# CLIMATE CHANGE AND CROP PRODUCTION AMONG MEMBERS OF FARMERS' COOPERATIVE SOCIETIES IN KADUNA STATE, NIGERIA

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***Abstract***
*Climate change poses a growing threat to agricultural production, food security, and rural livelihoods, particularly among smallholder farmers whose production systems depend substantially on climatic conditions. This study examined the relationship between selected climate-related factors and crop production among members of farmers' cooperative societies in Kaduna State, Nigeria. Specifically, the study assessed the relationship between pests and diseases and soya bean production and examined the relationship between heat waves and groundnut production. A descriptive survey research design was adopted. The population comprised 107,527 members of registered and active farmers' cooperative societies in Kaduna State. Using the Taro Yamane formula, a sample size of 400 respondents was determined, while a multistage sampling procedure was used for respondent selection. Data were collected using a structured questionnaire measured on a five-point Likert scale. The instrument was validated by experts and its reliability was established using Cronbach's alpha, with coefficients of 0.815 for pests and diseases and 0.786 for heat waves. Descriptive statistics and simple linear regression were used for data analysis. Results showed that respondents agreed to a great extent that pests and diseases were associated with reduced soya bean production, with a grand mean of 4.25. Similarly, respondents agreed to a great extent that heat waves were associated with reduced groundnut production, with a grand mean of 4.29. Regression results showed that pests and diseases had a statistically significant negative relationship with soya bean production, $R^2 = .234$, $\beta = -.484$, $t = -10.828$, $p < .001$. Heat waves also had a statistically significant negative relationship with groundnut production, $R^2 = .175$, $\beta \approx -.418$, $t = -9.022$, $p < .001$. The study concludes that pests and diseases and heat-wave conditions are significant constraints to crop production among members of farmers' cooperative societies in Kaduna State. The study recommends integrated pest and disease management, use of heat-tolerant crop varieties, adjustment of planting dates, improved extension services, climate information dissemination, and stronger institutional support for cooperative farmers.*

***Key words:*** *Climatic Change, Crop Production, Pests (Diseases), Beans Production, Heat Waves, Groundnut Production.*

## Introduction

Agriculture remains an important component of the economies and livelihoods of developing countries and is particularly sensitive to changes in environmental and climatic conditions. Variations in temperature, rainfall, drought occurrence, floods, and extreme heat can influence agricultural productivity and the livelihoods of farming households (Salahuddin, Gow, & Vink, 2020; Tiwari, Bajracharya, & Balla, 2022). The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as a change of climate attributed directly or indirectly to human activities that alter the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable periods. The Intergovernmental Panel on Climate Change (IPCC) similarly recognizes long-term changes in climatic conditions and associated increases in climate extremes. Observed manifestations of climate change include rising temperatures, changing precipitation patterns, droughts, floods, and heat waves (NASA Science, 2024a; NOAA, 2022). These changes have important implications for agricultural production because crop growth and development depend on temperature, water availability, soil conditions, and biological interactions. Climate-related changes may also alter the distribution and intensity of agricultural pests and diseases, thereby increasing production risks.

Kaduna State is one of Nigeria's important agricultural areas and contributes to national food production through the cultivation of crops such as maize, rice, soya bean, groundnut, sorghum, millet, guinea corn, and cotton. Agriculture provides livelihoods for a substantial proportion of the state's rural population. Farmers' cooperative societies are important institutional mechanisms through which smallholder farmers may gain access to production inputs, agricultural information, credit, markets, and collective services (Adesehin & Alayande, 2019). However, the agricultural production systems of cooperative farmers are increasingly exposed to climatic stresses. Changes in temperature and rainfall patterns can affect planting decisions, crop development, pest and disease occurrence, water availability, and yields. Heat waves can cause physiological stress to crops, while changes in environmental conditions may favour the emergence, survival, and spread of pests and diseases. Soya bean is an economically important crop in Nigeria because of its value as a source of protein, vegetable oil, and livestock feed. Groundnut is similarly important as an oilseed and food crop and contributes to household income and rural employment. Both crops are sensitive to environmental conditions, although the nature and severity of their responses to climatic stress may differ.

