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Climate Variability and Its Influence on the Productivity of Tomato Farmers in Nasarawa State, Nigeria

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ABSTRACT

Climate variability poses a significant threat to agricultural productivity and rural livelihoods, particularly among smallholder farmers who depend largely on rainfall for crop production. This study examined the influence of climate variability on the productivity of tomato farmers in Nasarawa State, Nigeria. Specifically, the study assessed farmers' perceptions of climate variability, evaluated productivity and resilience levels, and determined the influence of climate variability adaptation strategies on tomato productivity. A multistage sampling procedure was used to select 191 tomato farmers from Akwanga, Nasarawa Eggon, and Toto Local Government Areas of Nasarawa State. Primary data were collected using structured questionnaires and Focus Group Discussions (FGDs). Data were analyzed using descriptive statistics, Total Factor Productivity (TFP) analysis, the Food and Agriculture Organization's Resilience Index Measurement and Analysis (RIMA II), and Tobit regression analysis. The findings revealed that flooding resulting from heavy rainfall, erosion, shortened rainfall duration, insufficient rainfall, and rising temperatures were the major indicators of climate variability perceived by farmers. The average Total Factor Productivity index was 1.26, indicating that tomato farmers maintained relatively high productivity levels despite climatic challenges. Resilience analysis showed that 54.97% of farmers exhibited moderate resilience, while 45.03% demonstrated low resilience, with no farmer classified as highly resilient. The Tobit regression results indicated that crop diversification ($\beta = 0.33$, $p < 0.05$), changes in cropping patterns and planting dates ($\beta = 0.63$, $p < 0.01$), and tree planting/agroforestry ($\beta = 0.67$, $p < 0.01$) positively and significantly influenced productivity. Conversely, soil conservation measures ($\beta = -0.27$, $p < 0.05$) had a negative influence on productivity. The study concludes that climate variability significantly influences tomato productivity in Nasarawa State and that adaptation strategies play a critical role in mitigating its adverse effects. The study recommends strengthening climate information services, promoting climate-smart agricultural practices, expanding irrigation infrastructure, improving farmers' access to adaptation technologies, and integrating climate adaptation measures into agricultural development policies to enhance productivity and resilience among tomato farmers.

Keywords: Climate variability; Tomato productivity; Adaptation strategies; Resilience; Climate-smart agriculture; Nasarawa State; Nigeria.

1.0 INTRODUCTION

Climate variability has emerged as one of the most significant environmental challenges affecting agricultural production worldwide. Changes in temperature, rainfall distribution, humidity, and the frequency of extreme weather events have increasingly influenced agricultural productivity, food security, and rural livelihoods. According to the Intergovernmental Panel on Climate Change (IPCC, 2018), global

average surface temperature has increased by approximately 1°C above pre-industrial levels, with projections indicating continued warming due to rising greenhouse gas concentrations. These climatic changes have altered precipitation patterns, increased the occurrence of floods and droughts, and intensified environmental stress on agricultural systems (Mikhaylov et al., 2020; Sarkingobir & Dikko, 2020). Since crop growth and productivity depend largely on climatic conditions, agriculture remains one of the sectors most vulnerable to climate variability and climate change (Al-Bakri et al., 2011; Kurukulasuriya & Rosenthal, 2013).

The effects of climate variability are particularly severe in Sub-Saharan Africa, where agricultural production is dominated by smallholder farmers who depend largely on rainfall. Farmers across the region have increasingly experienced floods, droughts, erratic rainfall patterns, and rising temperatures, all of which have negatively affected crop productivity and food security (Rahut, Aryal, & Marenya, 2021). Climate-induced changes in rainfall and temperature have been shown to reduce agricultural output, increase production risks, and undermine the resilience of rural households (Lema & Majule, 2009; Kalungu, Filho, & Harris, 2013). Consequently, climate variability has become a major obstacle to achieving sustainable agricultural development and poverty reduction in many African countries.

