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Socioeconomic, Environmental and Institutional Factors Associated with Farmers' Perception of Climate Change Effects among Maize Farmers in Northwest Nigeria

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Abstract

The study examined the socioeconomic, environmental and institutional factors associated with farmers' perception of climate change effects among maize farmers in Northwest Nigeria. Specifically, the study described the socioeconomic, environmental and institutional characteristics of maize farmers, assessed their perception of climate change effects on maize production, and determined the factors associated with such perception. A field survey was conducted among 380 maize farmers selected from Kaduna, Kano and Katsina States using a multi-stage sampling procedure. Data were collected through a structured questionnaire and personal interviews and analysed using frequency counts, percentages, means, standard deviations, Composite Perception Index (CPI) and Tobit regression. The results showed that the farmers had a mean age of 37.20 years, mean household size of 9.00 persons, mean farming experience of 14.30 years and mean farm size of 1.46 ha. Environmental pressures reported by the farmers included drought (86.8%), pest and disease prevalence (82.1%), soil erosion (79.2%), deforestation (76.1%) and overgrazing (65.0%). Cooperative membership was reported by 57.6% of the farmers, while 67.1% had access to credit and only 20.5% had extension contact. Farmers had a high perception of climate change effects, with a CPI of 4.15. The Tobit regression model was statistically significant ($LR \chi^2 = 186.42, p < 0.01$; pseudo $R^2 = 0.184$). Age, education, household size, farm size, income, environmental pressures, extension contact, cooperative membership and credit obtained were significantly associated with perception, while sex was not significant. The study concluded that farmers' perception was associated with socioeconomic, environmental and institutional characteristics, highlighting the need for targeted extension and climate-information interventions

Keywords: Climate change perception; Maize farmers; Agricultural extension; Environmental factors; Institutional factors

Background to the Study

Climate change has become a major concern for agricultural production and rural livelihoods, particularly in developing countries where farming activities depend largely on rainfall and other climatic conditions. Changes in rainfall patterns, increasing temperatures, drought and other extreme weather events have affected agricultural productivity and farmers' livelihood opportunities. In Nigeria, maize production is particularly vulnerable to climate variability because of its dependence on seasonal rainfall and favourable temperature

conditions. Farmers' perception of climate change is therefore important for understanding how they recognise climatic changes and interpret their effects on agricultural production. Empirical studies have documented farmers' recognition of changes in rainfall, temperature and other climatic conditions in Nigeria, including among maize farmers in northern Nigeria (Ndawayo & Adamu, 2020; Msheliza & Bello, 2018). Ayanlade et al. (2017) further reported that farmers' perceptions of changes in rainfall and temperature in southwestern Nigeria showed correspondence with observed meteorological patterns, although the strength of this



correspondence varied across climatic indicators. These findings demonstrate the relevance of farmers' perceptions as an important dimension of understanding climate related changes in agricultural communities.

Farmers' perception of climate change is shaped by a combination of socioeconomic, environmental and institutional factors. Socioeconomic characteristics such as age, educational attainment, farming experience and income may be associated with farmers' ability to recognise and interpret climatic changes, while environmental conditions and access to institutional support may affect their understanding of climate-related risks. Studies have shown that farmers' perceptions are influenced by their experiences of changes in rainfall, temperature, drought and other environmental conditions (Ugwoke et al., 2013; Ogbodo et al., 2018). Access to agricultural extension services, credit facilities and climate information can also provide farmers with information that assists them in interpreting changing climatic conditions and making agricultural decisions. Evidence from Nigeria has linked farmers' characteristics, access to information and institutional support with climate-change perception and adaptation decisions (Coster & Adeoti, 2021; Ndawayo & Adamu, 2020). Similarly, Asare-Nuamah and Botchway (2019) found that farmers' perceptions of climate change were related to socioeconomic and institutional conditions, while Soubry et al. (2020), in their review of the literature on farmer perceptions, emphasised the importance of examining farmers' perceptions within their specific social, environmental and institutional contexts.

Environmental conditions are particularly relevant because farmers experience climate change through changes in their immediate production environment. Drought, irregular rainfall, soil degradation, pest and disease pressures, erosion and other environmental stresses may become important reference points through which farmers interpret climatic changes. In northern Nigeria, farmers have reported changes in rainfall and temperature conditions and associated effects on crop production (Msheliza & Bello, 2018; Ndawayo & Adamu, 2020). However, farmers' reported experiences represent perceptions and observations and should be distinguished from independently measured climatic trends. Comparing farmers' perceptions with meteorological evidence is therefore useful for establishing the extent to which perceived changes correspond with recorded climatic variability (Ayanlade et al., 2017; Asare-Nuamah & Botchway, 2019).

Despite the growing evidence on climate-change perception and adaptation among farmers in Nigeria, there remains a need for context-specific evidence on the socioeconomic, environmental and institutional factors associated with farmers' perception of climate-change effects among maize farmers in north-western Nigeria. Existing studies have examined climate-change perception and adaptation among farmers in different parts of Nigeria, but evidence that jointly considers socioeconomic characteristics, environmental pressures and institutional factors among maize farmers across Kaduna, Kano and Katsina States remains limited.

This gap is important from an agricultural extension and rural development perspective because extension agencies require an understanding of the characteristics and conditions associated with farmers' perceptions when developing climate information and awareness programmes. Therefore, this study examined the socioeconomic, environmental and institutional factors associated with farmers' perception of climate-change effects among maize farmers in north-western Nigeria, with a focus on Kaduna, Kano and Katsina States.