The increasing occurrence of climatic stresses therefore raises concerns about the ability of cooperative farmers to maintain crop production and food security. Understanding the relationship between specific climate-related factors and crop production is important for developing appropriate adaptation and agricultural support measures. This study consequently focuses on two specific relationships: pests and

diseases and soya bean production, and heat waves and groundnut production among members of farmers' cooperative societies in Kaduna State, Nigeria.

## Statement of the Problem

Agricultural production in Kaduna State is increasingly exposed to environmental and climatic stresses that can constrain productivity and threaten farmers' livelihoods. Changes in climatic conditions can affect agricultural calendars, water availability, crop development, and the occurrence of pests and diseases. These challenges may be particularly important for smallholder farmers who have limited capacity to absorb production losses.

Pests and diseases constitute important constraints to soya bean production. Insect pests can damage leaves, stems, flowers, and pods, while plant diseases can reduce crop vigour, quality, and yield. Pest and disease management may also increase farmers' production costs because of expenditures on pesticides, labour, and other control measures. Where infestation becomes severe, farmers may experience considerable reductions in marketable output. Heat waves constitute another climate-related risk to crop production. High temperatures can increase crop water requirements, disrupt flowering and pollination, reduce pod formation, and affect the physiological development of crops. Groundnut production may therefore be affected where periods of extreme heat coincide with sensitive stages of crop development.

Although previous studies have examined climate change and agricultural production in Nigeria and other regions, empirical evidence specifically relating selected climate stressors to crop production among members of farmers' cooperative societies in Kaduna State remains limited. The present study addresses this gap by examining the relationship between pests and diseases and soya bean production and between heat waves and groundnut production.

## Objectives of the Study

The broad objective of the study is to assess the effect of climatic change on crop production: assessing cooperative farms in Kaduna state, Nigeria. The specific objectives are to:

1. Ascertain the effect of pests (diseases) on soya bean production among members of farmers cooperative societies in Kaduna state, Nigeria.
2. Determine the effect of heat waves on groundnut production among members of farmers cooperative societies in Kaduna state, Nigeria.

**Research Question**

i. To what extent do pests (diseases) affect soya bean production of members of farmers cooperative societies in Kaduna state, Nigeria.

ii. To what extent has heat waves affected the groundnuts production of members of farmers cooperative societies in Kaduna state, Nigeria.

**Hypotheses**

$Ho_{1:}$ Pests (diseases) have no significant effect on soya bean production of members of farmers cooperative societies in Kaduna state, Nigeria.

$Ho_{2:}$ Heat wave has no significant effect on groundnut production of members of farmers cooperative societies in Kaduna state, Nigeria.

**Literature Review**

**Climatic Change**

Climate change refers to long-term changes in climatic conditions, including changes in temperature, precipitation, and the frequency or intensity of extreme weather events. The Royal Society (2017) identifies climate change as long-term changes in the Earth's climate system resulting from both natural processes and human activities. The IPCC (2018, 2021) similarly recognizes climate change as a major environmental challenge associated with changes in temperature and other climatic characteristics.

Human activities, including fossil-fuel combustion, deforestation, and other sources of greenhouse-gas emissions, have contributed substantially to observed warming and associated climatic changes (Rahmani & Ahmadi, 2024). Climate change has implications for agriculture because crop growth is dependent on environmental conditions. Changes in temperature and precipitation can alter crop suitability, water availability, pest and disease dynamics, and agricultural calendars.

In this study, climate change is operationalized through two selected climate-related stressors: pests and diseases affecting soya bean production and heat waves affecting groundnut production. The study therefore does not attempt to measure climate change as a single broad environmental phenomenon but examines selected manifestations or associated agricultural stressors reported by cooperative farmers.

**Pests and Diseases and Soya Bean Production**

Pests and diseases are important biological constraints to crop production. Soya bean may be attacked by insect pests such as aphids, beetles, and bugs, as well as by viral and bacterial diseases. Asala, Olubusuyi, and Abdulrazaq (2016) identified insect pests

associated with soya bean production in Nigeria, while Kolo, Salahudeen, and Wada (2019) reported the importance of insect vectors and plant viruses affecting legumes.

Aderibigbe (2019) classified crop insect pests according to their feeding mechanisms, including biting and chewing insects, piercing and sucking insects, and boring insects. Such pests may damage crop tissues, reduce photosynthetic capacity, transmit pathogens, and ultimately reduce crop yield and quality.

