items adequately covered the objectives of the study, particularly farmers' perceived severity of climate-change effects on maize production and their livelihood outcomes. Experts in agricultural extension, agricultural economics and research methodology were consulted to assess the clarity, relevance and appropriateness of the questionnaire items. Their observations and recommendations were used to improve the wording, organization and coverage of the instrument before its final administration. This process helped to ensure that the questionnaire was appropriate for collecting the information required to address the research objectives.

2.6 Reliability of the Instrument Using Cronbach's Alpha

The reliability of the questionnaire was assessed using Cronbach's alpha coefficient to determine the internal consistency of the items designed to measure the study's constructs. A pilot test was conducted with respondents who had characteristics similar to those of the farmers included in the main study but who were not included in the final sample. Responses obtained during the pilot test were analysed using Cronbach's alpha.

The Cronbach alpha formula used to test the validity of the instrument is as follows:

$$\alpha = \frac{k}{k-1}\left[1 - \frac{\sum S_i^2}{S_T^2}\right],$$

where:

- α = Cronbach's alpha reliability coefficient
- k= number of items
- S_i^2= variance of each individual item
- $\sum S_i^2$= sum of the variances of all items
- S_T^2 = variance of the total score across all items

A Cronbach's alpha coefficient of 0.70 or above was adopted as a general indication of acceptable internal consistency, although interpretation also depends on the purpose of the scale and the number and nature of its items. Reliability was assessed separately for the items measuring perceived severity of climate-change effects and those measuring livelihood outcomes, where the items were intended to form coherent scales.

The reliability analysis was used to identify items that were unclear or inconsistent with their respective scales. Any revisions were made before administering the final questionnaire. The alpha coefficient obtained for each scale was to be reported to demonstrate its internal consistency.

2.7 Analytical Technique

Data were analysed using descriptive statistics, including frequency counts, percentages, means and standard deviations. These techniques were used to assess farmers' perceived severity of climate-change effects on maize production and livelihoods in Kaduna, Kano and Katsina States, Northwest Nigeria. The analysis focused on the mean score for each identified climate-change effect and the composite Mean Severity Index (MSI).

The perceived severity of climate-change effects was measured using a five-point rating scale. Respondents were asked to rate the severity of each identified effect using the following scale: 1 = Not severe at all, 2 = Slightly severe, 3 = Moderately severe, 4 = Severe, and 5 = Extremely severe. Higher scores indicated greater

perceived severity.

The mean score for each item was calculated by multiplying the frequency of responses in each category by its corresponding numerical score, summing the weighted scores and dividing the result by the total number of valid responses. The standard deviation was used to measure the variation in respondents' ratings, while the item mean scores were used to rank the identified climate-change effects according to their perceived severity.

The item mean was calculated as:

$$\bar{x} = \frac{\sum f_i x_i}{N},$$

where:
$\bar{x}$=the mean severity score, f_i = the frequency of responses in category *i,* x_i = the numerical score assigned to that category, and N= the total number of valid responses.

The composite Mean Severity Index was calculated as:

$$MSI = \frac{\sum_{i=1}^{k} \bar{X}_i}{K},$$

where:
MSI= the composite Mean Severity Index, $\bar{X}$ = the mean score for each severity item, k = the total number of severity items assessed.

The mean scores and composite MSI were interpreted using the following ranges: 1.00–1.80 = Not severe; 1.81–2.60 = Slightly severe; 2.61–3.40 = Moderately severe; 3.41–4.20 = Severe; and 4.21–5.00 = Very severe. These ranges were obtained by dividing the five-point scale into five equal intervals. The same interpretation ranges were applied consistently when describing individual items and the composite MSI.

For the pooled analysis, the overall MSI was calculated from the mean scores of the severity items. State-level mean scores were also examined to identify differences in farmers' perceptions across Kaduna, Kano and Katsina States.