Statement of the Problem

Climate change has become a major challenge to maize production in north-western Nigeria, where farmers experience drought, irregular rainfall, increasing temperatures and other environmental pressures. These conditions create production risks for maize farmers whose farming activities depend substantially on seasonal climatic conditions. Studies among Nigerian farmers have reported perceived changes in rainfall and temperature and their implications for agricultural production (Ugwoke et al., 2013; Msheliza & Bello, 2018; Ndawayo & Adamu, 2020). However, farmers do not necessarily experience or interpret climate related changes in the same way. Differences in socioeconomic characteristics, environmental exposure and access to institutional support may be associated with variations in how farmers recognise and interpret climate-change effects.

Farmers' perception is particularly relevant to agricultural extension and rural development because perception provides an important basis for understanding farmers' recognition of climate related risks and their information needs. Educational attainment, farming experience, income, extension contact, access to credit and participation in farmer organisations may provide farmers with different opportunities to obtain and interpret climate information. At the same time, direct exposure to drought, erosion, pest and disease pressures and other environmental challenges may shape farmers' observations of changing production conditions. Previous studies have established the importance of socioeconomic and institutional conditions in understanding farmers' climate perceptions (Coster & Adeoti, 2021; Asare-Nuamah & Botchway, 2019). Nevertheless, much of the existing evidence has considered selected factors or specific locations, leaving a need for integrated, location specific evidence among maize farmers in north-western Nigeria.

The absence of clear evidence on the socioeconomic, environmental and institutional factors associated with farmers' perception may limit the ability of agricultural extension agencies and other relevant institutions to design climate information and awareness programmes that respond to farmers' actual circumstances. This is particularly relevant in Kaduna, Kano and Katsina States, where maize production constitutes an important agricultural activity and farmers are exposed to varying environmental and institutional conditions. Therefore, the study examined the socioeconomic, environmental and institutional factors associated with farmers' perception of climate-change effects among maize farmers in north-western Nigeria.

General Objective

The general objective of the study was to examine the socioeconomic, environmental and institutional factors associated with farmers' perception of climate change effects among maize farmers in Northwest Nigeria.

Specific Objectives

The specific objectives were to:

1. describe the socioeconomic, environmental and institutional characteristics of maize farmers in the study area.
2. assess farmers' perception of the effects of climate change on maize production in the study area. and
3. determine the socioeconomic, environmental and institutional factors associated with farmers' perception of the effects of climate change on maize production in the study area.

Research Hypothesis

H₀₁: Socioeconomic, environmental and institutional characteristics had no significant association with farmers' perception of climate change effects on maize production in the study area.

Justification of the Study

This study was justified by the increasing challenges of climate change to maize production and rural livelihoods in Northwest Nigeria. Understanding the socioeconomic, environmental and institutional factors associated with farmers' perception was important because farmers' recognition and interpretation of climate-related changes could shape their production decisions and responses to emerging risks. Previous empirical studies showed that farmers' perceptions of climate change were associated with demographic characteristics, farming conditions and access to information and institutional support (Ayanlade et al., 2017; Msheliza & Bello, 2018; Ndawayo & Adamu, 2020). However, limited context specific evidence had integrated these dimensions among maize farmers across Kaduna, Kano and Katsina States.

The study was particularly relevant to **agricultural extension and rural development** because extension services provided an important link between climate information, research knowledge and farmers' decisions. Evidence from Nigeria indicated that extension personnel played a role in disseminating climate information to farmers, although gaps in extension coverage and capacity remained (Ebenehi et al., 2018; Eta et al., 2022). By identifying the socioeconomic, environmental and institutional factors associated with farmers' perception, the study provided empirical evidence that could assist extension agencies and rural development organisations in designing more targeted climate information and extension programmes, strengthening farmer extension interaction and improving access to institutional support. The study therefore contributed to agricultural extension and rural development research by providing context specific evidence on climate-change perception among maize farmers in Northwest Nigeria.

Method of Data Collection

Primary data were collected through a field survey using a structured questionnaire and personal interviews with maize farmers in Kaduna, Kano and Katsina States, Northwest Nigeria. The data collection was conducted by the researcher and trained enumerators, who administered the questionnaires to the selected respondents to obtain relevant information on their socioeconomic, environmental and institutional characteristics and their perceptions of the effects of climate change on maize production.

The questionnaire covered the socioeconomic characteristics of the farmers, including age, sex, marital status, educational level, maize farming experience, farm size, annual income and land ownership. Institutional characteristics included access to extension services, cooperative membership and credit facilities. Information was also obtained on farmers' perceptions of climate change effects on maize production and the environmental conditions they associated with climate change.

The data collection further covered farmers' perceptions of the severity of climate change effects and the strategies they adopted to cope with these effects. Information was also obtained from extension workers of the Agricultural Development Programmes (ADPs) to provide additional insights into climate-related challenges and institutional support in the study areas.

Validity of the Research Instrument

The validity of the research instrument was established through **content and face validity**. The draft questionnaire was submitted to experts in Agricultural Economics, Agricultural Extension and Development, Rural Sociology, Climate Science and Development Studies for review. The experts assessed the relevance, clarity and adequacy of the questionnaire items in measuring the socioeconomic, environmental and institutional characteristics of maize farmers and their perceptions of climate change effects on maize production. Their recommendations were used to refine and restructure the questionnaire to ensure that the items adequately covered the study objectives.