The relationship between climatic conditions and pests and diseases is important because changes in temperature and moisture can influence pest reproduction, survival, geographical distribution, and disease development. FAO (2017) notes that pests can reduce crop viability and market value while increasing production costs. Effective pest and disease management is therefore important for maintaining agricultural productivity.

## Heat Waves

A heat wave is generally understood as a period of unusually high temperature relative to the normal climatic conditions of a location and season. The IPCC (2021) reports an increase in the frequency and intensity of heat extremes in many regions as the climate warms. Möller et al. (2022) describe heat waves as periods of unusually high temperatures that can generate substantial impacts on human and ecological systems.

Heat waves can affect crop production through several mechanisms. Excessive temperature can increase evapotranspiration and crop water requirements, cause physiological stress, interfere with flowering and pollination, and reduce reproductive success. García-León et al. (2021) further demonstrate the broad economic consequences associated with heat-wave conditions. For groundnut, temperature extremes during sensitive reproductive stages may affect flowering, peg formation, pod development, and kernel filling. Where high temperatures are accompanied by inadequate soil moisture, the adverse effects may become more pronounced.

## Crop Production

Crop production refers to the cultivation of crops for food, feed, fibre, fuel, and other uses. It involves a series of activities including land preparation, planting, crop management, pest and disease control, harvesting, and post-harvest handling. Agricultural production is influenced by biological, environmental, technological, economic, and institutional factors. FAO (2023) recognizes crop production as an important component of food and agricultural systems under both irrigated and rain-fed conditions. Soil fertility, seed quality, pest management, water availability, climatic conditions, and access to agricultural inputs are among the factors that can influence

crop productivity.

In the present study, crop production refers specifically to the production outcomes of soya bean and groundnut as perceived and reported by members of farmers' cooperative societies. The questionnaire items measured the extent to which selected climate-related stressors were associated with production outcomes using a five-point Likert scale.

## Soya Bean Production

Soya bean (_Glycine max_) is a leguminous crop belonging to the family Fabaceae. It is valued for its high-quality protein, edible oil, and use in livestock feed. The crop was introduced into Nigeria in the early twentieth century and has subsequently become an important crop in several parts of the country. Soya bean production is particularly important in the Guinea Savanna ecological zone, where environmental conditions can support its cultivation. Improved varieties and appropriate agronomic practices can contribute to improved productivity and resilience. However, pests, diseases, rainfall variability, soil conditions, and temperature may affect production. The management of pests and diseases is consequently an important aspect of maintaining soya bean productivity.

## Groundnut Production

Groundnut (_Arachis hypogaea_), also known as peanut, is an important oilseed and food crop cultivated in many parts of Nigeria. It provides edible oil, protein, livestock feed, and income for farming households. Groundnut production is sensitive to temperature and moisture conditions, particularly during flowering, pegging, pod formation, and kernel development. Excessive heat and moisture stress may interfere with reproductive processes and reduce yield and quality. Given the importance of groundnut to rural livelihoods and food production, understanding the relationship between heat-wave conditions and groundnut production is important for agricultural planning and adaptation.

## Theoretical Framework

### Systems Theory

This study is anchored on Systems Theory, associated with Ludwig von Bertalanffy. Systems Theory views a phenomenon as an integrated whole consisting of interconnected components. The theory emphasizes interactions, relationships, interdependence, and the manner in which changes in one component of a system can influence other components. Farmers' cooperative societies can be regarded as open socio-economic systems that interact continuously with their external environment.

Cooperative farmers depend on land, climate, water, biological resources, agricultural inputs, markets, institutions, and technological knowledge. Changes in one part of this system can affect other components.

Climate-related conditions therefore form part of the external environment of agricultural cooperatives. Pests and diseases may influence crop productivity, while heat waves may affect crop development and farmers' production decisions. The ability of farmers' cooperative societies to respond to such changes may depend on access to information, agricultural inputs, extension services, improved varieties, finance, and collective action.

Systems Theory is relevant to this study because it provides a framework for understanding crop production as the outcome of interactions among environmental and organizational factors rather than as the result of a single factor in isolation. The two regression models examined in this study therefore focus on selected climate-related factors while recognizing that other factors may also influence crop production.