Nigeria is among the countries most vulnerable to the effects of climate variability because agriculture remains a major source of employment, income, and food supply. The National Adaptation Strategy and Plan of Action on Climate Change for Nigeria projected that climate change could reduce the country's Gross Domestic Product (GDP) by between 6% and 30% by 2050 if adequate adaptation measures are not implemented (Federal Ministry of Environment, 2011). In recent decades, Nigeria has witnessed increasing temperatures, irregular rainfall patterns, flooding, erosion, droughts, and other climate-related events that have adversely affected agricultural productivity and rural livelihoods (Gambo et al., 2020). These climatic disturbances are particularly important because Nigerian agriculture remains largely rain-fed, making crop production highly susceptible to weather fluctuations.

Among the major food and vegetable crops cultivated in Nigeria, tomato (Solanum lycopersicum) occupies an important position due to its nutritional, economic, and industrial value. Tomato is one of the most widely consumed vegetables in the world, with an estimated global value exceeding US$90 billion annually (FAOSTAT, 2019). In Nigeria, tomato production contributes significantly to food security, employment generation, income creation, and agro-industrial development. However, tomato is highly sensitive to climatic conditions, particularly temperature fluctuations, drought stress, flooding, excessive rainfall, pest infestation, and disease outbreaks (Litskas et al., 2019; Biratu, 2018). Studies have shown that rising temperatures, erratic rainfall patterns, water shortages, and increased incidence of pests and diseases can significantly reduce tomato productivity and threaten the sustainability of tomato farming systems (Kugblenu et al., 2013; Silva et al., 2017; Biratu, 2018).

Nasarawa State is one of the important tomato-producing areas in North-Central Nigeria. The state provides favourable agroecological conditions for vegetable production, with an average annual temperature of 28.4°C and annual rainfall of approximately 839 mm (Abayomi, Rotimi, & Egahi, 2016). Despite these favourable conditions, tomato farmers in the state increasingly face climatic challenges associated with flooding, erosion, shortened rainfall duration, insufficient rainfall, and rising temperatures. Evidence from farmers' perceptions in the study area revealed that flooding caused by heavy rainfall, erosion, low yields resulting from inadequate rainfall, and high temperatures were among the major manifestations of climate variability affecting tomato production. These climatic disturbances have important implications for farm productivity, household income, and livelihood sustainability among tomato-producing households.

Farmers have adopted several adaptation measures to cope with these climatic challenges, including crop diversification, mixed farming, changes in planting dates, improved irrigation practices, drought-tolerant crop varieties, and soil conservation measures (Sani, Haji, & Goshu, 2016; Menikea, Keeragala, & Arachchib, 2016). While previous studies have examined climate variability, adaptation strategies, and agricultural productivity in different contexts (Bhandari et al., 2021; Malyse, 2021; Ojo & Baiyegunhi, 2018; Zakari et al., 2022), empirical evidence focusing specifically on how climate variability influences

the productivity of tomato farmers in Nasarawa State remains limited. Furthermore, most existing studies have concentrated on adaptation decisions without adequately examining the productivity implications of climate variability among tomato farmers.

It is against this background that this study examined climate variability and its influence on the productivity of tomato farmers in Nasarawa State, Nigeria. Specifically, the study assessed farmers' perceptions of climate variability, analyzed their productivity levels, evaluated their resilience to climate variability, and examined the influence of adaptation strategies on tomato productivity. The findings are expected to contribute to policy formulation and the design of climate-resilient agricultural interventions aimed at improving tomato productivity, strengthening farmers' resilience, and enhancing food security in Nigeria.