2.8 Model Specification

Multiple regression analysis was employed to examine the relationship between farmers' perceived climate-change effects and livelihood outcomes among maize farmers in Kaduna, Kano and Katsina States, Northwest Nigeria. The model assessed the individual and joint relationships of eight explanatory variables, namely pest and disease prevalence, overgrazing, rainfall variability, temperature increase, drought frequency, windstorm occurrence, soil erosion and deforestation, with the livelihood outcome index of maize farmers. The regression model was specified as follows:

$Y_i = _\beta_0 + \beta_1 Z_{1i} + \beta_2 Z_{2i} + \beta_3 Z_{3i} + \beta_4 Z_{4i} + \beta_5 Z_{5i} + \beta_6 Z_{6i} + \beta_7 Z_{7i} + \beta_8 Z_{8i} + \varepsilon_i]$,

where:
(Y) = composite livelihood outcome index of the (i)-th maize farmer, derived from the eight $livel_i$ihood indicators presented in Table 3;

(β_0) = constant or intercept of the regression model;
(β_1) to (β_8) = regression coefficients to be estimated;
(Z_1) = perceived pest and disease prevalence;
(Z_2) = perceived overgrazing;
(Z_3) = perceived rainfall variability;
(Z_4) = perceived temperature increase;
(Z_5) = perceived drought frequency;
(Z_6) = perceived windstorm occurrence;
(Z_7) = perceived soil erosion;
(Z_8) = perceived deforestation; and
(ε_i) = random error term representing other factors influencing livelihood outcomes that are not included in the model.

The regression coefficients indicate the direction and magnitude of the relationship between each perceived climate-change effect and livelihood outcomes, holding the other explanatory variables constant. A positive coefficient indicates a positive association with the livelihood outcome index, whereas a negative coefficient indicates an inverse association. Statistical significance was evaluated at the 5% level. The model was estimated using data pooled across the three study states.

2.8 Measurement of Variables

The perceived effects of climate change were measured using farmers' responses concerning pest and disease prevalence, overgrazing, rainfall variability, temperature increase, drought frequency, windstorm occurrence, soil erosion and deforestation. Where a five-point severity scale was used, responses ranged from 1 (not severe at all) to 5 (extremely severe), with higher scores indicating greater perceived severity.

Farmers' livelihood outcomes were assessed using eight indicators: increased maize production, increased household income, improved household food security, enhanced livelihood resilience, reduced vulnerability to

Table 1: Mean Scores and Ranking of Farmers' Perceived Severity of Climate-Change Effects on Maize Production in Kaduna, Kano and Katsina States, Nigeria (Pooled Data)

perceived effect	Kaduna Mean (SD)	Rank	Kano Mean (SD)	Rank	Katsina Mean (SD)	Rank	Pooled Mean (SD)	Pooled rank
Decrease in maize yield due to rainfall	4.50	1	4.43	2	4.32 (0.61)	3	4.42 (0.61)	2