## Empirical Review

Okonkwo, Okafor, Ogochukwu, and Ngene (2023) investigated the influence of climate change on agricultural production among members of farmers' cooperatives in Ehime Mbano Local Government Area of Imo State, Nigeria. The study examined flooding, drought, and pests and diseases in relation to crop yield, profitability, and farmers' income. Using data obtained from cooperative members, the researchers found that flooding reduced production, drought affected profitability, and pests and diseases reduced farmers' income. The study is relevant because it demonstrates the importance of climate-related factors in cooperative agricultural production. However, the present study differs in geographical location, crop focus, variables, and analytical approach.

Diallo, Traore, and Sanogo (2024) examined heat-wave shocks and groundnut productivity in the West African Sahel, with particular attention to micro-irrigation. The study reported that irrigation could moderate some of the effects of extreme heat, although prolonged heat exposure continued to reduce groundnut productivity. The study supports the importance of water management under extreme heat but differs from the present study because it used experimental observations rather than a cooperative-farmer survey.

Haro, Baldessari, and Giordano (2024) investigated the reproductive sensitivity of groundnut to nocturnal heat waves in Argentina. Their findings indicated that elevated nighttime temperatures could increase respiratory costs and reduce the resources available for pod development. The study demonstrates that heat stress can affect reproductive processes in groundnut. Its experimental and geographical context, however, differs from that of the present study.

Ilboudo and Sawadogo (2025) examined the implications of changing agro-ecological conditions for future groundnut cultivation in the Sudano-Sahelian region. Their modelling results suggested that increasing temperatures could alter the geographical suitability of some groundnut production areas. The study is relevant to the present research because it emphasizes the agricultural implications of rising temperatures, although it used ecological modelling rather than survey data from cooperative farmers.

Savary et al. (2019) estimated global yield losses associated with pests and pathogens affecting major food crops, including soybean. Their findings demonstrated that pests and pathogens constitute significant constraints to agricultural productivity, with substantial differences across crops and regions. Their study provides broader evidence of the importance of crop health management but differs from the present study in geographical scope and research design.

Kovács and Tóth (2024) examined emerging viral and bacterial threats affecting soybean production under changing climatic conditions in Central Europe. Their findings linked changing environmental conditions with pest-vector dynamics and disease occurrence. The study reinforces the importance of crop health under changing climatic conditions but differs from the present study in geographical setting and methodology.

The reviewed studies collectively indicate that climate-related conditions, pests, diseases, and extreme temperatures can constrain agricultural production. However, there remains a need for empirical evidence specifically focused on members of farmers' cooperative societies in Kaduna State. The present study contributes to this gap by examining two crop-specific relationships using data obtained from cooperative farmers.

## Methodology

The study adopted a descriptive survey research design. The design was considered appropriate because the study obtained information from members of farmers' cooperative societies concerning their experiences and perceptions of selected climate-related factors and crop production at a particular period. Descriptive survey research involves collecting information from a sample of a population to describe existing conditions and relationships among variables (Odigbo & Agbasi, 2022).

The population comprised all active members of registered farmers' cooperative societies in Kaduna State, Nigeria. According to the Cooperative Department, Ministry of Rural Development and Special Duties, Kaduna State, there were 2,192 registered and active farmers' cooperative societies with a total membership of 107,527. In determining the sample size for the study, a simplified formula by Taro Yamane (1967) was employed and stated thus:

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

Where; N = Population of the Study

n = Sample Size

(e) = Level of significance

I = Unit (a constant)

Note (e) = 0.05

N = 107,527

$$\frac{107,527}{1+107,527\ (0.05)^2}$$

$$= \frac{107,527}{1 + 107,527\ (0.0025)}$$

$$= \frac{107,527}{1 + 268.818} \qquad \frac{107,527}{269.818}$$

$$= 398.5167$$

Approximately = 400 sample size

Given that the Population of 107527 members of the registered and viable farmers cooperative societies under study, the application of the Yamene (1967) formula gave a sample size of 400.

A multistage sampling procedure was adopted. At the first stage, Kaduna State was considered in terms of its agricultural zones. Because insecurity and communal conflicts affected accessibility in some areas, the study purposively selected accessible agricultural zones where data collection could be safely conducted. At the second stage, ten Local Government Areas were selected from the accessible agricultural zones. Eight Local Government Areas were selected from the Samaru and Maigana agricultural zones, while two were selected from the Saminaka/Lere agricultural zone. No Local Government Area was selected from Birnin Gwari agricultural zone because of insecurity at the time of the study. At the third stage, four farmers' cooperative societies were randomly selected from each of the ten selected Local Government Areas, producing 40 cooperative societies. At the fourth stage, ten members were randomly selected from each of the 40 selected cooperative societies. This produced the intended sample of 400 respondents.