2.0 METHODS AND MATERIALS

2.1 Study Area

The study was conducted in Nasarawa State, Nigeria. The state lies between latitude 7°45′N and 9°25′N and longitude 7°E and 9°37′E. Nasarawa State experiences a tropical climate characterized by distinct wet and dry seasons, with an average annual rainfall of about 839 mm and mean annual temperature of approximately 28.4°C. Agriculture is the dominant occupation of the population, and tomato production constitutes an important source of income, employment, and food security among rural households. The state was selected because of its prominence in tomato production and its vulnerability to climate variability and related environmental challenges **(**Abayomi, Rotimi, & Egahi, 2016; Nasarawa State Government, 2020**).**

2.2 Sampling Procedure and Data Collection

A multistage sampling procedure was employed in selecting respondents for the study. Three major tomato-producing Local Government Areas (Akwanga, Nasarawa Eggon, and Toto) were purposively selected based on the intensity of tomato production activities. Subsequently, farming communities were selected, and tomato farmers were randomly sampled. A total of 191 tomato farmers were selected for the study.

Primary data were collected using structured questionnaires complemented by Focus Group Discussions (FGDs). Information obtained included farmers' socioeconomic characteristics, tomato production activities, perceptions of climate variability, adaptation strategies, resilience indicators, production inputs, output levels, and institutional support services. The use of questionnaires and focus group discussions provided both quantitative and qualitative information necessary for understanding farmers' experiences and responses to climate variability **(**Creswell, 2014; Kothari, 2004**).**

2.3 Analytical Techniques

Descriptive statistics including frequencies, percentages, means, and standard deviations were used to analyze farmers' perceptions of climate variability and adaptation practices. Total Factor Productivity (TFP) analysis was employed to estimate productivity levels among tomato farmers. The Food and Agriculture Organization (FAO) Resilience Index Measurement and Analysis (RIMA II) framework was used to assess resilience to climate variability, while Tobit regression analysis was employed to determine the influence of climate variability adaptation strategies on tomato productivity.

The TFP approach has been widely applied in agricultural productivity studies because it provides a comprehensive measure of the efficiency with which farmers convert inputs into outputs **(**Coelli, Rao, O'Donnell, & Battese, 2005**)**. Similarly, the RIMA II framework developed by the Food and Agriculture Organization has been extensively used to assess household resilience to shocks and stresses, particularly in climate-vulnerable agricultural systems **(**FAO, 2016**).** The Tobit regression model was considered appropriate because the dependent variable is censored and allows for the estimation of factors influencing productivity under such conditions **(**Tobin, 1958; Gujarati & Porter, 2009**).**

2.4 Model Specification

2.4.1 Total Factor Productivity (TFP) Model

To achieve stated objective two (ii), Total Factor Productivity Index (TFP) model following Key and Macbride (2003) and Sadiq *et al* (2019) was used. The TFP approach adopted is given as: -

$$TFP = \frac{Y}{TVC} \quad 1$$

$$TFP = \frac{Y}{\sum P_i X_i} \quad 2$$

Where,

Y = Output (Kg),

TVC = Total Variable Cost (₦),

P_i = Unit Price of i^{th} Variable Input (₦), and

X_i = Quantity of i^{th} Variable Input (Kg).

This methodology ignores the role of total fixed cost (TFC) as it does not affect both the profit maximization and the resource use efficiency conditions as the study focused on smallholder farmers. Total fixed cost is constant as it is fixed.

From Cost Theory:

$$AVC = \frac{TVC}{Y} \quad 3$$

Where, AVC = Average Variable Cost in naira (₦)

Therefore, the transpose of AVC will be TFP

$$TFP = \frac{Y}{TVC} = \frac{1}{AVC} \quad 4$$

As such, TFP is the inverse of the AVC. The partial productivity estimate is the marginal products (MP) given as

$$MP = \frac{\Delta TFP}{\Delta X} \quad 5$$

This was used to achieve specific objective two (2)

Resilience Index Measurement and Analysis (RIMA II)

The FAO Resilience Index Measurement and Analysis (RIMA) II was used to analyze the resilience of tomato farmers to climate change in the study area. RIMA II estimates resilience using direct and indirect measurement as well as long and short-term measurement approaches. Direct measurement gives descriptive information on resilience capacity which aims at targeting and ranking households while indirect measurement can be adopted as a predictor tool for intervention that builds and strengthens resilience i.e., it looks at its main determinants.