Reliability of the Research Instrument

The reliability of the research instrument was established through a pre-test involving **38 questionnaires**, representing approximately 10% of the study's sample size of 380 respondents. The pre-test was conducted to assess the clarity, consistency and appropriateness of the questionnaire items. The data obtained were analysed using the Cronbach's alpha reliability coefficient. The instrument recorded a reliability coefficient of **0.81**, which exceeded the minimum acceptable threshold of 0.70. This indicated that the instrument had an acceptable level of internal consistency and was considered reliable for data collection.

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

Sampling Procedure and Sample Size

The sample size for the study was determined using the Yamane (1973) formula for finite populations. The sampling frame consisted of 7,664 maize farmers across Kaduna, Kano and Katsina States. At a 5% level of precision, a sample size of 380 respondents was obtained using the **Yamane (1967) formula:**

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

Where:

n = required sample size
N = sampling frame (1225)
e = level of precision (0.05)

Thus, **380 maize farmers** were selected for the study. A multi-stage sampling procedure was used to select respondents for the study. In the first stage, Kaduna, Kano and Katsina States were purposively selected because of their relevance to maize production and the study's focus on farmers' perception of climate change effects.

In the second stage, two Local Government Areas (LGAs) were purposively selected from each state: Lere and Soba LGAs in Kaduna State; Doguwa and Kura LGAs in Kano State; and Funtua and Dandume LGAs in Katsina State.

In the third stage, three maize-producing villages were purposively selected from each of the six LGAs, 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.

In the fourth stage, the sample of 380 respondents was proportionately allocated across the selected villages based on the number of registered maize farmers in each village. The respondents were then selected through simple random sampling from the available lists of registered maize farmers, with assistance from relevant agricultural extension personnel.

Measurement of Variables

Dependent Variable: Farmers' Perception of Climate Change Effects

Farmers' perception of the effects of climate change on maize production was measured using a five-point Likert-type scale. Respondents indicated their level of agreement with statements relating to perceived climate-change effects on maize production. The response categories were Strongly Agree (SA) = 5, Agree (A) = 4, Undecided (UD) = 3, Disagree (D) = 2 and Strongly Disagree (SD) = 1.

The mean score for each perception indicator was computed by multiplying the frequency of responses by the corresponding scale weight and dividing the sum by the total number of respondents. The individual indicator scores were subsequently averaged to obtain the Composite Perception Index (CPI), which represented the overall perception of each farmer. Higher CPI values indicated a higher level of perceived climate-change effects.

Table 1: Scale for the CPI

Mean score	Level of perception
4.50–5.00	Very high
3.50–4.49	High
2.50–3.49	Moderate
1.50–2.49	Low
1.00–1.49	Very low

The CPI served as the dependent variable in the regression analysis.

Independent Variables

The independent variables comprised socioeconomic, environmental and institutional characteristics of maize farmers.

Socioeconomic variables: These included age, educational level, household size, farm size and annual income. Age was measured in years, household size in number of household members, farm size in hectares and annual income in naira. Educational level was measured according to the respondent's highest level of formal education attained.

Environmental variables: Environmental characteristics were measured using indicators relating to farmers' experiences and perceptions of climatic and environmental conditions affecting maize production. These included changes in rainfall patterns, temperature, drought, windstorms, soil erosion and the prevalence of pests and diseases. Responses were measured using the relevant perception or rating scales in the questionnaire.

Institutional variables: Institutional characteristics were measured using indicators of farmers' access to institutional support and agricultural information. These included access to extension services, access to climate-related information, access to credit facilities and participation in farmers' organisations, where included in the questionnaire. Categorical variables were coded numerically for analysis.

The independent variables were entered into the regression model to examine their associations with farmers' perception of climate-change effects on maize production.

Analytical Technique

Objective 1 was achieved using frequency counts, percentages, means and standard deviations. Frequencies and percentages were used to describe categorical variables such as educational level, access to extension services and membership of farmers' organisations. Means and standard

deviations were used to summarise continuous variables such as age, household size, farm size and annual income.

Objective 2 was achieved using mean scores and the Composite Perception Index (CPI). Farmers' responses to perception statements were measured using a five-point Likert-type scale:

Table 2

Response	Score
Strongly Agree (SA)	5
Agree (A)	4
Undecided (UD)	3
Disagree (D)	2
Strongly Disagree (SD)	1

The mean score for each perception indicator was calculated using:

$$MPI = \frac{\sum FX}{N} \dots \dots \dots (1)$$

Where:

MPI = Mean Perception Index, $\sum FX$ = Summation of weighted responses, F = Frequency of respondents in each response category, X = Assigned weight of each response category, N = Total number of respondents

The Composite Perception Index was calculated by averaging the mean scores of all perception indicators:

$$CPI = \frac{\sum MPI_j}{K} \dots \dots \dots (2)$$

where:

- CPI = Composite Perception Index
- MPI_j = mean score of perception indicator j
- K = total number of perception indicators.

Higher CPI values indicated a higher level of farmers' perception of climate-change effects on maize production.

Objective 3 was achieved using the Tobit regression model, with the Composite Perception Index (CPI) as the dependent variable and the socioeconomic, environmental and institutional characteristics as the independent variables.

The model was specified as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13} X_{13} + \beta_{14} X_{14} + U_i \dots \dots \dots (3)$$

Where:

Y= index of farmers' perception.

X= factors affecting farmers perception explanatory variables
 X_1 = Age (in years), X_2 = Sex (male=1, female=2), X_3 = Educational level (years spent), X_4 = Household size (number of people living and eating in the same pot), X_5 = Farm size (number of hectares), X_6 = Annual income (₦), X_7 = Pest and disease prevalence (VH, H, M, L, VL), X_8 = Overgrazing (VH, H, M, L, VL), X_9 = Deforestation (VH, H, M, L, VL), X_{10} = Erosion (VH, H, M, L, VL), X_{11} = Drought (VH, H, M, L, VL), X_{12} = Extension contact (number of extension visit in last one year), X_{13} = Cooperative membership (number of years as a member of a cooperative group), X_{14} = Credit obtained (number of loans accessed) β_0 = constant term; β_1 – β_{14} = regression coefficients; and U_i = error term.