Data were collected using a structured questionnaire titled "Climate Change and Crop Production among Members of Farmers' Cooperative Societies in Kaduna State, Nigeria. The questionnaire consisted of items designed to obtain information on the selected climate-related factors and crop production. Responses were measured on a five-point Likert scale:

- Very Great Extent = 5
- Great Extent = 4
- Undecided = 3
- Some Extent = 2
- No Extent = 1

The questionnaire focused specifically on pests and diseases in relation to soya bean production and heat waves in relation to groundnut production.

***The independent variables were:***

**Pests and diseases (PEDS):** measured through respondents' assessment of the extent to which pest and disease occurrence was associated with reductions in soya bean yield and quality, increased production costs, crop damage, and reduced market value.

**Heat waves (HEWV):** measured through respondents' assessment of the extent to which prolonged heat conditions were associated with reductions in groundnut yield and quality, disruption of flowering and pollination, changes in planting dates, and reduced market value.

***The dependent variables were:***

**Soya bean production (SOBPRO):** measured using questionnaire items relating to the production outcomes of soya bean.

**Groundnut production (GRNPRO):** measured using questionnaire items relating to the production outcomes of groundnut.

The production measures in this study are therefore survey-based measures of reported production outcomes rather than independently verified physical quantities such as tonnes or kilograms.

The questionnaire was subjected to face and content validation by experts in Education Foundation and Cooperative Economics and Management. The experts assessed the clarity, relevance, adequacy, and appropriateness of the items in relation to the study objectives. Their observations and recommendations were incorporated into the final version of the questionnaire.

A pilot test involving 20 members of farmers' cooperatives in Kaduna states, Nigeria was conducted using Cronbach's Alpha to assess the internal consistency of the measurement scales used for each climatic variable affecting crop production. All variables recorded Cronbach's Alpha values above 0.70, showing good internal consistency. Pests (diseases) (0.815), and heat waves (0.786) each demonstrated reliable measurement scales. The overall Cronbach Alpha's reliability coefficient is 0.80, which is considered sufficiently high and above the cutoff point of 0.6 (Hair, Bush, |& Ortinua, 2006). Data collected were analyzed using descriptive statistics (frequencies, percentages, mean, and standard deviation) and inferential statistics such as regression analysis. The objectives were processed using descriptive statistics (like percentages, mean and standard deviation) and the two hypotheses, $Ho_1$ and $Ho_2$, set for the study were analyzed through regression analysis, complete with explicit and implicit models.

**Model Specification**

**Model for Hypothesis One**

**Ho1**: Pests (diseases) have no significant effect on soya bean production of farmers' cooperatives members. This present study modified the model as:

*The functional form of the model*

SOBPRO = f (PEDS) …… Eqn 1.

*The Explicit form of the model into an econometric equation thus:*

SOBPRO = $\beta 0 + \beta 1$ (PEDS) + $\varepsilon$…… Eqn 2.

*The Implicit form of the model into an econometric equation thus:*

SOBPRO - $\beta 0$ - $\beta 1$ (PEDS) = 0 …… Eqn 3.

***Dependent Variables***

SOBPRO - Soya Beans Production

GRNPRO - Groundnut Production

***Independent Variables***

PEDS - Disease and Pest

HEWV - Heat Waves

**Model for Hypothesis Two**

**Ho2**: Heat wave has no significant effect on groundnut production of farmers' cooperative members. This present study modified the model as:

*The functional form of the model is*

GRNPRO = f (HEWV …… Eqn 4.

*The Explicit form of the model into an econometric equation thus:*

GRNPRO = β0 + β1 (HEWV) + ε …… Eqn 4.

*The Implicit form of the model into an econometric equation thus:*

GRNPRO - β0 - β1 (HEWV) = 0 …… Eqn 5.