Resilience Capacity Index (RCI) was estimated using a two-stage Factor Analysis (FA) with Bartlett's prediction technique (Alinovi *et al*., 2010). In the first stage, resilience pillars was estimated through factor analysis of observable variables on each pillar. Following Malhotra (1996), this can be specified as:

$$X_i = A_{i1}F_i + A_{i2}F_i + \cdots + A_{in}F_i \quad 6$$

Where:

X_i = Constructed i-th pillar

A_{in} = n-th component that made up i-th pillar.

F_i= Factor of i-th component

In the second stage, RCI was estimated through factor analysis of the overall pillars by adopting a Structural Equation Model (SEM), and each pillar is considered an observable index. Following Constas *et al.,* (2014):

$$RCI_i = W_iX_1 + W_iX_2 + W_iX_3 + W_iX_4 \quad 7$$

Where:

RCI_i = Resilience Capacity Index of i-th household

W_i = Factor of i-th pillar

X_1 = Access to Basic Service (ABS)

X_2 = Assets (AST)

X_3 = Social Safety Nets (SSN)

X_4 = Adaptive Capacity (AC)

The Resilience Capacity Index (RCI) of the ith household depends on the levels of ABS, AST, SSN, and AC. The following are the variables to be used to construct the pillars:

Table 3.2: Variables used to Construct the Pillars

Pillar	Definition
ABS	**Access to basic services:** proximity to main services, proximity to a water source, safe drinking water, and sanitation.
AST	**Household assets:** per capita land used (ha), financial assets and per capita number of livestock owned.
SSN	**Social Safety Nets:** formal transfers (per capita, Naira), Informal transfers (per capita, Naira), access to credit.
AC	**Adaptive Capacity:** diverse Income portfolio, number of trainings attended by a household, crop diversification index, household head with a university degree.

Source: Nakuja *et al.* (2012)

Following Nakuja *et al.* (2012), farmers was classified into low, moderate, and high resilience capacity based on the computed resilience capacity index.

Table 3.3: Classification of Resilience Capacity Index

Index	Status
0 – 0.33	Low resilience capacity
0.34 – 0.66	Moderate resilience capacity
0.67 – 1.00	High resilience capacity

Source: USAID, 2007

This was used to achieve specific objective two (3)

Tobit model following Sadiq *et al*. (2016) was used to analyze influence of climate change adaptation strategies on total factor productivity of tomato farmers in the study area. Tobit model is stated explicitly as:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \mu_i \quad 8$$

Where,

Y_i = TFP (index)

i = Number of Independent Variables

β_0 = Constant Term

$\beta_1 – \beta_6$ = Regression coefficients

X_1 = Planting of drought resistant varieties of crops (4, Frequently adopted; 3, moderately adopted; 2, rarely adopted; 1, not adopted)

X_2 = Crop diversification (4, Frequently adopted; 3, moderately adopted; 2, rarely adopted; 1, not adopted)

X_3 = Change in cropping pattern and calendar of planting (4, Frequently adopted; 3, moderately adopted; 2, rarely adopted; 1, not adopted)

X_4 = Mixed cropping (4, Frequently adopted; 3, moderately adopted; 2, rarely adopted; 1, not adopted)

X_5 = Improved Irrigation Efficiency (4, Frequently adopted; 3, moderately adopted; 2, rarely adopted; 1, not adopted)

X_6 = Soil Conservation Measures to Conserve Soil Moisture (4, Frequently adopted; 3, moderately adopted; 2, rarely adopted; 1, not adopted)

Ui = Error Term

This was used to achieve specific objective six (vi)

Table 3.5: Unit of Measurements and Apriori Expectation of Explanatory Variables Included in the Tobit Regression Models