The regression coefficients were used to examine the direction and statistical significance of the associations between the explanatory variables and farmers' perception of climate-change effects. Statistical significance was tested at the 5% level.

Test of Hypothesis

The null hypothesis was tested using the tobit regression model at 5% level of significance.

H₀: Socioeconomic, environmental and institutional characteristic have no significant association with farmer's perception climate-change effect

RESULTS AND DISCUSSION

Socioeconomic Characteristics of Maize Farmers

Table 3: Socioeconomic Characteristics of Maize Farmers in Kaduna, Kano and Katsina States (n = 380)

Variable	Category	Frequency	Percentage	Mean	SD
Age (years)	Less than 20	22	5.8	37.20	11.10
	20-29	74	19.5		
	30-39	148	38.9		
	40-49	86	22.6		
	50-59	36	9.5		
	60 and above	14	3.7		
Sex	Male	262	68.9	—	—
	Female	118	31.1		
Marital status	Single	58	15.3	—	—
	Married	276	72.6		
	Divorced	18	4.7		

	Widow	16	4.2		
	Widower	12	3.2		
Household size	1-6 persons	76	20.0	9.00	3.27
	7-12 persons	251	66.1		
	13-18 persons	53	13.9		
Educational level	Primary education	68	17.9	—	—
	Secondary education	54	14.2		
	Tertiary education	36	9.5		
	Qur'anic education	96	25.0		
	Adult education	58	15.3		
	No formal education	68	17.9		
	Formal education subtotal	158	41.6		
	Informal education subtotal	222	58.4		
Farming experience(yrs)	1-10	168	44.2	14.30	9.80
	11-20	143	37.6		
	21-30	39	10.3		
	31-40	24	6.3		
	41-50	6	1.6		
Farm size (ha)	0.1-1.0	209	55.0	1.46	1.23
	1.1-2.0	97	25.5		
	2.1-3.0	39	10.3		
	3.1-4.0	15	3.9		
	4.1-5.0	12	3.2		
	Above 5.0	8	2.1		
Quantity of maize produced (100-kg bags)	Less than 20	74	19.5	—	—
	20-39	112	29.5		
	40-59	96	25.3		
	60-79	61	16.1		
	80 and above	37	9.7		
Annual income from maize sales (₦)	Less than ₦200,000	96	25.3	420,388	260,382
	₦200,000-₦399,999	118	31.1		

₦400,000-₦599,999	82	21.6
₦600,000-₦799,999	51	13.4
₦800,000 and above	33	8.7

Source: *Field Survey, 2025.*

The results in table 3 showed that maize farmers were predominantly within the economically active age groups. Farmers aged 30-39 years constituted 38.9%, while those aged 40-49 years accounted for 22.6%, giving a combined proportion of 61.5% between 30 and 49 years. The mean age of 37.20 years indicated that the respondents were generally in an active farming age. Males constituted 68.9%, while females accounted for 31.1%. Married farmers represented the largest marital group (72.6%), suggesting that maize production was largely undertaken within family-based livelihood systems. The mean household size was nine persons, with 66.1% having between 7 and 12 household members. Such household structures may provide considerable family labour for farm operations, although larger households may also increase consumption requirements where land and income are limited. The socioeconomic pattern was broadly comparable with recent evidence from Nigerian smallholder farming households, where farmers were predominantly male, married and engaged in relatively small-scale production. Kehinde et al. (2025), for example, reported that Nigerian smallholder farming households were predominantly male, with an average farming experience of about 14 years and considerable participation in agricultural cooperatives.

Educational attainment showed that 41.6% of the farmers had some form of formal education, while 58.4% had informal education, including Qur'anic and adult education or no formal education. This distribution suggested that although formal schooling was not universal, farmers possessed different forms of educational and experiential knowledge that could support agricultural decision-making. Farming experience averaged 14.30 years, with 81.8% having between 1 and 20 years of experience. The mean farm size was 1.46 ha, and 80.5% cultivated less than 2 ha, confirming the smallholder nature of maize production in the study area. Similarly, 54.8% produced between 20 and 59 bags of 100 kg, while the largest income group (31.1%) earned ₦200,000-₦399,999 from maize sales. These characteristics suggest that most respondents operated with relatively limited land and financial resources, making their production systems potentially sensitive to climatic and other production shocks. Recent evidence from Nigeria also indicates that socioeconomic characteristics such as age, education, farming experience and household income were significantly associated with farmers' perception of climate change, reinforcing the importance of considering these characteristics in climate related agricultural extension programming (Yakubu et al., 2026).

Environmental Characteristics of Maize Farmers

Table 4: Environmental Characteristics Affecting Maize Production among Maize Farmers

Environmental factor	Yes (freq.)	Yes (%)	No (freq.)	No (%)
Pest and disease prevalence	312	82.1	68	17.9
Overgrazing	247	65.0	133	35.0
Deforestation	289	76.1	91	23.9
Soil erosion	301	79.2	79	20.8
Drought	330	86.8	50	13.2

Source: *Field Survey, 2025.*

The results in table 4 indicated that maize farmers were exposed to several environmental pressures that were perceived as important challenges to maize production. Drought was the most commonly reported environmental factor, with 86.8% of respondents indicating its occurrence. This was followed by pest and disease prevalence (82.1%), soil erosion (79.2%), deforestation (76.1%) and overgrazing (65.0%). The concentration of responses around drought, pest and disease prevalence and land degradation indicated that climate related production risks were not restricted to rainfall variability alone but were also associated with biological and land resource pressures. These conditions have important implications for agricultural extension because farmers require information that combines climate advisories with practical recommendations on soil conservation, moisture

management, pest management and sustainable land use practices.

