

Perceived effects of climate change on tomato production in selected local government areas of Ondo state, Nigeria

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ABSTRACT

The study examined the perceived effects of climate change on tomato production in selected Local Government Areas (LGAs) of Ondo State, Nigeria. A total of 126 tomato farmers were randomly sampled from six communities. Data were garnered using an interview schedule and were analysed using frequency, percentage, mean, and Pearson Product Moment Correlation. Tomato farmers were aged 39.56 ± 8.33 years, males (87.3%), married (54.8%), formally educated (82.6%), and had a household size of 6.02 ± 2.27 persons. Farming experience was 5.46 ± 3.53 years, farm size was 4.44 ± 3.28 acres, 54.0% cultivated local varieties, 46.0% cultivated improved varieties, and 61.1% had access to credit. The average quantity of tomatoes sold in 2022 was $23,860.56 \pm 8,812.12$ kg, and the average income from tomato sales was ₦ $6,445,269.84 \pm 2,393,836.26$. Major information sources were radio ($\bar{x}=1.54$), internet ($\bar{x}=1.54$), television ($\bar{x}=1.41$), and relations/family ($\bar{x}=1.39$). Farmers' knowledge of deforestation ($\bar{x}=1.56$), pesticide use ($\bar{x}=1.32$), soil erosion ($\bar{x}=1.31$), fertiliser use ($\bar{x}=1.25$), greenhouse gas emissions ($\bar{x}=1.25$), and temperature fluctuations ($\bar{x}=1.21$) as the major causes and effects of climate change was highest. Severe climate change effects include temperature fluctuations ($\bar{x}=1.56$), changes in soil fertility ($\bar{x}=1.26$), decreased fruit quality ($\bar{x}=1.18$), and changes in rainfall patterns ($\bar{x}=1.15$). There was a significant relationship between the quantity of tomatoes lost ($r=0.194$, $p=0.030$), information source ($r=0.336$, $p=0.000$), knowledge ($r=0.504$, $p=0.000$) and the perceived effects of climate change. Tomato farmers need government education programs on how to combat the various effects of climate change and improved access to climate change information.

Keywords: Climate change, Perceived effects, Tomato quantity, Information sources

INTRODUCTION

The menace of climate change continually threatens the sustainable development of socioeconomic activities and, more importantly, agricultural development and sustainability. Agriculture in Africa is rain-fed and the most vulnerable sector to climate change. The farm sector supplies food and raw materials to the industries, provides income and employment, and generates foreign earnings. This is crucial to the economy of any nation, particularly Nigeria. Despite the importance of the agricultural sector, it faces numerous challenges, including climate change, which affects farmers at every level of agricultural production on the farm.

Climate change connotes shifts in the frequency and magnitude of sporadic weather events. Climate refers to the average weather, in terms of both mean and variability, over a specific period and area (Baede *et al.*, 2018). Climate change can manifest in several ways including but not limited to changes in average climatic conditions, in such a way that an area can be drier or wetter, with changes in climatic variability like erratic rainfall, changes in the frequency and magnitude of extreme weather events, sunshine, temperature, relative humidity, and extreme drought. In Nigeria, shreds of evidence of climate change, including rising temperatures, irregular rainfall patterns, increasing sea levels, dwindling freshwater

supplies, flooding, land degradation, drought, desertification, increased extreme weather events, and a decline in biodiversity (Awiti, 2022; Okon *et al.*, 2021).

Hence, climate change is expected to seriously threaten Nigeria's environment, agricultural production and food security. The effects of climate change on farmers and agriculture, in particular, could be relatively more severe on crops if adaptive strategies are not in place to cushion the effects of the changes on farm crops. Climate change has been a topical issue in the sustainability of the environment as crop yield and production become very important to the economy and human livelihoods (Piya *et al.*, 2012). Agricultural production in Nigeria is weather-dependent, and climate variability and change have a direct effect, often an adverse influence on the quantity and quality of agricultural yield in Nigeria. A report by Raza *et al.* (2019) submits that climate change affects crop production through direct, indirect, and socio-economic effects.

Various crops are grown in the rural areas of Nigeria in a characteristic pattern that is responsive to local climatic conditions. Notably among the crops grown in Nigeria are fruit vegetables such as tomatoes. Tomato (*Lycopersicum esculentum*), being a vegetable, is in a group of specialised crops and is important economically from a health point of view. It

is an essential component of every Nigerian family meal and an important source of minerals, proteins, vitamins, and energy. According to Onyeneke *et al.* (2023), tomatoes are the main dietary source of the antioxidant lycopene, which has been linked to several health benefits, like a lower risk of heart disease and cancer. Tomato production is a good source of income and employment and a means of livelihood in the rural areas of Nigeria and even urban centres. One of the biggest challenges facing tomato farmers in rural areas has been the response of tomatoes to climate change. The production of tomatoes in rural areas suffers from diverse problems such as temperature fluctuations, irregular rainfall, topographic features, poor soil nutrients and other climatic conditions. The production of tomatoes is susceptible to climatic variations, which can adversely affect their production. Heavy rainfall and high humidity do great harm to the tomato plants.