**Presentation and Analysis of Data**

**Analysis of Data Related to Research Question**

**Decision Rule:**

The decision in the analysis section is determined by the average of the responses of respondents. Very Great Extent (5 points), Great Extent (4 points), Undecided(3 points), Some Extent (2 points) and No Extent (1 point). The average of the responses:

$$\frac{(5 + 4 + 3 + 2 + 1)}{5} = 3.0$$

Therefore, a mean score below 3.0 would be considered rejected and a mean score of 3.0 and above would be considered accepted.

**Table 1: To what extent do pests (diseases) affect soya bean production of members' 0f farmers' cooperative societies in Kaduna State, Nigeria?**

| S/N | Items | Mean | Standard Deviation | Remark |
|---|---|---|---|---|
| **1** | Reduces Soya bean yields (quantity). | 4.42 | 0.883 | Accepted |
| **2** | Reduces Soya bean quality. | 4.28 | 0.911 | Accepted |
| **3** | Increases production costs. | 4.21 | 0.995 | Accepted |
| **4** | Leads to increased pesticide use, which can harm beneficial insects, contaminate soil and water, and affect human health. | 4.17 | 1.134 | Accepted |
| **5** | Lowers the market value of crops. | 4.33 | 1.058 | Accepted |
| **6** | Affects crop health and yield. | 4.32 | 1.020 | Accepted |
| **7** | Causes contamination of Soya Bean s. | 4.12 | 1.144 | Accepted |
| **8** | Leads to damage of leaves and stems. | 4.11 | 1.188 | Accepted |
| **GRAND MEAN** | | **4.25** | | |

**Source**: Field survey, 2025

All 8 items were accepted with means ranging from 4.11 to 4.42. The grand mean of 4.25 indicates that respondents agreed to a great extent that pests (diseases) affect soya bean production. Specifically, pests (diseases) were reported to reduce yield and quality, increase production costs through pesticide use, damage plant parts, cause contamination, and lower market value. The low standard deviations indicate a high level of agreement among respondents.

**Table 2: To what extent has heat waves affected the groundnuts production of members' 0f farmers' cooperative societies in Kaduna State, Nigeria?**

| S/N | Items | Mean | Standard Deviation | Remark |
|---|---|---|---|---|
| **1** | Prolonged exposure to heat stress causes damage to plants, reducing yields (quantity). | 4.37 | 0.891 | Accepted |
| **2** | Prolonged exposure to heat stress reduces quality. | 4.26 | 0.857 | Accepted |
| **3** | Causes plants to drop their flowers and reduces pod formation as a result of drought. | 4.11 | 0.997 | Accepted |
| **4** | Weakens groundnut plants, making them more susceptible to pests (diseases). | 4.14 | 1.091 | Accepted |
| **5** | Disrupts traditional planting dates. | 4.09 | 1.074 | Accepted |
| **6** | Disrupts pollination and fertilization processes, reducing fruit set. | 4.22 | 1.090 | Accepted |
| **7** | Causes groundnuts to become discolored, shriveled, or develop off-flavors, reducing their quality. | 4.48 | 1.060 | Accepted |
| **8** | Reduces the market value | 4.59 | .897 | Accepted |
| **9** | Reduces soil fertility and water-holding capacity. | 4.37 | .891 | Accepted |
| **GRAND MEAN** | | | **4.29** | |

**Source**: Field survey, 2025

All 9 items were accepted with means ranging from 4.09 to 4.59. The grand mean of 4.29 shows strong agreement that heat waves affect groundnut production. Respondents indicated that heat stress reduces yield and quality, disrupts flowering, pollination and planting dates, weakens plants, and reduces soil fertility and market value.

## Test of Hypotheses

**Table 3: Regression summary results for Hypothesis One**

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | ..484[a] | .234 | .232 | 3.70239 |

a. Predictors: (Constant), Pest (Diseases)

Source: SPSS V. 26 Production (2025)

The model summary indicates a correlation coefficient of approximately R = .484 and an $R^2$ of 234. Thus, pests and diseases account for approximately 23.4% of the observed variation in the reported soya bean production measure. The adjusted $R^2$ of .232 indicates that the explanatory power remains approximately 23.2% after adjustment for model degrees of freedom. The standard error of 3.70239 shows reasonable prediction accuracy. Overall, the findings suggest that PEST factors strongly affect soya bean production, although other variables outside the model also contribute to production outcomes.