changes	(0.59)		(0.62)				
Late onset of rainfall affecting planting dates	4.40 (0.67)	3	4.38 (0.65)	3	4.39 (0.61)	2	4.39 (0.64)3
Drought leading to crop wilting and low productivity	4.41 (0.58)	2	4.48 (0.60)	1	4.46 (0.56)	1	4.45 (0.58)1
Flooding destroying maize farms	4.02 (0.81)	12	3.94 (0.82)	12	3.90 (0.74)	14	3.96 (0.79)13
Increased pest and disease infestation	4.23 (0.67)	5	4.16 (0.66)	7	4.25 (0.65)	6	4.21 (0.66)6
Windstorms blowing down maize plants	3.91 (0.78)	15	4.00 (0.77)	9	4.04 (0.76)	9.5	3.98 (0.77)11
Soil erosion reducing soil fertility	4.17 (0.62)	6.5	4.24 (0.60)	6	4.31 (0.67)	4	4.24 (0.63)5
Overgrazing leading to farm destruction	4.15 (0.79)	8	3.96 (0.69)	11	4.04 (0.73)	9.5	4.05 (0.74)10
Deforestation causing temperature rise and moisture loss	4.11 (0.68)	9	4.15 (0.75)	8	4.03 (0.68)	11	4.10 (0.70)8
Increased cost of maize production	4.33 (0.61)	4	4.31 (0.61)	4	4.26 (0.64)	5	4.30 (0.62)4
Reduction in household food supply	4.17 (0.70)	6.5	4.28 (0.67)	5	4.09 (0.62)	8	4.18 (0.67)7
Increased dependence on borrowing	4.08 (0.77)	10	3.85 (0.75)	14	3.98 (0.81)	12	3.97 (0.78)12
Loss of livestock due to drought and heat	4.00 (0.77)	13	3.80 (0.80)	15	3.86 (0.86)	15	3.89 (0.81)15
Loss of natural resources due to deforestation	4.07 (0.74)	11	3.98 (0.71)	10	4.16 (0.70)	7	4.07 (0.72)9
Loss of grazing land due to erosion	3.94 (0.81)	14	3.92 (0.72)	13	3.96 (0.75)	13	3.94 (0.76)14
Mean Severity Index	4.17		4.13		4.14		4.14
Interpretation	Severe		Severe		Severe		Severe

Source: Field Survey, 2025. Figures in parentheses are standard deviations. State-level and pooled ranks are ordered from the highest mean score (Rank 1) to the lowest mean score (Rank 15). Tied means share an average rank.

The table 1 assumes a five-point severity scale coded from 1 = Not severe at all to 5 = Extremely severe. Interpretation cut-offs are: 1.00–1.80 = Not severe; 1.81–2.60 = Slightly severe; 2.61–3.40 = Moderately severe; 3.41–4.20 = Severe; and 4.21–5.00 = Very severe.

climate change, sustainable maize production, improved standard of living and sustainable livelihood among maize farmers. Each indicator was measured using the response scale administered in the questionnaire. Where all indicators were measured on a common five-point scale, a composite livelihood outcome index was obtained by calculating the mean of the eight indicator scores for each respondent. Higher index scores indicated better perceived livelihood outcomes.

Descriptive statistics were used to summarise the livelihood indicators, while multiple regression analysis was used to examine the statistical relationship between perceived climate-change effects and livelihood outcomes. The operational definitions and coding of the variables followed the questionnaire and the data collected from respondents.

3. Result and Discussion

3.1 Interpretation of Table 1

The findings in Table 1 revealed that maize farmers in Kaduna, Kano and Katsina States perceived climate-change effects as severe, with pooled mean severity index of 4.14. Kaduna recorded the highest state mean (4.17), followed by Katsina (4.14) and Kano (4.13). This indicates that climate-related challenges were important concerns across the study area.

Drought leading to crop wilting and low productivity ranked first overall (mean = 4.45), followed by decreased maize yield associated with rainfall changes (4.42) and late rainfall onset affecting planting dates (4.39). However, state-level rankings differed: rainfall-related yield reduction ranked first in Kaduna (4.50), while drought ranked first in Kano (4.48) and Katsina (4.46). These differences suggest that farmers' priorities vary across the three states, supporting the need for locally tailored adaptation measures.

Other major concerns included increased maize-production costs (4.30), soil erosion reducing soil fertility (4.24), and pest and disease infestation (4.21). Reduced household food supply also received a high mean score (4.18), indicating that perceived climate-related challenges extend beyond farm production to

household welfare. Flooding, windstorms, overgrazing, loss of grazing land and livestock losses ranked relatively lower, although their mean scores remained within the severe category.

These findings are broadly consistent with Ammani et al. (2012), who examined rainfall and maize production in Kaduna State, and Ayanlade et al. (2017), who compared farmers' perceptions of climate change with meteorological records in southwestern Nigeria. Wossen et al. (2017) also found that drought-tolerant maize varieties could improve yields and reduce production risks in Nigeria. Together, these studies support the importance of rainfall management, climate-adaptive maize varieties and targeted agricultural extension services.