According to Onyeneke *et al.* (2023), climate change effects such as changing temperatures adversely affect tomato yields both in the short and long runs. Likewise, Olubango & Alade (2018) established that climate variability affects the yield of tomatoes in Ondo State, Nigeria. The perspectives of tomato farmers on the effects of climate change on tomato production are crucial for agricultural growth, food security, and people's livelihood in Ondo State, Nigeria. It is important to empirically determine if tomato farmers had access to climate-related information to help in navigating climate-related challenges in tomato farming. This research added more insights to existing studies as it provided empirical evidence on the current effects of climate change experienced in tomato production in Ondo State, Nigeria. Hence, it stresses the importance of addressing the issue of climate change by developing strategies to mitigate the impact of climate change on tomato farming. This study specifically determined tomato farmers' personal and enterprise characteristics, income and quantity of tomato produced, sources of climate change information, and the knowledge of the causes and effects of climate change.

METHODOLOGY

The study was conducted in Ondo State, Nigeria. The state covers a land area of about 15,500 square kilometres and has GPS coordinates of 7° 6' 0.0180" N and 4° 50' 30.0984" E. The State has 18 Local Government Areas (LGAs) and is known for its fertile soil and favourable climate, which has made it an agricultural hub in the southwest region of Nigeria. The population for the study consists of tomato farmers in Ondo State, Nigeria.

Three local government areas (LGAs) namely Akure South, Owo and Ose LGAs were purposively selected based on the prominence of these LGAs in tomato farming activities. Two communities notable for tomato production were purposively selected in each LGA to make a total of six communities. Emure and Ago-Paanu communities were selected in Owo LGA, Ago-Ajayi and Ose-Oba communities in Ose LGA, Oda and Okearo communities in Akure South LGA. From the list of tomato farmers obtained from respective LGAs, 50% of tomato farmers were randomly sampled from Emure (20), Ago-Paanu (41), Ago-Ajayi (20), Ose-Oba (19), Oda (18) and Okearo (8) communities. A total of one hundred and twenty-six (126) tomato farmers were sampled for the study. Data was collected with the aid of a structured interview schedule.

The data on tomato production for the year 2022 was garnered as the quantity of tomatoes produced. The quantity of tomatoes produced was determined in crates and thereafter converted to the equivalent kilogram. A crate of tomatoes weighs an average of 35kg; this was used to compute the quantity of tomatoes produced for each farmer. The study determined the quantity of tomatoes harvested, quantity sold, quantity consumed, quantity given out, quantity not sold, and quantity lost for the year 2022. Tomato farmers indicated the price/crate of tomatoes sold in 2022, and this was used to compute the income realised from tomato production. The quantity of tomatoes not sold in this study simply referred to harvested tomatoes that are in good condition but have not yet been sold as of the time of data collection. The quantity of lost tomatoes refers to tomatoes that were not sold at the time of data collection as a result of pest and disease infestation, decay, theft, among others. These tomatoes were waste, unsellable and unusable. Climate change information sources were measured on a 3-point scale of always, sometimes and not at all, with scores of 2, 1 and 0 assigned, respectively. Tomato farmers' knowledge of the causes and effects of climate change was measured on a 3-point scale of to a larger extent, to a lesser extent and not a cause, with scores of 2, 1 and 0 assigned, respectively. The mean value for each item was computed and used to rank farmers' knowledge items. The perceived effects of climate change on tomato production were measured on a 3-point scale of major effect, minor effect and not an effect, with scores of 2, 1 and 0 assigned, respectively. The perceived effect score for each tomato farmer was computed. The minimum score was 12, and the maximum score was 26. The average perceived effect score was calculated and used to categorise tomato farmers as either perceiving the effects of climate change on tomato production to be high (for those with scores equal to or above the mean score) or low (for those with scores below the mean score). The mean value for each item was computed

and used to rank perceived effect items in order of severity. Descriptive statistics such as frequency, percentage and means were used for data analysis. The inferential statistics used for hypothesis testing was Pearson Product Moment Correlation.

RESULTS AND DISCUSSION

Personal characteristics of tomato farmers

Table 1 presents the distribution of the tomato farmers based on their personal characteristics. Most tomato farmers were male (87.3%), implying that tomato production in the study area was male-dominated. This result aligns with previous research by Obot *et al.* (2022), who found that males constitute the larger percentage of small-scale farmers in Anambra State, Nigeria. Most of the tomato farmers were less than 41 years in age (53.9.0%) with an average age of 39.56 ± 8.33 years, indicating that productive and active individuals dominate tomato production in the study area. This corroborates the findings of Obot & Obiekwe (2022) that young people of economically productive age dominated the agricultural activities in Akwa Ibom State, Nigeria. Over half of the tomato

farmers were married (54.8%), and 23.0% were singles. Similarly, Adeagbo, Ojo & Adetoro (2021) reported a high percentage of married farmers among smallholder farmers in Southwest, Nigeria. A significant proportion of the tomato farmers had completed primary (32.9%), secondary (29.4%), and tertiary (20.3%) education. This indicates that the majority of the tomato farmers are formally educated. Similarly, study by Olabanji *et al.* (2021) on smallholder farmers' perception and adaptation response to climate change found that most farmers had at least primary education. The average household size was 6.02 ± 2.27 years, with 53.2% having 5-7 members in their households. This was close to the average household size of 7.5 reported among tomato farmers in Nasarawa State, Nigeria (Onuk, Girei & Amfani-Joe, 2018). Tomato farmers were primarily crop farmers (26.2%), agro-dealers (23.0%), traders (17.5%), and livestock farmers (15.9%). The results imply that about 70.0% of the farmers engaged in tomato production as a secondary occupation or side hustle. This is at variance with Ngbede *et al.* (2021) who reported tomato production as the major occupation of smallholder tomato farmers sampled in Benue State, Nigeria.