Explanatory Variables	Parameter	Variable Code	Unit of Measurements	Expected Sign (Apriori Expectations)
Planting of drought resistant varieties of crops	β_1	X_1	Likert (4, Frequently adopted; 3, moderately adopted; 2, rarely adopted; 1, not adopted)	+
Crop diversification	β_2	X_2	Likert (4, Frequently adopted; 3, moderately adopted; 2, rarely adopted; 1, not adopted)	+
Change in cropping pattern and calendar of planting	β_3	X_3	Likert (4, Frequently adopted; 3, moderately adopted; 2, rarely adopted; 1, not adopted)	+
Mixed cropping	β_4	X_4	Likert (4, Frequently adopted; 3, moderately adopted; 2, rarely adopted; 1, not adopted)	+

Improved Irrigation Efficiency	β_5	X_5	Likert (4, Frequently adopted; 3, moderately adopted; 2, rarely adopted; 1, not adopted)
Soil Conservation Measures to Conserve Soil Moisture	β_6	X_6	Likert (4, Frequently adopted; 3, moderately adopted; 2, rarely adopted; 1, not adopted)

Source: Authors Compilation (2023)

3.0 Results and Discussion

3.1 Perceived Evidence of Climate Variability

The findings revealed that tomato farmers in Nasarawa State perceived flooding resulting from heavy rainfall, erosion, reduction in rainfall duration, low yields due to insufficient rainfall, and rising temperatures as the major indicators of climate variability in the study area. Flooding and erosion emerged as the most frequently reported manifestations of climate variability, suggesting that farmers have experienced increasing environmental disturbances capable of affecting agricultural production and livelihood sustainability. These climatic events have direct implications for tomato production because excessive rainfall and flooding can damage crops, increase nutrient leaching, encourage disease outbreaks, and reduce yield quality, while erosion contributes to the loss of fertile topsoil and soil nutrients essential for crop growth.

The perception of reduced rainfall duration and increasing temperatures further indicates that farmers are experiencing changes in the temporal and spatial distribution of climatic elements. Reduced rainfall duration may shorten the growing season and increase moisture stress, particularly during critical growth stages of tomato production. Similarly, rising temperatures can affect flowering, fruit setting, fruit quality, and overall crop productivity. These findings demonstrate that farmers are highly aware of changes in climatic conditions and their implications for agricultural production.

The results are consistent with the findings of Lema and Majule (2009), Kalungu et al. (2013), and Rahut et al. (2021), who reported that irregular rainfall patterns, increasing temperatures, floods, and droughts constitute major manifestations of climate variability affecting agricultural production in developing countries. Similarly, Gambo et al. (2020) and Sarkingobir and Dikko (2020) observed that climate variability in Nigeria is increasingly characterized by extreme weather events, fluctuating rainfall patterns, and rising temperatures that negatively affect agricultural productivity. The findings also support the observations of Biratu (2018) and Silva et al. (2017), who reported that tomato production is particularly sensitive to temperature fluctuations and irregular rainfall conditions.

From a theoretical perspective, the findings support the Vulnerability Framework, which posits that farming households are highly exposed to climatic shocks due to their dependence on natural environmental conditions. The results imply that climate variability is no longer a perceived future threat but a current reality affecting tomato farmers in Nasarawa State. Consequently, policies aimed at enhancing climate adaptation and resilience are necessary to reduce farmers' vulnerability and sustain agricultural productivity.

3.2 Productivity of Tomato Farmers

The Total Factor Productivity (TFP) analysis revealed that tomato farmers in Nasarawa State achieved an average productivity index of 1.26. Approximately 49.21% of the farmers operated above the optimal productivity threshold, while only 32.98% were classified as sub-optimal producers. These results indicate that, on average, tomato farmers were able to generate output levels that exceeded the combined value of production inputs utilized, suggesting relatively efficient resource utilization despite prevailing climate-related challenges.

The relatively high productivity level may be attributed to farmers' adoption of adaptation strategies, accumulated farming experience, and favourable agroecological conditions within the study area. The findings suggest that although climate variability poses significant risks to agricultural production, farmers have developed mechanisms that enable them to maintain productive farming operations. This

observation indicates that adaptation efforts may have played an important role in reducing the adverse effects of climate variability on tomato production.