The prominence of drought in the present study was consistent with recent evidence showing the importance of climate related water stress in maize production systems. Mugisho et al. (2024), in their study of smallholder maize farmers in sub-Saharan Africa, reported substantial farmer perceptions of climate vulnerability and highlighted the importance of access to resources, education and support in strengthening adaptation capacity. Similarly, Komolafe et al. (2024) found that maize farmers perceived several weather-related changes and adopted different responses to manage the resulting production risks. The environmental conditions reported by the farmers therefore suggested a need for extension programmes that move beyond general climate-change awareness towards location specific climate information, drought management, soil and water

conservation, integrated pest management and sustainable land management.

Institutional Characteristics of Maize Farmers

Table 5: Institutional Characteristics of Maize Farmers in Kaduna, Kano and Katsina States (n = 380)

Variable	Category	Freq.	Percentage	Mean	SD
Cooperative membership	Yes	219	57.6	—	—
	No	161	42.4		
Years of cooperative membership	1-10 years	168	76.7	8.42	6.18
	11-20 years	42	19.2		
	21-30 years	7	3.2		
	41-50 years	2	0.9		
Access to credit	Yes	255	67.1	—	—
	No	125	32.9		
Amount of credit received (₦)	₦100,000-₦299,999	78	30.6	639,411.76	362,596.40
	₦300,000-₦599,999	48	18.8		
	₦600,000-₦899,999	32	12.5		
	Above ₦900,000	97	38.1		
Extension contact	Yes	78	20.5	—	—
	No	302	79.5		
Number of extension visits	1-4	62	79.5	3.58	2.29
	5-8	11	14.1		
	9 and above	5	6.4		

Soruce: Field Survey, 2025

The result in table 5 showed that 57.6% of the maize farmers belonged to cooperative societies, while 42.4% did not. Among cooperative members, 76.7% had belonged to their organisations for 1-10 years, with a mean membership duration of 8.42 years. This indicated that farmer organisations constituted an important institutional platform for a considerable proportion of respondents, although sustained participation over longer periods was less common. Cooperatives could provide channels for information exchange, collective input procurement, credit access, marketing and interaction with extension personnel. Recent Nigerian evidence supports this institutional role. Kehinde et al. (2025) found that 57.5% of sampled smallholder farming households belonged to agricultural cooperatives and reported significant relationships between cooperative membership and variables such as education, household size, farming experience, farm size and access to credit.

Access to credit was reported by 67.1% of the respondents, while 32.9% had no access. Among those who obtained credit, 38.1% received more than ₦900,000 and the mean amount received was ₦639,411.76, with a standard deviation of ₦362,596.40. This wide variation indicated that access to credit did not necessarily imply equal access to financial resources. Credit was particularly relevant because financial resources could facilitate the acquisition of improved seed, fertiliser, labour, crop-protection inputs and climate resilient technologies. Recent research in Nigeria has similarly shown

the importance of credit and cooperative participation within smallholder farming systems (Kehinde et al., 2025).

However, extension contact represented the major institutional weakness identified in the study. Only 20.5% of the farmers had contact with extension agents, whereas 79.5% reported no extension contact. Among those who received extension services, 79.5% had received between one and four visits, while only 6.4% reported nine or more visits. This indicated that the majority of maize farmers had limited direct access to formal agricultural advisory services. The finding was particularly important from an agricultural extension and rural development perspective because extension contact represents a major pathway through which climate information, improved production technologies and locally appropriate adaptation recommendations could reach farmers. Recent evidence from North-Central Nigeria showed that inadequate numbers of extension personnel, insufficient motivation and inadequate transportation constrained effective dissemination of climate-smart agricultural practices (Ojo et al., 2024).

The limited extension contact observed in the present study also has implications for climate-change perception. Alhassan and Haruna (2024) included agricultural extension service access among the factors examined in explaining farmers' climate-change perception and adaptation in Nigeria and Ethiopia, while their results demonstrated the relevance of socioeconomic and institutional characteristics within the perception-adaptation process. More recently, Yakubu et al. (2026), working specifically in Kano State, reported that age,

education, farming experience and household income were significant determinants of farmers' climate-change perception and recommended stronger extension services and reliable climate information. Thus, the institutional profile of the farmers in the present study suggested that strengthening extension coverage, farmer organisations and access to

appropriate financial services would be important components of climate information and rural development interventions in Northwest Nigeria.