Table 1: Distribution of tomato farmers based on their personal characteristics

Personal Characteristics	Frequency	Percentage	Mean $\pm$ S.D
Sex			
Male	110	87.3	
Female	16	12.7	
Age (years)			
< 31	25	19.8	
31-40	43	34.1	
41-50	49	38.9	39.56 ± 8.33
51-60	9	7.1	
Marital status			
Single	29	23.0	
Married	69	54.8	
Widowed/widower	5	4.0	
Divorced	9	7.1	
Separated	14	11.1	
Level of education			
No formal education	27	21.4	
Primary education	44	34.9	
Secondary education	37	29.4	
Tertiary education	18	14.3	
Household size			
2-4	30	23.8	
5-7	67	53.2	6.02 ± 2.27
> 7	29	23.0	
Primary occupation			
Crop farming	33	26.2	
Livestock farming	20	15.9	
Agro-dealer	29	23.0	
Trading	22	17.5	
Artisan	16	12.7	
Civil servant	6	4.8	

Source: Field survey, 2023

Enterprise characteristics of tomato farmers

The result in Table 2 shows the distribution of tomato farmers based on their enterprise characteristics. The average year of farming experience in tomato farming was 5.46 ± 3.53 years, with the majority having 2-5 years of experience. This implies that most of the tomato farmers are relatively new to tomato farming. Hence, adaptation to climate change may require tailored strategies and support for novice farmers. The tomato farming experience obtained in this study does not align with Ngbede *et al.* (2021), who reported majority have 11-15 years of experience (86.7%) in tomato production among smallholder tomato farmers sampled in Benue State, Nigeria. The average farm size was 5.07 ± 3.93 acres. Farm sizes could influence the feasibility and effectiveness of different climate adaptation approaches (Jha and Gupta, 2021). The average farm size cultivated for tomatoes was 4.44 ± 3.28 acres, indicating small farm holdings for tomato production in the study area. This aligns with Ngbede *et al.* (2021), who reported that tomatoes were cultivated on a small scale in Benue State, Nigeria. It was found that tomato farmers in the study area cultivate either a local variety (54.0%) or an improved variety (46.0%). The tomato species cultivated by farmers were cherry (30.2%), Roma (29.4%), beefsteak (19.8%), and plum tomatoes (18.3%). The diversity of tomato species grown may play a role in the resilience of tomato farming in the face of climate challenges, as different varieties may exhibit varying levels of tolerance to climate-related stressors. The tomato cropping system was mostly mixed cropping (70.6%), but 29.4% practiced sole cropping. This corroborates Ogunwande (2024) that mixed cropping is a common practice among small-scale farmers in

Nigeria. However, the result is at variance with Ddamulira *et al.* (2021) who reported that most tomato farmers (78.4%) sampled in Uganda use a sole cropping system.

Furthermore, most tomato farmers in the study area used irrigation for tomato cultivation. The irrigation types used were drip (27.0%), sprinkler (42.9%), and flood (18.3%) irrigation. This aligns with the submission of Danso-Abbeam *et al.* (2021) that smallholder farmers in Nigeria are increasingly using irrigation to address the negative effects of climate change. Similarly, Akinagbe & Irohibe (2014) reported that farmers tend to irrigate often as temperature increases. Most of the farmers cultivated tomatoes twice a year (65.9%), while some cultivated only once a year (34.1%). A large percentage of the farmers were members of farmers' groups or cooperatives (75.4%). Membership in farmers' groups or cooperatives is an avenue to be abreast of information on climate change. The major sources of labour were family (42.9%) and friends (29.4%). This indicates that a large proportion of the respondents used family labour for their farming activities. This does not align with the study of Ngbede *et al.* (2021) where most smallholder tomato farmers (78.3%) relied on the use of family members for their tomato production. The sources of land used for farming include bought land (20.6%), inherited land (19.8%), rented land (15.1%), family-owned land (23.0%), and communal land (12.7%). About 60.0% had access to credit from sources such as cooperatives (20.6%), non-governmental organisations (15.1%), friends (15.1%), microfinance (14.3%) and 'ajo' (10.3%). The marketing outlets used were farm gate (44.4%), rural market (34.9%), and urban market (19.0%).