**Table 4 ANOVA[a]**

| Model | | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 856.197 | 1, 384 | 856.197 | 117.240 | .000[b] |
| | Residual | 2804.321 | 384 | 7.303 | | |
| | Total | 3660.518 | 385 | | | |

a. Dependent Variable: SOYA_PROD

b. Predictors: (Constant), PEST (DISEASES)

The ANOVA result reveals that pest (diseases) infestation significantly influences soya bean production. The regression model is statistically significant with F = 117.240 and p = 0.000, indicating that pests have a strong effect on soya bean yield. This means that changes in pest infestation levels significantly account for variations observed in soya bean production.

**Table 5. Regression Coefficients[a] production for Hypothesis One**

| | | Unstandardized Coefficients | | Standardized Coefficients | | |
|---|---|---|---|---|---|---|
| 11 | | B | Std. Error | Beta | T | Sig. |
| 1 | (Constant) | 7.832 | .847 | | 9.248 | .000 |
| | PEST | -.530 | .049 | -.484 | -10.828 | .000 |

a. Dependent Variable: SOYA_PROD

Source: SPSS V. 26 Production (2025)

The coefficient for pests and diseases is negative and statistically significant (B = −0.530, β = −0.484, t = −10.828, p \< .001). This indicates that higher reported levels of pest and disease pressure are associated with lower reported soya bean production.

Since the relationship is statistically significant at the 0.05 level, the null hypothesis is rejected.

**Test of Hypothesis II**

**Table 6: Regression Model summary results for Hypothesis Two**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .418[a] | .175 | .173 | 4.34987 |

a. Predictors: (Constant), HEAT WAVE
Source: SPSS V. 26 Production (2025)

The regression analysis revealed that heat waves significantly influence groundnut production. The correlation coefficient (R = 0.418) indicates a moderate to strong relationship, while the $R^2$ value of 0.175 shows that heat explains 17.5% of the variation in production. The adjusted $R^2$ of 0.173 confirms moderate explanatory power, suggesting other factors also affect production.

Table 7 **ANOVA[a]**

| Model | | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 913.326 | 1 | 913.326 | 81.390 | .000[b] |
| | Residual | 4309.110 | 384 | 11.222 | | |
| | Total | 5222.435 | 385 | | | |

a. Dependent Variable: GROUDNUT_PROD
b. Predictors: (Constant), HEAT WAVE

The ANOVA result indicates that heat has a significant effect on groundnut production. The regression model is statistically significant with F = 81.390 and p = 0.000, showing a strong relationship between heat and groundnut production. This implies that variations in heat wave conditions significantly influence changes in groundnut production levels.

**Table 8: Regression Coefficients[a] production for Hypothesis Two.**

| 1 | | Unstandardized Coefficients B | Unstandardized Coefficients Std. Error | Standardized Coefficients Beta | T | Sig. |
|---|---|---|---|---|---|---|
| 1 | (Constant) | 12.115 | 1.056 | | 11.477 | .000 |
| | HEAT WAVE | -.551 | .061 | -.418 | -9.022 | .000 |

a. Dependent Variable: GROUDNUT_PROD
Source: SPSS V. 26 Production (2025)

The model is statistically significant, $F(1, 384) = 81.390$, $p < .001$. $R^2 = .175$ indicates that 17.5% of the variation in groundnut production is associated with heat waves. The standardized coefficient $\beta = -0.418$, $t = -9.022$, $p < .001$ shows a significant negative relationship. Therefore, H0 is rejected. The result suggests that increased heat wave intensity is associated with lower groundnut production among members of farmers cooperative societies in Kaduna state, Nigeria.

## Discussion of Findings

### Pests and Diseases and Soya Bean Production

The study found a statistically significant negative relationship between pests and diseases and soya bean production among members of farmers' cooperative societies in Kaduna State. The descriptive result produced a grand mean of 4.25, indicating that respondents perceived pests and diseases as an important constraint to soya bean production. The regression analysis further showed that pests and diseases were significantly associated with soya bean production, with $R^2 = .234$, $\beta = -.484$, $t = -10.828$, $p < .001$. The negative coefficient indicates that higher levels of reported pest and disease pressure are associated with lower reported soya bean production. The finding is consistent with Okonkwo et al. (2023), who found that pests and diseases constrained agricultural outcomes among cooperative farmers in Imo State. It is also consistent with Savary et al. (2019), who documented substantial crop losses associated with pests and pathogens globally.