Farmers' Perception of the Effects of Climate Change on Maize Production

Table 6: Maize farmers' perception of the effect of climate change on maize production in Kaduna, Kano and Katsina States (Pooled Data)

Perceived Effects	SA	A	UD	DA	SD	Mean	Decision
Change in income	171	139	38	20	12	4.15	Agree
Influence on financial planning	166	142	41	19	12	4.13	Agree
Climate variability affects crop productivity	182	144	32	14	8	4.26	Agree
Rainfall pattern has become unpredictable	176	148	35	13	8	4.24	Agree
Temperature increase affects maize production	169	146	39	17	9	4.18	Agree
Cost of adaptation strategies influences perception	158	141	45	22	14	4.07	Agree
Increased windstorm affects maize production	149	137	50	27	17	3.99	Agree
Frequency of drought affects maize production	181	143	33	14	9	4.25	Agree
Climate variability influences household labour	156	135	52	23	14	4.04	Agree
Climate change affects availability of natural resources	168	146	40	16	10	4.18	Agree
Weather patterns now unpredictable and unreliable	179	147	34	12	8	4.25	Agree
Increased cost of production	174	149	34	14	9	4.22	Agree
Need for soil moisture practices (mulching)	163	142	44	19	12	4.12	Agree
Late rainfall affects germination and growth	178	145	36	13	8	4.24	Agree
Climatic changes affect planting time and planning	170	151	35	15	9	4.21	Agree
Increase in drought will not increase maize yield	167	143	42	18	10	4.15	Agree
Heat stress reduces maize growth	173	146	36	15	10	4.20	Agree
Increased fertilizer use due to climate change	160	141	48	19	12	4.10	Agree
Unpredictable weather favour disease prevalence	168	147	38	16	11	4.17	Agree
Flooding causes erosion and reduces maize growth	154	139	51	22	14	4.04	Agree
Land becoming less suitable for maize cultivation	149	138	54	24	15	3.99	Agree
Rainfall onset now later than past 10 years	172	148	37	14	9	4.22	Agree
Rainfall cessation now earlier than before	165	145	42	17	11	4.17	Agree
Number of rainy days increasing	143	129	58	30	20	3.89	Agree
Yearly rains not supporting maize as before	169	147	40	15	9	4.19	Agree
Rainfall amount decreasing yearly	174	144	35	16	11	4.20	Agree
Weather becoming drier	176	141	37	15	11	4.20	Agree
Increased pest infestation due to climate change	170	149	36	15	10	4.20	Agree
Climate change affecting human and animal health	162	143	45	18	12	4.12	Agree
Increased poverty, migration and farmer–herder clashes	158	141	47	20	14	4.07	Agree
Number of Items	30						
Composite Mean	4.15						
DECISION	AGREED						

Source: Field Survey, 2025; SA=Strongly Agree, A=Agree, UD=Undecided, DA=Disagree, SD=Strongly Disagree

Discussion

The result in table 6 showed that, the Composite Perception Index of 4.15 indicated that the respondents had a high level of perception of climate-change effects on maize production. The result was consistent with previous empirical evidence

showing substantial recognition of climate-related changes among Nigerian farmers. Coster and Adeoti (2021) reported that 81.5% of maize-based farming households in Nigeria had perceived changes in climatic variables. Similarly, Msheliza and Bello (2018) found that 85.6% of smallholder maize farmers in Gombe State were fully aware of changing climate. These findings, together with the present CPI of 4.15, indicated that recognition of climate-related changes was widespread among maize farmers in different Nigerian production environments.

The high scores for delayed rainfall onset (4.22), decreasing rainfall amount (4.20), drier weather (4.20) and earlier rainfall cessation (4.17) showed that rainfall variability constituted one of the most prominent components of farmers' climate-change perception. This finding agreed with Ayanlade et al. (2017), who reported that farmers' perceptions of rainfall variability in South-West Nigeria were broadly consistent with meteorological analyses. Asare-Nuamah and Botchway (2019) similarly found that farmers' perceptions of climatic changes could be meaningfully examined alongside climate data. The consistency between the present result and these studies strengthened the interpretation that changes in rainfall timing and amount were important dimensions of farmers' perceived climate related experiences.

The high mean score for increased pest infestation associated with climate change (4.20) also corresponded with previous evidence from maize producing areas. Ogbodo et al. (2018) reported that pest and disease problems were among the climate related effects perceived by maize farmers in Anambra State. The present finding extended this evidence to Northwest Nigeria by showing that farmers also associated increasing pest pressure with changing climatic conditions. However, the result represented farmers' attribution of pest

increases to climate change and did not independently demonstrate that climate change was the direct cause of the observed pest problems.

The mean score of 4.20 for heat stress reducing maize growth further showed that farmers recognised temperature-related effects on maize production. This was consistent with Msheliza and Bello (2018), who reported that 59.4% of maize farmers in Gombe State indicated that increased temperature damaged their crops. The present result therefore provided further evidence that farmers' perceptions of climate change encompassed both rainfall and temperature dimensions.

The perception that climate change was associated with poverty, migration and farmer-herder clashes (mean = 4.07) showed that respondents also perceived climate related effects beyond direct crop production. This broader interpretation was consistent with Soubry et al. (2020), who argued that farmers' perceptions of climate change were embedded within wider social-ecological contexts rather than being limited to measured climatic variables. However, the present finding should be interpreted as a reported perception of association; it did not establish that climate change directly caused poverty, migration or farmer-herder conflicts.

Socioeconomic, Environmental and Institutional Factors Associated with Farmers' Perception of Climate-Change Effects

The dependent variable was the Composite Perception Index (CPI), while the explanatory variables included age, sex, educational level, household size, farm size, annual income, pest and disease prevalence, overgrazing, deforestation, soil erosion, drought frequency, extension contact, cooperative membership and credit obtained.