Table 2: Distribution of tomato farmers based on their enterprise characteristics

Variables	Frequency	Percentage	Mean±SD
Tomato farming experience in years			
2-5	96	76.2	5.46±3.53
6-9	15	11.9	
> 9	15	11.9	
Tomato farm size(acres)			
1.00-4.00	84	66.7	4.44±3.28
4.01-8.00	34	27.0	
>8.00	8	6.3	
Variety of tomatoes cultivated			
Local variety	68	54.0	46.0
Improved variety	58	46.0	
Tomato species cultivated			
Cherry tomatoes	38	30.2	18.3
Roma tomatoes	37	29.4	
Beefsteak tomatoes	25	19.8	
Plum tomatoes	23	18.3	
Tomato cropping system			
Mixed cropping	89	70.6	29.4
Sole cropping	37	29.4	

Variables	Frequency	Percentage	Mean±SD
Irrigation type			
Drip irrigation	34	27.0	
Sprinkler irrigation	54	42.9	
Flood irrigation	23	18.3	
Number of times tomatoes are cultivated in a year			
Once	43	34.1	
Twice	83	65.9	
Membership in farmers' groups or Cooperatives	95	75.4	
Source of labour			
Family	54	42.9	
Friends	37	29.4	
Hired	25	19.8	
Sources of land			
Bought	26	20.6	
Inherited	25	19.8	
Rent	19	15.1	
Family	29	23.0	
Communal	16	12.7	
Gift	13	10.3	
Access to credit			
Yes	77	61.1	
Source of credit			
Personal savings	9	7.1	
Friends	19	15.1	
Family	3	2.4	
NGO	19	15.1	
A particular Individual	15	11.9	
Ajo	13	10.3	
Cooperative	26	20.6	
Microfinance	18	14.3	
Commercial bank	6	4.8	
Marketing outlets			
Farm gate	56	44.4	
Rural market	44	34.9	
Urban market	24	19.0	

Source: Field survey, 2023

Tomato production in 2022 and income realised

Table 3 shows that the average price per crate of tomato in 2022 was ₦9,444.44±202.21. The average quantity of tomatoes harvested was 713.42±252.310 crates (25,060.10±8,884.77 kg). The average quantity of tomatoes sold was 681.73±251.78 crates (23,860.56±8,812.12 kg). The result resonates with the role of market access and opportunities in influencing the quantity of tomatoes sold. The quantity of tomatoes sold can vary widely depending on factors such as market access and market demand. The average income realised from tomato production was ₦6,445,269.84±2,393,836.26. This suggests that tomato farmers in the study area engaged in substantial tomato sales. The result is at variance with the income levels obtained by Akingba *et al.* (2022) among crop farmers engaging in small-scale farming practices in Edo North, Edo State, Nigeria, where most of the farmers reportedly realised a monthly income of less than ₦61,000.00. The average quantity of tomatoes

consumed was 7.86±7.71 crates (275.20±269.83 kg). The average quantity consumed reflects the dietary importance of tomato among farmers. Tomatoes are a significant component of the local diet and are often consumed by farming households. The average quantity of tomatoes given out was 5.29±4.11 crates (183.93±142.74 kg). The practice of giving out tomatoes may be related to customary sharing among community people. The average quantity of unsold tomatoes was 32.15±116.85 crates (1125.36±1089.77 kg). The quantity of tomatoes that were yet to be sold could be attributed to various factors, including fresh harvest, market access, lack of storage facilities, and other market dynamics. The average quantity of tomatoes lost was 42.52±116.90 crates (1488.06±4091.50 kg). Tomato losses can be attributed to factors such as poor post-harvest handling, transportation-associated constraints, theft and other market conditions. The monetary value of the quantity of tomatoes lost was ₦394,067.46±376,520.98.

Table 3: Tomato production and income realised in 2022

Variables	N	Minimum	Maximum	Mean	Std. Dev
Price/Crate	126	9000	10000	9444.44	202.21
Crates					
Quantity harvested (in crates)	126	240	1340	713.42	252.31
Quantity sold (in crates)	126	200	1309	681.73	251.78
Quantity consumed (in crates)	124	1	40	7.86	7.71
Quantity given out (in crates)	75	1	20	5.29	4.11
Quantity not sold (in crates)	124	1	720	32.15	116.85
Quantity lost (in crates)	126	1	710	42.52	116.90
Kilograms					
Quantity harvested (in kg)	126	8400	46900	25060.10	8884.77
Quantity sold (in kg)	126	7000.00	45815.00	23860.56	8812.12
Quantity consumed (in kg)	124	35	1400	275.20	269.83
Quantity given out (in kg)	75	35	700	183.93	142.74
Quantity not sold (in kg)	124	35	25200	1125.36	1089.77
Quantity lost (in kg)	126	35	24850	1488.06	1091.50
Monetary value (₦)					
Quantity harvested (in naira)	126	2280000.00	12730000.00	6736468.25	2390978.43
Quantity sold (in naira)	126	1900000	12435500	6445269.84	2393836.26
Quantity consumed in naira	124	9500	360000	73516.13	70527.92
Quantity given out (in naira)	75	9500	190000	49660.00	38406.45
Quantity not sold (in nara)	124	9500	6840000	315479.84	276466.42
Quantity lost (in naira)	126	9500	6745000	394067.46	376520.98