The finding can be explained by the direct effects of pests and diseases on crop tissues and plant development. Damage to leaves, stems, flowers, and pods can reduce photosynthetic activity and reproductive success. Farmers may also incur additional costs when attempting to control pest and disease outbreaks. The result therefore emphasizes the importance of crop health management among cooperative farmers. However, the $R^2$ value of .234 also indicates that approximately 76.6% of the variation in the production measure is associated with factors outside the model. This suggests that pests and diseases are important but are not the sole determinants of soya bean production. Other factors such as rainfall, soil fertility, seed quality, farm size, access to inputs, labour, extension services, and market conditions may also contribute to production outcomes.

### Heat Waves and Groundnut Production

The study also found a statistically significant negative relationship between heat waves and groundnut production. The descriptive analysis produced a grand mean of 4.29, indicating substantial agreement among respondents that heat-wave conditions are associated with adverse groundnut production outcomes. The regression analysis produced $R^2 \approx .175$, with a negative coefficient ($B = -.551$, $t = -9.022$, $p < .001$). The

finding indicates that higher reported heat-wave conditions are associated with lower reported groundnut production. This result is consistent with Diallo et al. (2024), whose findings showed that extreme heat could reduce groundnut productivity even where irrigation was available. It also agrees with Haro et al. (2024), who demonstrated that elevated temperatures can interfere with reproductive development in groundnut. Ilboudo and Sawadogo (2025) similarly emphasized the implications of increasing temperature for the geographical suitability of groundnut production.

The relationship may be explained by the sensitivity of groundnut development to temperature and moisture conditions. Excessive heat can increase crop water requirements and cause physiological stress, while high temperatures during reproductive stages may interfere with flowering, pollination, pod formation, and kernel development. Nevertheless, the $R^2$ value indicates that heat waves account for approximately 17.5% of the variation in the reported groundnut production measure. Therefore, other production factors remain important and should be considered in future studies.

## Conclusion

The study examined the relationship between selected climate-related factors and crop production among members of farmers' cooperative societies in Kaduna State, Nigeria. The findings demonstrate that pests and diseases are significantly and negatively associated with soya bean production, while heat waves are significantly and negatively associated with groundnut production. The descriptive findings further indicate that cooperative farmers perceive both pests and diseases and heat-wave conditions as important constraints to crop production. The regression results provide statistical evidence that the two selected factors are significantly associated with the respective crop-production outcomes.

The findings underscore the importance of strengthening farmers' capacity to manage climate-related agricultural risks. However, the results also show that the selected factors do not account for all variations in crop production, indicating that other environmental, technological, economic, and institutional factors should be considered in future research.

## Recommendations

Based on the findings, the study recommends that:

a. Farmers' cooperative societies should strengthen integrated pest and disease management. Cooperatives should encourage regular monitoring of crop fields, early identification of pest and disease outbreaks, and use of resistant or tolerant varieties, appropriate biological control measures, and responsible application of approved pesticides.

b. Agricultural extension agencies should intensify climate and crop-health extension services. Extension personnel should provide cooperative farmers with practical information on pest identification, disease management, appropriate pesticide application, and climate-related production risks.

c. Agricultural research institutions should promote heat-tolerant and locally suitable groundnut varieties. Research and dissemination of varieties capable of maintaining productivity under high-temperature conditions should receive greater attention.

d. Farmers should adjust planting dates where reliable climate information indicates increased heat risk. Appropriate adjustment of planting periods may help reduce exposure of sensitive crop-development stages to extreme temperatures.

e. Cooperatives should promote soil-moisture conservation practices. Practices such as mulching, conservation agriculture, appropriate soil management, and water-conservation measures can help reduce the effects of heat and moisture stress.

f. Government and relevant agricultural agencies should strengthen agricultural early-warning systems. Timely information on extreme temperatures, rainfall conditions, pest outbreaks, and disease risks should be communicated to cooperative farmers in accessible formats.

g. Farmers' cooperative societies should facilitate collective access to agricultural inputs and services. Collective procurement and distribution of approved crop-protection products, improved seeds, extension services, and climate information can reduce individual farmers' constraints.

h. Further research should incorporate additional determinants of crop production. Future studies should consider rainfall variability, drought, soil fertility, access to irrigation, farm size, improved seed adoption, extension services, access to credit, and market conditions in multivariate models.

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