The findings corroborate those of Ojo and Baiyegunhi (2020), who found that farmers who adopted climate adaptation measures recorded higher productivity and farm income compared with non-adopters. Similarly, Zakari et al. (2022) reported that adaptation strategies significantly improved agricultural productivity and household welfare among farming households facing climate-related challenges. The results also agree with Bhandari et al. (2021), who observed that climate-smart agricultural practices contribute significantly to maintaining productivity under changing climatic conditions.

However, the fact that approximately one-third of the farmers remained sub-optimal producers suggests that not all farmers possess equal adaptive capacity or access to productive resources. This finding implies that productivity gains are unevenly distributed and may depend on factors such as access to information, assets, extension services, and adaptation technologies. The results therefore support the Sustainable Livelihood Framework, which emphasizes that access to livelihood assets significantly influences productivity and livelihood outcomes among rural households.

3.3 Resilience of Tomato Farmers to Climate Variability

The resilience analysis revealed that 54.97% of tomato farmers exhibited moderate resilience to climate variability, while 45.03% demonstrated low resilience. Notably, no farmer was classified within the high-resilience category. This finding suggests that although farmers have adopted coping and adaptation mechanisms to manage climate-related risks, their ability to withstand severe climatic shocks remains limited.

The absence of highly resilient farmers indicates that tomato-producing households remain vulnerable to extreme weather events and environmental disturbances. Moderate resilience implies that farmers possess some capacity to absorb and recover from climatic shocks; however, their adaptive resources may be insufficient to cope with prolonged or severe climate-related events. This vulnerability may expose households to fluctuations in production, income instability, and food insecurity.

The findings are consistent with those of Rahut et al. (2021), who reported that many smallholder farmers in Sub-Saharan Africa possess limited resilience due to inadequate access to productive assets, climate information, financial services, and institutional support. Similarly, Kalungu et al. (2013) found that limited adaptive capacity significantly constrains farmers' ability to respond effectively to climate variability.

The results further revealed that access to basic services, adaptive capacity, asset ownership, and income diversification contributed significantly to resilience. This finding aligns with the FAO Resilience Index Measurement and Analysis (RIMA II) framework, which identifies these dimensions as critical determinants of household resilience. It also validates the Sustainable Livelihood Framework, which emphasizes that human, social, financial, physical, and natural capital collectively determine households' capacity to withstand shocks and maintain sustainable livelihoods.

The implication of this finding is that enhancing resilience among tomato farmers will require interventions that go beyond agricultural production support to include improved infrastructure, financial inclusion, access to climate information, education, and livelihood diversification opportunities.

3.4 Influence of Climate Variability Adaptation Strategies on Productivity

The Tobit regression results showed that several adaptation strategies significantly influenced tomato productivity in the study area. Crop diversification positively influenced productivity ($\beta = 0.33$, $p < 0.05$), indicating that farmers cultivating multiple crops were better able to spread production risks and reduce vulnerability to climate-induced crop failures. Diversification allows farmers to stabilize income and maintain productivity even when climatic conditions adversely affect a particular crop.

The findings support the work of Zakari et al. (2022) and Rahut et al. (2021), who reported that crop diversification enhances resilience and productivity by reducing farmers' exposure to climate-related risks. The positive effect observed in this study suggests that diversification remains an effective adaptation strategy for tomato farmers facing uncertain climatic conditions.

Changes in cropping patterns and planting dates recorded the strongest positive effect on productivity ($\beta = 0.63$, $p < 0.01$). This finding indicates that farmers who adjusted their production calendars in response to changing rainfall and temperature patterns achieved higher productivity levels than those who maintained traditional planting schedules. The result suggests that flexibility in production decisions enables farmers to better synchronize crop growth with favourable climatic conditions.

This finding corroborates the studies of Sani et al. (2016) and Menikea et al. (2016), who found that adjustments in planting dates constitute one of the most effective adaptation strategies for minimizing the adverse effects of climate variability on crop production. The result further supports the Diffusion of Innovation Theory, which argues that farmers who adopt innovative production practices are more likely to achieve improved productivity outcomes.