Source: Field survey, 2023

Climate change information sources

Table 4 presents data on the sources of climate change information used by tomato farmers. Radio ($\bar{x}=1.54$) and the internet ($\bar{x}=1.54$) were the foremost sources of climate change information. This result underscores the significance of radio and internet devices as primary media for disseminating climate-related knowledge to rural communities. Similarly, Salisu, Danwanka & Hassan (2024) established the prominent use of radio among crop farmers in Bauchi State,

Nigeria. The use of the internet implies the increased use of mobile phones in sourcing climate change information. This is consistent with previous research that established increased use of mobile phones in accessing information among rural people (Salisu, Danwanka, & Hassan, 2024; Aker & Mbiti, 2010). The use of radio and the internet was followed by television ($\bar{x}=1.41$), relations/family ($\bar{x}=1.39$), social media ($\bar{x}=1.35$), and friends ($\bar{x}=1.33$).

Table 4: Distribution of the tomato farmers based on their climate change information sources

Sources of information	Mean	Std. Dev.	Rank
Radio	1.54	0.52	1 st
Internet (Email)	1.54	0.60	1 st
Television	1.41	0.58	2 nd
Relations/family	1.38	0.71	3 rd
Social media	1.35	0.60	4 th
Friends	1.33	0.58	5 th
Publications	1.14	0.77	6 th
International research organizations	1.06	0.85	7 th
Historical events	1.05	0.76	7 th
Government agricultural extension services	1.04	0.80	8 th
Newspaper	1.04	0.72	8 th
Agricultural weather apps	0.99	0.76	9 th
Local agricultural cooperatives/groups	0.98	0.79	10 th
Research institutions	0.97	0.77	11 th
Non-governmental organizations	0.91	0.81	12 th
Weather websites apps	0.86	0.77	13 th

Source: Field survey, 2023

Knowledge of the causes and effects of climate change

The result in Table 5 shows that tomato farmers' knowledge of deforestation ($\bar{x}=1.56$) as the cause of climate change was the highest. This implies a strong consensus among tomato farmers on the pivotal role of deforestation in driving climate change, underscoring the pressing need to tackle this issue within the country. This result aligns with Madaki *et al.* (2023) that most farmers knew the detrimental effects of deforestation on the environment and climate in Nigeria. Additionally, findings from this study reveal that tomato farmers had high knowledge that pesticide use ($\bar{x}=1.32$), fertiliser use ($\bar{x}=1.25$), and greenhouse gas emissions ($\bar{x}=1.25$) are parts of the causes of climate change. Also, tomato farmers had knowledge that soil erosion ($\bar{x}=1.31$) and temperature fluctuations ($\bar{x}=1.21$) are parts of climate change effects. These aforementioned variables were known by tomato farmers as major contributors and effects of

climate change, which decreases the fertility of soils, soil nutrients, water availability and crop yield. Tomato farmers' knowledge of the causes of climate change is a function of their awareness that the climate is changing. Tajudeen *et al.* (2022) affirm a high level of awareness of climate change among crop farmers in Lagos State, Nigeria. Their study also established that crop farmers agreed there had been changes in temperature, rainfall patterns, pest infestation, disease outbreaks, flooding, drought, and soil erosion due to climate change. Also, tomato farmers had knowledge that intensive farming practices ($\bar{x}=1.13$) contributed to climate change. This highlights the significance of agricultural practices in contributing to climate change. The result of this study aligns with the submission of the United States Environmental Protection Agency (2024) that the agriculture industry releases greenhouse gases into the atmosphere, which fuels climate change.

Table 5: Distribution of tomato farmers based on their knowledge of the causes and effects of climate change

Indicators	Mean	Std. Dev.	Rank
Causes			
Deforestation	1.56	0.65	1 st
Pesticide use	1.32	0.71	2 nd
Greenhouse gas emission	1.25	0.70	4 th
Fertiliser use	1.25	0.81	4 th
Intensive farming practices	1.13	0.78	4 th
Bush burning	1.13	0.83	4 th
Poor waste management	1.10	0.77	5 th
Industrial activities	1.09	0.74	6 th
Livestock emission	1.06	0.77	7 th
Natural processes	1.10	0.74	5 th
Effects			
Temperature fluctuations	1.21	0.81	3 rd
Soil erosion	1.31	0.74	3 rd
Heatwaves	1.06	0.85	7 th
Extreme weather event	0.90	0.70	8 th
Loss of biodiversity	0.89	0.75	9 th
Pollinator disruption	0.89	0.81	9 th