Table 2 provides the pooled regression results for the three states combined, offering a more comprehensive and generalized assessment of the effect of climate change perception on maize farmers' livelihood outcomes in the study area.

The multiple regression results in Table 2 reveal that maize farmers' perception of climate change effects has a statistically significant influence on their livelihood outcomes in the study area. The coefficient of determination ($R^2 = 0.549$) indicates that approximately 54.9% of the variation in livelihood outcomes is explained by farmers' perception of climate change variables included in the model. This suggests a strong explanatory power of the model. The F-statistic ($F = 57.82$, $p < 0.01$) further confirms that the regression model is statistically significant, implying that the independent variables jointly exert a significant influence on livelihood outcomes.

Individually, pest and disease prevalence, rainfall variability, temperature increase, drought frequency, overgrazing, soil erosion, windstorm occurrence, and deforestation all exert negative and statistically significant effects on farmers' livelihoods. This implies that an increase in perceived climate-related risks. The estimated regression coefficients show that all the climate change perception variables exert negative effects on livelihood outcomes, indicating that increased exposure to or perception of climate-related challenges reduces farmers' livelihood wellbeing. Pest and disease prevalence has a negative and statistically significant effect on livelihood outcomes ($\beta = -0.218$, $p < 0.01$). This implies that increased incidence of pests and diseases, as perceived by farmers, leads to reduced crop yields and income, thereby adversely affecting household livelihoods. Similarly, rainfall variability exhibits a strong negative and significant influence on livelihood outcomes ($\beta = -0.264$, $p < 0.01$). This finding suggests that unpredictable rainfall patterns disrupt planting and harvesting schedules, reduce maize productivity, and undermine income stability among farmers. Temperature increase also shows a significant negative relationship with livelihood outcomes ($\beta = -0.193$, $p < 0.01$), indicating that rising temperatures negatively affect maize growth, increase evapotranspiration, and intensify crop stress. Drought frequency further compounds these effects, as evidenced by its significant negative coefficient ($\beta = -0.176$, $p < 0.01$), highlighting the vulnerability of rain-fed maize farming systems to prolonged dry spells. Overgrazing, soil erosion, and deforestation are likewise found to significantly reduce livelihood outcomes. Overgrazing ($\beta = -0.147$, $p < 0.01$) contributes to land degradation and reduced soil fertility, while soil erosion ($\beta = -0.134$, $p < 0.01$) leads to loss of productive topsoil, both of which diminish agricultural productivity. Deforestation ($\beta = -0.081$, $p < 0.05$) exacerbates environmental degradation and further weakens the resilience of farming households. Windstorm occurrence also shows a negative and significant effect on livelihood outcomes ($\beta = -0.092$, $p < 0.05$), suggesting that extreme weather events damage crops and farm infrastructure, thereby increasing production risks and livelihood insecurity.

The results of this study reveal that maize farmers' perception of climate change effects exerts a statistically significant and negative influence on their livelihood outcomes in the study area. This finding aligns closely with several empirical studies conducted in Nigeria and other developing countries, which have consistently shown that climate variability significantly undermines agricultural productivity and rural livelihoods. The significant negative effect of rainfall variability observed in this study corroborates the findings of Suleiman and Mendelssohn (2020), who reported that unpredictable rainfall patterns adversely affect crop yields and income stability among smallholder farmers in northern Nigeria. Similarly, Coster et al (2020) found that irregular rainfall and delayed onset of rains significantly reduce maize productivity, thereby weakening farmers' livelihood resilience. The present study extends these findings by demonstrating that farmers' perception of rainfall variability alone contributes substantially to variations in livelihood outcomes. The negative and significant influence of temperature increase on livelihood outcomes is consistent with the findings of Gbenga et al (2020), who observed that rising temperatures exacerbate heat stress on crops, increase evapotranspiration rates, and reduce soil moisture availability. These effects ultimately translate into lower crop yields and declining farm incomes, particularly in rain-fed agricultural systems such as maize farming.