Table 7: Tobit Regression Results for Factors Associated with Farmers' Perception of Climate-Change Effects on Maize Production

Variable	Coefficient	Std. Error	t-value	Marginal effect
Constant	0.842	0.311	2.71**	—
Age (years)	0.012	0.005	2.40**	0.009
Sex	-0.063	0.041	-1.54	-0.048
Educational level (years)	0.028	0.009	3.11***	0.021
Household size	0.017	0.008	2.13**	0.013
Farm size (ha)	0.046	0.014	3.29***	0.035
Annual income (₦)	0.000004	0.000001	3.67***	0.000003
Pest and disease prevalence	0.083	0.019	4.37***	0.063
Overgrazing	0.071	0.021	3.38***	0.054
Deforestation	0.065	0.020	3.25***	0.049
Soil erosion	0.092	0.022	4.18***	0.070
Drought frequency	0.109	0.025	4.36***	0.083
Extension contact	0.058	0.018	3.22***	0.044
Cooperative membership	0.031	0.011	2.82***	0.024
Credit obtained	0.067	0.023	2.91***	0.051

Model statistics	
Sigma (σ)	0.684
Log likelihood	-412.76
LR Chi-square (14)	186.42***
Probability > Chi-square	0.0000
Pseudo R ²	0.184

Source: Field Survey, 2025. ** and *** indicate statistical significance at the 5% and 1% levels, respectively.

Discussion

The results in table 7 show that the pooled Tobit model was statistically significant (LR $\chi^2 = 186.42$, $p < 0.01$), indicating that the explanatory variables jointly contributed to explaining variation in farmers' perception scores. The pseudo R² of 0.184 indicated that the model accounted for a measurable proportion of variation in the dependent variable. The significant associations observed across socioeconomic, environmental and institutional variables demonstrated that farmers' perception was related to several dimensions of their farming and livelihood circumstances rather than to a single characteristic.

Socioeconomic Factors

Age had a positive and statistically significant association with perception ($\beta = 0.012$, $p < 0.05$). This finding suggested that older farmers tended to report higher perception scores after controlling for the other explanatory variables. The result was consistent with evidence from Northern Nigeria reported by Ndawayo and Adamu (2021), who found a significant association between farmers' perception of climate change and demographic characteristics. Msheliza and Bello (2018) also reported that farming experience was associated with awareness of changing climate among maize farmers in Gombe State. The present finding could therefore be interpreted within the context of accumulated exposure to farming conditions over time, although age and farming experience were not identical variables in the present model.

Educational level was positively and significantly associated with perception ($\beta = 0.028$, $p < 0.01$). This finding agreed with Ojo and Baiyegunhi (2021), who found education to be a significant determinant of climate-change perception among smallholder rice farmers in South-West Nigeria. Ejiba and Adams (2017) similarly observed differences in farmers' ability to perceive climatic changes according to educational attainment. The consistency across these studies suggested that education was relevant to farmers' ability to obtain, interpret and process information relating to changing climatic conditions.

Household size had a positive and significant association with perception ($\beta = 0.017$, $p < 0.05$). This finding was consistent with Ojo and Baiyegunhi (2021), who identified household size as a significant determinant of climate-change perception. This suggest that farmers from larger households have more frequent interactions with diverse livelihood and production activities, increasing exposure to information and climate related experiences.

Farm size was positively associated with farmers' perception ($\beta = 0.046$, $p < 0.01$). The result suggested that farmers cultivating larger areas tended to report higher perception scores. This is associated to greater exposure to variations in soil, rainfall, pests and other production conditions across larger cultivated areas. The result was also compatible with Ojo and Baiyegunhi (2021), who found farm size to be associated with the intensity of perceived climate change among smallholder rice farmers. The similarity suggested that farm scale was relevant to the extent of farmers' exposure to climate related production risks.

Annual income was positively and significantly associated with perception ($\beta = 0.000004$, $p < 0.01$). Coster and Adeoti (2021) similarly reported that farm income was positively associated with farmers' likelihood of perceiving changes in climate among maize based farming households in Nigeria. The present finding therefore supported the view that financial resources and farmers' exposure to commercial production activities was associated with recognition of climate related changes. The very small coefficient should, however, be interpreted in relation to the naira unit in which annual income was measured.

Sex was not statistically significant ($\beta = -0.063$, $p > 0.05$). This indicated that, after controlling for the other variables, the study did not establish a statistically significant association between sex and farmers' perception. This finding differed from Ndawayo and Adamu (2021), who reported a significant association between gender and perception of climate change among farmers in Northern Nigeria. The difference reflect variations in study locations, sample characteristics, measurement of perception, or the other explanatory variables included in the respective models. It also indicated that demographic relationships with climate-change perception were not necessarily uniform across farming populations.

Environmental Factors

Drought frequency recorded the largest marginal effect among the significant environmental variables ($\beta = 0.109$; marginal effect = 0.083; $p < 0.01$). The positive association indicated that farmers reporting more frequent drought conditions tended to report higher perception scores. This finding was consistent with Ayanlade et al. (2017), who found that farmers' perceptions of rainfall variability in Nigeria broadly reflected observed climatic trends. It was also consistent with Msheliza and Bello (2018), who reported prolonged dry spells and declining rainfall among important climate-related effects perceived by maize farmers in Gombe State.

Soil erosion was positively and significantly associated with perception ($\beta = 0.092$, $p < 0.01$; marginal effect = 0.070). This finding was compatible with the evidence of Msheliza and Bello (2018), who reported soil erosion as one of the highly perceived impacts of changing climate among maize farmers. Ogbodo et al. (2018) also identified erosion related concerns among maize farmers' perceived climate impacts. The consistency suggested that environmental degradation was an important component of how farmers interpreted changes in their production environment.

Pest and disease prevalence was positively and significantly associated with perception ($\beta = 0.083$, $p < 0.01$; marginal effect = 0.063). The result agreed with Ogbodo et al. (2018), who found pest and disease problems among the perceived effects of climate variability on maize production. It also corresponded with the present descriptive finding in which 82.1% of respondents reported pest and disease prevalence. The result suggested that direct experiences with biological production pressures were associated with stronger perceptions of climate-change effects.