Source: Field survey, 2023

Perceived effects of climate change on tomato production

The results in Table 6 show that the most pronounced effect of climate change is fluctuations in temperature ($\bar{x}=1.56$). Findings from this study suggest that tomato farmers are increasingly concerned about the erratic temperature patterns affecting their crop yield. This result supports previous studies that established the negative effects of temperature variations on tomato production (Onyeneke *et al.* 2023; Ayankojo & Morgan, 2020). With climate change leading to more frequent and extreme temperature fluctuations, adaptation strategies such as improved crop varieties

and irrigation methods are essential to mitigate these impacts. Gowda *et al.* (2018) noted that changes in temperature and precipitation will also probably increase the frequency and range of weeds and insects. Tomato farmers attest that they experienced changes in soil fertility ($\bar{x}=1.26$) due to climate change. Soil fertility is a critical factor in agricultural productivity. Tomato farmers recognised the significance of preserving soil fertility in the face of climate change. Findings from this align with Tajudeen *et al.* (2022), who established that climate change effects such as decreased crop yield, reduced soil fertility, water scarcity, increasing soil erosion, and the spread of pests negatively affect crop productivity. Climate

change effects, such as poor fruit quality ($\bar{x}=1.18$), were attested to by most (74.7%) tomato farmers. Decreased fruit quality affects tomatoes' marketability and consumer satisfaction. Also, most of the tomato farmers experienced changes in rainfall patterns ($\bar{x}=1.15$), loss of genetic diversity ($\bar{x}=1.13$), shift in plant phenology ($\bar{x}=1.10$), altered nutrient availability ($\bar{x}=1.07$), increased frequency of extreme weather events ($\bar{x}=1.07$), pest and disease outbreak ($\bar{x}=1.06$), reduced crop yield ($\bar{x}=1.06$) and water scarcity ($\bar{x}=1.00$). Chukwuone & Amaechina (2021) also reported evidence of climate change among smallholder farmers, including delays in the onset of rains, too much rainfall, higher temperatures, and erratic rainfall patterns. The result of altered nutrient availability indicates the importance of nutrient management in sustainable tomato farming. Tomato farmers experienced a shift in plant phenology due to climate change. Plant phenology refers to the timing of plant development stages, and changes in phenology can impact crop yields. The loss of genetic diversity is a major climate change effect among tomato farmers. The result of this study aligns with the submission of the United States Environmental

Protection Agency (2024) that heavy rainfall is expected to occur more frequently due to climate change, which might be detrimental to crops by eroding soil and depleting soil nutrients. Also, the results of this study corroborate Akingba *et al.* (2022), who identified climate change effects on crop production to include poor quality and quantity of yield, washing away of valuable nutrients, increased disease outbreaks, frequent pest attacks and increased heat stress. Surprisingly, economic impacts ($\bar{x}=0.95$) were the least ranked perceived effect of climate change among tomato farmers. This aligns with a previous report in this study that established that some tomato farmers realised a good income from tomato sales. Nevertheless, some tomato farmers faced economic challenges due to climate change. Furthermore, the result in Table 7 shows that 54.8% of tomato farmers perceive the effects of climate change on tomato production to be low, while 45.2% perceive the effects to be high. The result implies that farmers experienced the effects of climate change on tomato production at varying degrees. Thus, the perception of these effects is not the same for farmers.

Table 6: Perceived effects of climate change on tomato production

Effects	Major Effect	Minor Effect	Not an Effect	Mean	Std. Dev.	Rank
Temperature fluctuations	63.5	29.4	7.1	1.56	0.63	1 st
Changes in soil fertility	46.0	34.1	19.8	1.26	0.77	2 nd
Decreased fruit quality	43.7	31.0	25.4	1.18	0.81	3 rd
Changes in rainfall patterns	36.5	42.1	21.4	1.15	0.75	4 th
Loss of genetic diversity	33.3	46.0	20.6	1.13	0.73	5 th
Shifts in plant phenology	37.3	34.9	27.8	1.10	0.80	6 th
Altered nutrient availability	34.1	38.9	27.0	1.07	0.78	7 th
Increased frequency of extreme weather events	31.7	43.7	24.6	1.07	0.75	7 th
Pest and diseases outbreak	33.3	38.9	27.8	1.06	0.78	8 th
Reduced crop yields	38.1	30.2	31.7	1.06	0.84	8 th
Water scarcity	31.7	36.5	31.7	1.00	0.80	9 th
Changes in growing seasons	34.1	30.2	35.7	0.98	0.84	10 th
Changes in CO ₂ concentrations	29.4	39.7	31.0	0.98	0.78	11 th
Shifts in weed distribution	30.2	35.7	34.1	0.96	0.80	12 th
Economic impacts	27.0	41.3	31.7	0.95	0.77	13 th

Source: Field survey, 2023

Table 7: Categorisation of tomato farmers based on the perceived effects of climate change on tomato production

Category	Frequency	Percent	Minimum	Maximum	Mean	SDev.
Low (12.00 - 16.51)	69	54.8	12.00	26.00	16.52	2.53
High (16.52 - 26.00)	57	45.2				

Source: Field survey, 2023

Hypotheses testing

Table 8 shows the results of the relationship between the quantity of tomatoes harvested, the quantity of tomatoes lost, the information source, knowledge, the

causes of climate change and perceived climate change effects. The results of the inferential statistics show that there was no significant relationship between the quantity of tomatoes produced and the perceived effects of climate change ($r=-0.080$,

$p=0.375$). However, a significant relationship exists between the quantity of tomatoes lost and the perceived effects of climate change on tomato production ($r=0.194$, $p=0.030$). The relationship was significant and in a positive direction, implying that tomato farmers who experienced increased loss of tomato fruits were those who perceived the effects of climate change on tomato production to be severe. The relationship between climate change information sources and the perceived effects of climate change on tomato production ($r=0.336$, $p=0.000$) was significant. The result indicates that tomato farmers who perceived

climate change effects on tomato production to be high were those who sought climate change information more. Also, a significant relationship exists between tomato farmers' knowledge of climate change and the perceived effects of climate change ($r=0.504$, $p=0.000$). The result indicates that as knowledge of climate change increases, the perceived effects of climate change increase. Thus, increased knowledge of tomato farmers does not translate to a reduction in the severity of the climate change effects experienced by tomato farmers.