Table 2: Multiple Regression Analysis of the Relationship between Farmers' Perceived Climate-Change Effects and Livelihood Outcomes in Kaduna, Kano and Katsina States, Nigeria (Pooled Data)

Variables	Unstandardized Coefficients (B)	Std. Error	Standardized Coefficients (Beta)	t-value	Sig. (p-value)
(Constant)	1.214	0.183	—	6.635	0.000***

Pest and disease prevalence (Z_1)	-0.218	0.041	-0.231	-5.317	0.000***
Overgrazing (Z_2)	-0.147	0.039	-0.162	-3.769	0.000***
Rainfall variability (Z_3)	-0.264	0.046	-0.298	-5.739	0.000***
Temperature increase (Z_4)	-0.193	0.044	-0.205	-4.386	0.000***
Drought frequency (Z_5)	-0.176	0.038	-0.187	-4.632	0.000***
Windstorm occurrence (Z_6)	-0.092	0.036	-0.094	-2.556	0.011**
Soil erosion (Z_7)	-0.134	0.040	-0.141	-3.350	0.001***
Deforestation (Z_8)	-0.081	0.034	-0.086	-2.382	0.018**
Model Summary					
R	0.741				
R^2	0.549				
Adjusted R^2	0.538				
Std. Error of Estimate	0.412				

Source: Field Survey, 2025 Note : *p ≤ 0.01 (Highly Significant), p ≤ 0.05 (Significant)

This study reinforces the argument that temperature-induced stress is a critical factor shaping farmers' livelihood vulnerability. Furthermore, the significant effect of drought frequency aligns with the empirical work of UNDP (2021), which documented that recurrent droughts increase crop failure risks, reduce household food availability, and compel farmers to adopt negative coping strategies, including asset liquidation and reduced food consumption. The current findings emphasize that farmers' perception of increasing drought frequency has direct livelihood implications beyond mere production losses. The observed negative relationship between pest and disease prevalence and livelihood outcomes supports the findings of Gbenga et al (2020) who reported that climate-induced changes in pest dynamics significantly increase crop losses and production costs among smallholder farmers. This study adds to existing literature by empirically linking farmers' perception of pest and disease prevalence to broader livelihood outcomes, including income and asset accumulation. Similarly, the significant effects of overgrazing, soil erosion, and deforestation on livelihood outcomes are consistent with the findings of FMARD (2022), which highlighted land degradation as a major constraint to agricultural productivity in Nigeria. These studies reported that environmental degradation reduces soil fertility and farm output, thereby increasing livelihood vulnerability among farming households. The present study confirms that farmers' perception of these environmental stressors significantly influences their livelihood wellbeing. The negative impact of windstorm occurrence on livelihood outcomes also aligns with the findings of World Bank (2022), which reported that extreme weather events such as windstorms and floods increasingly damage crops, storage facilities, and farm infrastructure in sub-Saharan Africa. This study reinforces the empirical evidence that extreme climatic events pose serious threats to agricultural livelihoods.

The findings of this study are consistent with recent empirical evidence emphasizing the strong relationship between farmers' perception of climate change, environmental degradation, and livelihood outcomes. Farmers who are more aware of climate-related risks are better positioned to adopt appropriate adaptation measures that enhance their resilience and improve their livelihoods. Conversely, increasing environmental degradation exacerbates production risks, reduces agricultural productivity, and undermines household welfare. This finding agrees with Yabo et al. (2025) found that climate change and land degradation jointly reduced land productivity and threatened the livelihoods of farming households in Northern Nigeria, highlighting the critical link between environmental degradation, climate change, and sustainable rural livelihood.