Overgrazing and deforestation were also positively and significantly associated with perception, with coefficients of 0.071 and 0.065, respectively ($p < 0.01$). These findings demonstrated that farmers' perception of climate related change was associated not only with rainfall and drought but also with broader environmental degradation. Soubry et al. (2020) emphasised the importance of considering farmers' perceptions within their wider social-ecological contexts. The present findings were consistent with that perspective because respondents linked their perception of climate change with several interacting environmental pressures.

Institutional Factors

Extension contact was positively and significantly associated with perception ($\beta = 0.058$, $p < 0.01$; marginal effect = 0.044). This finding closely agreed with Coster and Adeoti (2021), who found access to extension agents to be positively associated with the likelihood of farmers perceiving climate change among maize based farming households in Nigeria. Ogbodo et al. (2018) similarly identified extension agents as an important source of climate-related information among maize farmers. The present finding therefore reinforced the relevance of agricultural extension in providing farmers with information that could assist them in recognising and interpreting changes in rainfall, temperature, pests, diseases and other production conditions.

Cooperative membership was positively and significantly associated with perception ($\beta = 0.031$, $p < 0.01$; marginal effect = 0.024). The finding was consistent with Ejiba and Adams (2017), who reported a positive relationship between cooperative membership and farmers' climate-change adaptation, and with Ojo and Baiyegunhi (2021), who recommended stronger farmer cooperatives as part of climate-change support interventions. Cooperatives could facilitate peer-to-peer information exchange, collective learning and contact with extension and other service providers. Nevertheless, the present regression result did not establish

the specific pathway through which cooperative membership was associated with perception.

Credit obtained was positively and significantly associated with perception ($\beta = 0.067$, $p < 0.01$; marginal effect = 0.051). This finding was consistent with Ojo and Baiyegunhi (2021), who identified access to credit as a significant determinant of climate-change perception. It also corresponded with Coster and Adeoti (2021), who incorporated access to credit among the factors associated with farmers' climate-change perception and adaptation. The finding suggested that farmers with greater financial resources tended to report higher perception scores. Credit could provide greater opportunities to obtain farm inputs, climate related information and agricultural services, although the present cross-sectional analysis did not establish that credit access directly caused higher perception.

Taken together, the regression findings showed that farmers' perception of climate-change effects was associated with a combination of socioeconomic, environmental and institutional characteristics. The direction and significance of many of these relationships were consistent with empirical evidence from maize and other smallholder farming systems in Nigeria. However, differences observed for variables such as sex demonstrated that the determinants of climate-change perception could vary according to location, farming system, measurement approach and model specification. The findings therefore supported the importance of examining climate-change perception within specific agricultural and institutional contexts rather than assuming that the same factors would operate identically across all farming communities.

Test of Hypothesis

The null hypothesis stated that socioeconomic, environmental and institutional characteristics had no significant association with farmers' perception of climate-change effects on maize production.

The pooled Tobit model was statistically significant ($LR \chi^2 = 186.42$, $p < 0.01$). Age, educational level, household size, farm size, annual income, pest and disease prevalence, overgrazing, deforestation, soil erosion, drought frequency, extension contact, cooperative membership and credit obtained were statistically significant, whereas sex was not significant.

Therefore, the null hypothesis was rejected implying that **socioeconomic, environmental and institutional characteristics were significantly associated with farmers' perception of climate-change effects on maize production.**

Conclusion

The study examined the socioeconomic, environmental and institutional factors associated with farmers' perception of climate-change effects among maize farmers in Northwest Nigeria. The findings revealed that farmers experienced various environmental challenges, particularly drought, pest and disease prevalence, soil erosion, deforestation and overgrazing. The high Composite Perception Index of 4.15 indicated that the respondents had a high level of perception of climate-change effects on maize production. The regression

results further revealed that age, educational level, household size, farm size, annual income, environmental pressures, extension contact, cooperative membership and credit obtained were positively and significantly associated with farmers' perception, while sex was not statistically significant. The study concluded that farmers' perception of climate-change effects was associated with a combination of socioeconomic, environmental and institutional characteristics. These findings highlighted the relevance of accessible climate information, extension services, farmer cooperatives and financial resources in supporting farmers' understanding of climate-related challenges in maize production.

Recommendations

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

1. **Strengthening agricultural extension and climate information services:** Agricultural extension agencies and relevant research institutions should increase the coverage and frequency of extension contact with maize farmers in Northwest Nigeria. Extension programmes should provide timely, locally relevant climate information on rainfall variability, drought, pest and disease outbreaks and other climate related risks, while emphasising practical interpretation and management through farm demonstrations, radio, mobile phones and farmer groups.
2. **Promoting sustainable environmental and climate resilient maize production:** Agricultural and environmental agencies should intensify extension interventions on drought management, soil and water conservation, erosion control, tree planting, sustainable land management, control of overgrazing and integrated pest and disease management. These interventions should be targeted towards the major environmental challenges identified by farmers, particularly drought (86.8%), pest and disease prevalence (82.1%) and soil erosion (79.2%).
3. **Strengthening farmer institutions and access to productive resources:** Government agricultural programmes, financial institutions and farmer organisations should strengthen cooperative participation and improve farmers' access to affordable credit and other productive resources. Extension programmes should use cooperatives as platforms for disseminating climate information and facilitating access to improved inputs, credit and climate-resilient production technologies, while giving particular attention to farmers' socioeconomic differences that were significantly associated with their perception of climate-change effects.

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