Table 8: PPMC analysis between selected independent variables and climate change perceived effects

Variable	r-value	p-value	Decision
Quantity harvested	-0.080	0.375	Not Significant
Quantity of tomato lost and climate change effects	0.194*	0.030	Significant
Information source	0.336**	0.000	Significant
Knowledge of the causes of climate change	0.504**	0.000	Significant

*Significant at 5%; **Significant at 1%

Source: Field Survey, 2023

CONCLUSION AND RECOMMENDATIONS

Tomato farmers knew the various drivers of climate change. Climate change has various effects on tomato production in the study area. Temperature fluctuation was the most severe effect of climate change experienced by tomato farmers. Tomato farmers made a good income from tomato sales, even though the years of involvement in tomato production were few. The involvement of young people, especially males, was evident in the study area. The study concluded that tomato production can still be a thriving enterprise in the study area despite the effects of climate change. The study recommends that extension agents should promote and provide support for sustainable farming practices in tomato production. Government and NGOs should organise comprehensive climate education programs tailored to the specific needs of tomato farmers on how to combat the various effects of climate change in Ondo State, Nigeria. Also, there is a need for the government and NGOs to enhance timely access of tomato farmers to climate change information.

REFERENCES

- Adeagbo, O. A., Ojo, T. O., & Adetoro, A. A. (2021). Understanding the determinants of climate change adaptation strategies among smallholder maize farmers in South-west, Nigeria. *Heliyon*, 7(2), e06231. <https://doi.org/10.1016/j.heliyon.2021.e06231>
- Akingba, O. O., Olubanjo, O. O., Emeribe, C. N., Ibanga, O. A., & Alade, A. E. (2022). Perceived evidence of climate change and effects on smallholders' farming practices in Edo North, Edo State, Nigeria. *American Journal of Water Resources*, 10(2), 35-45. <https://doi.org/10.12691/ajwr-10-2-1>
- Akinagbe, O. M., & Irohibe, I. J. (2014). Agricultural adaptation strategies to climate change impacts in Africa: A review. *Bangladesh Journal of Agricultural Research*, 39(3), 407-418. <https://doi.org/10.3329/bjar.v39i3.21984>
- Awiti, A. O. (2022). Climate change and gender in Africa: A review of impact and gender-responsive solutions. *Frontiers in Climate*, 4, 895950. <https://doi.org/10.3389/fclim.2022.895950>
- Ayankajo, I. T., & Morgan, K. T. (2020). Increasing air temperatures and its effects on growth and productivity of tomato in South Florida. *Plants (Basel)*, 9(9), 1245. <https://doi.org/10.3390/plants9091245>
- Baede, A. P. M., Ahlonsou, E., Ding, Y., & Schimel, D. (2018). The climate system: An overview. *IPCC Special Report*. <https://www.ipcc.ch/site/assets/uploads/2018/03/TAR-01.pdf>
- Chukwuone, N. A., & Amaechina, E. C. (2021). Factors affecting climate change coping strategies used by smallholder farmers under root crop farming systems in derived savannah ecology zone of Nigeria. *Environmental Development*, 39, 100627.