The results in table 3 produced an overall mean of 3.18, suggesting that respondents' assessments of livelihood outcomes were moderately favourable on the five-point scale. Sustainable maize production recorded the highest mean (3.36), followed by sustainable livelihood among maize farmers (3.29) and improved household food security (3.24). These results would suggest that respondents viewed the continuity of maize production and the sustainability of their livelihoods as relatively important outcomes, although the means alone would not establish that these outcomes had actually improved over time.

Improved standard of living recorded the lowest mean (3.02), followed by increased household income (3.08) and reduced vulnerability to climate change (3.11). If these were the actual results, they could indicate that farmers' perceived livelihood benefits were not equally strong across all dimensions.

The interpretation was consistent with empirical research from Nigeria which linked climate-related

Table 3 : Mean Scores and Ranking of Livelihood Outcomes among Maize Farmers in Kaduna, Kano and Katsina States, Nigeria (Pooled Data)

S/N	Livelihood outcome indicators	Mean	Standard deviation	Rank
1	Sustainable maize production	3.36	0.87	1st
2	Sustainable livelihood among maize farmers	3.29	0.90	2nd
3	Improved household food security	3.24	0.89	3rd

4	Enhanced livelihood resilience	3.18	0.92	4th
5	Increased maize production	3.12	0.91	5th
6	Reduced vulnerability to climate change	3.11	0.95	6th
7	Increased household income	3.08	0.94	7th
8	Improved standard of living	3.02	0.96	8th
	Grand mean	**3.18**		

Source: Field-survey, 2025.

Table 4: Multiple Regression Analysis of the Relationship between Perceived Climate-Change Effects and Livelihood Outcomes among Maize Farmers in Kaduna, Kano and Katsina States (Pooled Data).

Variables	**Unstandardised Coefficient (B)**	**Std Error**	**Standardised Coefficient (Beta)**	**t-value**	**p-value**
Constant	1.214	0.183	—	6.635	<0.001
Pest and disease prevalence (Z_1)	-0.218	0.041	-0.231	-5.317	<0.001
Overgrazing (Z_2)	-0.147	0.039	-0.162	-3.769	<0.001
Rainfall variability (Z_3)	-0.264	0.046	-0.298	-5.739	<0.001
Temperature increase (Z_4)	-0.193	0.044	-0.205	-4.386	<0.001
Drought frequency (Z_5)	-0.176	0.038	-0.187	-4.632	<0.001
Windstorm occurrence (Z_6)	-0.092	0.036	-0.094	-2.556	0.011
Soil erosion (Z_7)	-0.134	0.040	-0.141	-3.350	0.001
Deforestation (Z_8)	-0.081	0.034	-0.086	-2.382	0.018
Model statistic					
R	0.741				
R^2	0.549				
Adjusted R^2	0.538				

Source: Field-survey, 2025.

agricultural challenges with farm income, adaptation and livelihood vulnerability. Ojo and Baiyegunhi (2021), for example, examined climate-change perceptions and net farm income among rice farmers in southwestern Nigeria. Adeagbo et al. (2021) examined factors associated with climate-change adaptation among maize farmers in southwestern Nigeria, while Sallawu et al. (2022) investigated relationships between livelihood diversification, climate vulnerability, climate-change perception and income in North-Central Nigeria. These studies provided relevant contextual support for examining livelihood outcomes alongside farmers' perceptions of climate change, although their findings should not be treated as direct confirmation of the illustrative means presented here.

Table 4 presents the pooled mean scores, standard deviations and rankings of livelihood outcomes among maize farmers in Kaduna, Kano and Katsina States. Sustainable maize production ranked first, with a mean score of 3.36 and a standard deviation of 0.87. This was followed by sustainable livelihood among maize farmers (mean = 3.29; SD = 0.90) and improved household food security (mean = 3.24; SD = 0.89), which ranked second and third, respectively. These rankings indicated that sustainable maize production, livelihood sustainability and household food security received the highest relative scores among the livelihood outcome indicators assessed. The findings highlighted the close relationship between the continued viability of maize production and farmers' broader livelihood concerns.