Tree planting and agroforestry also exerted a positive and highly significant influence on productivity ($\beta = 0.67$, $p < 0.01$). Agroforestry practices improve soil fertility, enhance moisture retention, reduce erosion, and create favourable microclimatic conditions for crop growth. Consequently, farmers who integrated trees into their farming systems achieved superior productivity outcomes compared with those relying solely on conventional farming methods.

The positive influence of agroforestry agrees with the findings of Bhandari et al. (2021), who reported that ecosystem-based adaptation practices improve agricultural productivity and strengthen resilience to climate variability.

Conversely, soil conservation measures exhibited a negative and significant influence on productivity ($\beta = -0.27$, $p < 0.05$). This unexpected result may indicate that the soil conservation practices adopted by farmers required substantial labour, financial resources, or land adjustments that temporarily reduced productive efficiency. It may also suggest that farmers implemented these measures on degraded or vulnerable plots already experiencing low productivity levels. Similar findings have been reported in some developing-country contexts where the short-term costs of conservation investments outweighed immediate productivity gains.

Overall, the findings demonstrate that adaptation strategies substantially moderate the adverse effects of climate variability on tomato production. Farmers who actively adjusted their production systems through diversification, changes in planting dates, and agroforestry practices achieved significantly higher productivity outcomes than those relying primarily on traditional farming practices. These results affirm the Theory of Change, which posits that adaptation interventions enhance agricultural productivity by reducing vulnerability and strengthening farmers' capacity to respond to climatic challenges. The findings also validate the Sustainable Livelihood Framework by demonstrating that adaptive strategies enhance farmers' ability to utilize available livelihood assets more effectively, thereby improving productivity and resilience under changing climatic conditions.

5. CONCLUSION

This study examined climate variability and its influence on the productivity of tomato farmers in Nasarawa State, Nigeria. The findings revealed that climate variability remains a major challenge affecting tomato production in the study area, as evidenced by the increasing occurrence of flooding, erosion, shortened rainfall duration, inadequate rainfall, and rising temperatures. These climatic conditions have important implications for crop performance, farm productivity, and the livelihoods of tomato-producing households.

Despite these challenges, the study found that tomato farmers maintained a relatively high level of productivity, with an average Total Factor Productivity index of 1.26. However, resilience analysis showed that most farmers possessed only moderate resilience, while a substantial proportion exhibited low resilience, indicating limited capacity to withstand severe climatic shocks. This suggests that although farmers have adopted coping mechanisms, their vulnerability to climate-related risks remains considerable.

The study further established that climate variability adaptation strategies play a critical role in sustaining productivity. Crop diversification, adjustment of cropping patterns and planting dates, and agroforestry

practices significantly enhanced productivity by reducing farmers' exposure to climate-related risks and improving resource-use efficiency. These findings demonstrate that adaptation measures are essential for mitigating the adverse effects of climate variability and improving the sustainability of tomato production. Overall, the study concludes that climate variability significantly influences tomato productivity in Nasarawa State. While farmers have responded through various adaptation strategies, strengthening their adaptive capacity and resilience remains essential for sustaining productivity, improving livelihoods, and ensuring long-term agricultural sustainability under changing climatic conditions.

6. RECOMMENDATIONS

Government and relevant agencies should strengthen climate information services by providing timely and reliable weather forecasts to support farmers' production decisions.

i. Agricultural extension services should intensify the promotion of climate-smart agricultural practices, particularly crop diversification, agroforestry, and adjustment of planting dates.
ii. Investment in irrigation infrastructure should be increased to reduce dependence on rainfall and improve year-round tomato production.
iii. Programmes aimed at enhancing farmers' resilience should focus on improving access to productive assets, agricultural finance, and climate adaptation technologies.
iv. Climate change adaptation measures should be integrated into agricultural development policies and tomato value chain programmes to ensure sustainable productivity and livelihood improvement among tomato farmers.

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