- <https://doi.org/10.1016/j.envdev.2021.100627>
- Danso-Abbeam, G., Ojo, T. O., Baiyegunhi, L. J. S., & Ogundeji, A. A. (2021). Climate change adaptation strategies by smallholder farmers in Nigeria: Does non-farm employment play any role? *Heliyon*, 7, e07162. <https://doi.org/10.1016/j.heliyon.2021.e07162>
- Ddamulira, G., Isaac, O., Kiryowa, M., Akullo, R., Ajero, M., Logoose, M., Otim, A., Mundingotto, J., Matovu, M., & Ramathan, I. (2021). Practices and constraints of tomato production among smallholder farmers in Uganda. *African Journal of Food Agriculture Nutrition and Development*, 21(2), 17560-17580. <https://doi.org/10.18697/ajfand.97.19905>
- Gowda, P. H., Steiner, J. L., Grusak, M. A., Boggess, M. V., & Farrigan, T. (2018). Agriculture and rural communities. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* (Reidmiller, D. R., Avery, C. W., Easterling, D. R., Kunkel, K. E., Lewis, K. L. M., Maycock, T. K., & Stewart, B. C. (Eds.), pp. 391-437). U.S. Global Change Research Program. <https://doi.org/10.7930/NCA4.2018.CH10>
- Jha, C. K., & Gupta, V. (2021). Farmers' perception and factors determining the adaptation decisions to cope with climate change: Evidence from rural India. *Environmental and Sustainability Indicators*, 10, 100112. <https://doi.org/10.1016/j.indic.2021.100112>
- Madaki, M. Y., Muench, S., Kaechele, H., & Bavorova, M. (2023). Climate change knowledge and perception among farming households in Nigeria. *Climate*, 11(6), 115. <https://doi.org/10.3390/cli11060115>
- Ngbede, S. O., Igbegwu, F. C., Nwankwo, E. N., & Okpara, S. C. (2021). Socio-economic characteristics and production constraints of smallholder tomato production in Benue State, Nigeria. *Nigerian Journal of Horticultural Science*, 26(1), 58-67. https://hortson.org.ng/images/Journals/2021Volume/Ngbede_et_al_2021_compressed.pdf
- Obot, A., & Obiekwe, N. (2022). Climate adaptive measures among smallholder farmers in Akwa Ibom State, Nigeria. *American Journal of Agricultural and Biological Sciences*, 17, 58-64. <https://thescipub.com/pdf/ajabssp.2022.58.64.pdf>
- Obot, A., Okeke, C., Precious, C., & Onuoha, F. (2022). Factors influencing the adoption of FARO-44 rice among smallholder farmers in Anambra State, Nigeria. *Canadian Journal of Agriculture and Crops*, 7(1), 30-37.
- Ogunwande, I. O. (2024). Factors affecting the adoption of cropping systems among arable crop farmers in Southwest Nigeria. *Nigerian Journal of Horticultural Science*, 28(1), 1-9. https://hortson.org.ng/images/Journals/2024Volume/Ogunwande_2024_compressed.pdf
- Okon, E. M., Falana, B. M., Solaja, S. O., Yakubu, S. O., Alabi, O. O., Okikiola, B. T., Awe, T. E., Adesina, B. T., Tokula, B. E., Kipchumba, A. K., & Edeme, A. B. (2021). Systematic review of climate change impact research in Nigeria: Implications for sustainable development. *Heliyon*, 7(9), e07941. <https://doi.org/10.1016/j.heliyon.2021.e07941>
- Olabanji, M. F., Davis, N., Ndarana, T., Kuhudzai, A. G., & Mahlobo, D. (2021). Assessment of smallholder farmers' perception and adaptation response to climate change in the Olifants catchment, South Africa. *South African Journal of Water and Climate Change*, 12(7), 3388-3403. <https://doi.org/10.2166/wcc.2021.138>
- Olubanjó, O. O., & Alade, A. E. (2018). Effect of climate variability on the yield of crops in Ondo State, Nigeria. *International Journal of Water Resources and Environmental Engineering*, 10(5), 54-63. <https://doi.org/10.5897/IJWREE2018.0783>
- Onuk, E. G., Girei, A. A., & Amfani-Joe, C. E. (2018). Determinants of microfinance accessibility among tomato farmers in Kokona Local Government Area of Nasarawa State, Nigeria. *International Journal of Horticulture, Agriculture and Food Science*, 2(2), 46-53. <https://dx.doi.org/10.22161/ijhaf.2.3.4>
- Onyeneke, R. U., Agyarko, F. F., Onyeneke, C. J., Osuji, E. E., Ibeneme, P. A., & Esfahani, I. J. (2023). How does climate change affect tomato and okra production? Evidence from Nigeria. *Plants*, 12, 3477. <https://doi.org/10.3390/plants12193477>
- Piya, L., Maharjan, K. L., & Joshi, N. P. (2012). Comparison of adaptive capacity and adaptation practices in response to climate change and extremes among the Chepang households in rural areas of Mid-Hills in Nepal. *Journal of International Development and Cooperation*, 18(4), 55-75. <https://www.academia.edu/29061227>
- Raza, A., Razzaq, A., Mehmood, S. S., Zou, X., Zhang, X., Lv, Y., & Xu, J. (2019). Impact of climate change on crops adaptation and strategies to tackle its outcome: A review. *Plants (Basel)*, 8(2), 34. <https://doi.org/10.3390/plants8020034>

- Salisu, A., Danwanka, H. A., & Hassan, A. B. (2024). Role of radio and mobile phone in disseminating agricultural information to crop farmers in the central zone of Bauchi State, Nigeria. *Nigerian Journal of Agriculture and Agricultural Technology*, 4(2), 20-32. <https://doi.org/10.59331/njaat.v4i2>
- Tajudeen, T. T., Omotayo, A., Ogundele, F. O., & Rathbun, L. C. (2022). The effect of climate change on food crop production in Lagos State. *Foods*, 11(24), 3987. <https://doi.org/10.3390/foods11243987>
- Ugonna, B. F. (2022). Knowledge and skills for accessing agricultural information by rural farmers in South-East Nigeria. *Sage Journals*, 47(2). <https://doi.org/10.1177/0340035220951>
- United States Environmental Protection Agency. (2024). Climate change impacts on agriculture and food supply. Retrieved from <https://www.epa.gov/climateimpacts/climate-change-impacts-agriculture-and-food-supply>