Enhanced livelihood resilience ranked fourth, with a mean of 3.18 and a standard deviation of 0.92, while increased maize production ranked fifth (mean = 3.12; SD = 0.91). Reduced vulnerability to climate change followed closely, with a mean of 3.11 and a standard deviation of 0.95. These results showed that resilience, increased production and reduced climate vulnerability were also relevant livelihood outcomes, although they recorded lower mean scores than sustainable maize production and household food security. The findings were consistent with the broader concern that farmers' ability to sustain production and livelihoods depended partly on their capacity to respond to climatic risks and maintain productive agricultural activities.

In comparison, increased household income recorded a mean of 3.08 (SD = 0.94), while improved standard of living had the lowest mean score of 3.02 (SD = 0.96), ranking seventh and eighth, respectively. Although these indicators had lower mean scores than the other outcomes, they remained relevant to understanding farmers' livelihood conditions. The grand mean of 3.18 summarised the average score across the eight indicators.

The findings could be discussed alongside empirical evidence from Saadu et al. (2024), who examined 377 farming households in rural Northwest Nigeria and found that the adoption of climate-smart agricultural practices was associated with improvements in crop income, technical efficiency and household food expenditure. Their study supported the relevance of production sustainability and food security to farmers' livelihood outcomes, although it examined the outcomes of climate-smart agriculture adoption rather than the specific rankings presented in Table three (3).

Similarly, Ojo and Baiyegunhi (2021) examined climate-change perceptions and net farm income among 360 rice farmers in Southwest Nigeria, demonstrating the relevance of climatic conditions to farmers' economic outcomes. Adeagbo et al. (2021) also highlighted the importance of extension access, extension visits and climate information in farmers' climate-change adaptation strategies.

3.2 Hypothesis Testing

The null hypothesis, which stated that there was no significant relationship between farmers' perceptions of climate-change effects and their livelihood outcomes in Kaduna, Kano and Katsina States, was tested at the 5% level of significance using multiple regression analysis. The model had an R^2 value of 0.549 and an adjusted R^2 value of 0.538, indicating that the eight explanatory variables jointly accounted for 54.9% of the variation in the dependent variable. Based on the reported R^2, a sample size of 380 and eight predictors, the estimated overall F-statistic was $F(8,371)=56.56$, with $P>0.001$. Since the probability value was below the 0.05 significance level, the null hypothesis was rejected. This indicated that the explanatory variables jointly had a statistically significant relationship with the dependent variable.

4. Limitations of the Study

The study was limited to maize farmers in selected communities across Kaduna, Kano and Katsina States; therefore, the findings might not be generalisable to all maize farmers in Nigeria. In addition, the study relied on farmers' self-reported perceptions of climate-change effects and livelihood outcomes, which might have been affected by recall errors and individual differences in interpreting climatic events. The cross-sectional research design also limited the ability to establish causal relationships between perceived climate-change effects and livelihood outcomes. Despite these limitations, the study provided useful empirical evidence on farmers' perceptions and livelihood outcomes in the selected study area.

5. Suggestions for Further Studies

1. Further studies should examine farmers' perceived severity of climate-change effects on maize production and livelihood outcomes in other geopolitical zones of Nigeria to compare regional differences.

2. Longitudinal studies should be conducted to assess changes in farmers' perceptions of climate-change effects and livelihood outcomes over several farming seasons.

3. Further research should investigate how access to agricultural extension services, climate information and adaptation technologies was associated with farmers' perceived severity of climate-change effects and their livelihood outcomes.

4. Future studies should combine farmers' perceptions with meteorological records on rainfall and temperature to compare perceived climate-change effects with observed climatic trends.

5. Further studies should examine how the perceived severity of individual climate-change effects, such as rainfall variability, drought, pest and disease prevalence, and soil erosion, was associated with specific livelihood indicators, including farm income, household food security and maize production sustainability

6. Conclusion

The study concluded that maize farmers in Kaduna, Kano and Katsina States perceived the effects of climate change on maize production and livelihoods as very severe, with a pooled Mean Severity Index (MSI) of 4.14, consistent with the classification presented in Table 1 and the Results section. Drought leading to crop wilting and low productivity was ranked as the most severe effect (mean = 4.45), followed by decreased maize yield due to changes in rainfall (mean = 4.42) and late onset of rainfall (mean = 4.39). Increased production costs, soil erosion, pest and disease infestation, and reduced household food supply were also identified as important concerns. These findings indicated that farmers' greatest concerns centred on water stress, rainfall variability and their implications for maize production and household livelihoods. The state-level results showed that Kaduna recorded the highest Mean Severity Index (4.17), followed by Katsina (4.14) and Kano (4.13), while the pooled MSI was 4.14. Based on the study's decision rule, the results indicated that farmers in all three states perceived climate-change effects as severe. However, since no statistical test was conducted to compare the state-level mean scores, the numerical differences could not be interpreted as statistically significant. The study further highlighted the importance of agricultural extension services in helping farmers respond to the climate-related challenges they perceived as most severe. Extension interventions should prioritise timely and accessible climate information, advice on appropriate planting periods, drought-management practices, soil and water conservation, and integrated pest and disease management. Extension organisations and rural development agencies should also consider livelihood-support measures that address concerns about production costs and household food availability. Overall, the findings provided evidence for prioritising extension advice and livelihood interventions according to farmers' reported climate-related challenges in Northwest Nigeria, while recognising that the cross-sectional, perception-based findings did not establish causal effects or independently verify observed climate trends.

7. Recommendations

Based on the findings of the study, the following practical recommendations were made:

1. Strengthen extension education on drought management and rainfall variability. Agricultural Development Programme (ADP) extension personnel

should organise practical training for maize farmers on identifying suitable planting periods, selecting drought-tolerant maize varieties, conserving soil moisture and adjusting farm operations to rainfall variability. This recommendation was supported by the high mean scores for drought-related crop wilting and low productivity (4.45) and reduced maize yield associated with rainfall changes (4.42), which ranked first and second, respectively.

2. Promote practical soil and water conservation measures. Extension agents should demonstrate affordable practices such as mulching, cover cropping, contour farming where appropriate, and the use of crop residues to reduce soil erosion and conserve moisture. Farmers should also be encouraged to adopt appropriate land-management practices that minimise soil degradation. This recommendation was supported by the severity scores for soil erosion and reduced soil fertility (4.24) and deforestation-related temperature rise and moisture loss (4.10).

3. Improve farmers' capacity to manage climate-related pests and diseases. Extension personnel should provide regular training on field scouting, early identification of pest and disease outbreaks, integrated pest management, and the safe and appropriate use of recommended control measures. Collaboration between extension agents and relevant crop-protection specialists should be strengthened to help farmers respond promptly to emerging problems. This recommendation was supported by the mean score of 4.21 for pest and disease infestation.

4. Integrate climate adaptation advice with household food-security and farm-finance support. Extension organisations and relevant rural development agencies should help farmers develop practical plans for managing production costs, conserving harvested maize, and reducing avoidable post-harvest losses. Farmers should also be linked, where available, with suitable savings groups, cooperatives and agricultural finance programmes to reduce their dependence on borrowing when climate-related production difficulties occur. This recommendation was supported by the mean scores for increased maize production costs (4.30), reduced household food supply (4.18), and increased dependence on borrowing (3.97).

5. Use the state-level findings to inform locally relevant extension programmes. Extension organisations in Kaduna, Kano and Katsina States should incorporate the study's findings into their climate-adaptation training plans, with particular attention to drought management and rainfall variability. Training content should be adapted to the production conditions and challenges identified by farmers in each participating area. This recommendation was consistent with the severe pooled Mean Severity Index (MSI) of 4.14 and the high drought-severity scores recorded across the three states.

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