Food Science and Technology 11(2): 97-110, 2023 http://www.hrpub.org
DOI: 10.13189/fst.2023.110201

Food Production and Security under Changing Climatic Conditions in Nigeria

Osuji E. E.[1,*], Igberi C. O.[1], Balogun O. L.[2], Nwachukwu E. U.[3], Enyia C. O.[4], Munonye J. O.[1]

[1]Department of Agriculture, Alex-Ekwueme Federal University Ndufu-Alike Abakaliki, Nigeria
[2]Department of Agricultural Economics and Extension, Babcock University, Ilishan-Remo, Ogun State, Nigeria
[3]Department of Agricultural Economics, Federal University of Technology, Owerri, Nigeria
[4]Department of Agricultural Technology, Federal Polytechnic Nekede Owerri, Imo State, Nigeria

Received January 4, 2023; Revised March 8, 2023; Accepted March 19, 2023

Cite This Paper in the Following Citation Styles

***(a):** [1] Osuji E. E., Igberi C. O., Balogun O. L., Nwachukwu E. U., Enyia C. O., Munonye J. O. , "Food Production and Security under Changing Climatic Conditions in Nigeria," Food Science and Technology, Vol. 11, No. 2, pp. 97 - 110, 2023. DOI: 10.13189/fst.2023.110201.*

***(b):** Osuji E. E., Igberi C. O., Balogun O. L., Nwachukwu E. U., Enyia C. O., Munonye J. O. (2023). Food Production and Security under Changing Climatic Conditions in Nigeria. Food Science and Technology, 11(2), 97 - 110. DOI: 10.13189/fst.2023.110201.*

Abstract Food production and security under changing climatic conditions in Nigeria were investigated. A total of 191 food crop producers were chosen using a multi-stage sample technique and a data instrument. Descriptive statistics, the food security index, and the ordinary least squares multiple regression model were used to evaluate the data gathered. The findings indicated that food crop growers were primarily female, married, moderately experienced, and of productive age. Food crop output was dominated by rice, cassava, maize, and fluted pumpkin. The majority, 43% indicated that food production is decreasing rapidly due to external factors. According to the food security index, 16.2% of farmers who grow food crops have access to food, compared to 84% who had no access. The estimated food security index for families with access to food was 4.21 compared to 2.46 for households without access to food. Food production was positively impacted by household size, farm size, education, agricultural experience, and extension connections. Food security was unfavorably impacted by temperature, precipitation, and the frequency of wet days, but favourably impacted by sunlight and relative humidity. Production restrictions were noted as being caused by capital, input costs, pests, and diseases. Food crop farmers were advised to embrace climate change and continually seek for early warning signals and information to increase food production and forestall future negative impacts.

Keywords Food Production, Food Security, Food Crops, Food Farmers, Climate Change, Nigeria

1. Introduction

Out of 192 nations in the globe, Nigeria comes in at number 129 in terms of climate change vulnerability [1]. Nigeria's internal strife is now mostly fueled by climate change, which has also deteriorated the nation's food security position and exacerbated poverty in certain rural areas. More than 70% of Nigerian farmers work primarily for subsistence [2] in the agricultural industry. Nigeria's agricultural industry, despite its economic contribution, confronts several difficulties that have a detrimental influence on food security and production. They include inadequate land tenure structures, meager irrigation infrastructure for farming, land degradation, and most recently, climate change-related disruptions [3]. The amount and quality of food land are directly impacted by climate fluctuation and change, frequently in the opposite direction [4]. Data from the literature and earlier research have shown that the ongoing climate change has affected agricultural productivity, which has resulted in falling national food production and security. Globally, unfavorable climate change causes bad weather conditions including drought and flooding, which worsen food shortages and food insecurity in both rich and developing nations, including Nigeria [5]. According to studies, Nigeria's food security and productivity have suffered as a result of climate factors [6]. In light of this, food production cannot be effective if these climatic factors continue to compete with crop production. Many home farmers' food security and production are threatened by extreme temperatures and unexpected precipitation patterns. The beginning of the growing season may be uncertain owing to shifts in rainfall characteristics (initial rains are unlikely to be prolonged and crops planted at their time may become suffocated by heat waves), which may cause an unconventional succession of seed sowing and replanting that could eventually cause crop failures due to crop yield collapse [7]. Farmlands are destroyed by extreme weather conditions like floods and strong winds, which further threaten the availability and security of food. High temperatures encourage the growth of more agricultural pests and illnesses, which leads to severe field crop assaults and a lack of food [3]. Severe and unfavorable weather also causes food prices to rise and food imports to supplement locally produced food, which has been heavily attacked. For instance, Nigeria's total food imports from 2016 to 2019 totaled N3.35 trillion, which is four times more than the country's N803 billion in agricultural exports during the same era [8]. Climate change and shifting weather patterns have a detrimental impact on all four of the factors that make up food security: availability, access, usage, and system stability. As Nigeria's food supply is thought to be rapidly dropping, these unjustified negative factors have a significant impact on it. The majority of Nigerian farmers' livelihoods are still dependent on rain-fed agriculture, making them susceptible to increasingly unexpected catastrophic weather occurrences. Such an incident not only makes food production systems unstable, but it also damages the land and reduces crop yields [9]. The fact that almost 70% of Nigerians are smallholder farmers with somewhat archaic adaption techniques, which is concurrent with climate change, exacerbates the consequences of climate change on agricultural productivity. In Nigeria, it is reported that between 30% and 40% of food is lost each year, amounting to an estimated $750 billion [2]. Moreover, Nigeria's spending on food imports has increased from N389 million in the first quarter of 2020 to over N951 million by the second quarter of 2021 [10]. In addition to reflecting the reality that Nigeria continues to be a net importer of food due in part to climate change disruptions, foreign exchange constraints are a contributing cause to the growing cost of food imports. In the meanwhile, climate change has continued to cause poor growth in Nigeria's agriculture industry. From 2.28 percent in the first quarter of 2021 to 1.22 percent now, the sector's performance has subsequently decreased [11]. It was in the light of the above circumstances that this study was designed to evaluate the extent to which food production and security thrive under changing climatic conditions in Ebonyi State, Nigeria which had not been documented, hence the gap in knowledge and motivation for the study.

1.1. Conceptual and Theoretical Framework

One of the sub-Saharan African nations identified as being most vulnerable to climate change is Nigeria. Climate variation and change have a direct influence on the quantity and quality of agricultural products, usually in the opposite direction. The current condition of climate change has impacted agricultural productivity, which has led to deterioration in the nation's food production and security, according to literature and prior study [11]. Food production and food systems in Nigeria are negatively impacted by climate change-induced changes such as droughts, excessive precipitation, floods of farmlands, rising temperatures, increasing aridity and soil acidity, changes in relative humidity, and increased evaporation, among other things. Food quality and access are impacted, as well as food supply, by climate change. Reduced food productivity, for instance, is a result of a number of factors, including expected temperature rises, modifications to precipitation patterns, modifications to extreme weather events, and decreases in water availability. Again, as a largely rain-fed country, Nigeria is completely dependent on weather, and unfavorable atmospheric conditions have a negative impact on crop productivity by reducing crop yield and soil fertility, limiting the amount of water available to the soil, causing more soil erosion, and promoting the spread of pests. Debates on sustainable food and production have been sparked by Nigeria's expanding population, which will soon surpass 200 million [7]. These developments promulgated the conceptualization of this study with the intention of x-raying food production and security along changing climate in Nigeria.

1.2. Analytical Framework

The methods employed for data analysis included descriptive statistics, the food security index, and ordinary least squares multiple regression. In descriptive statistics, methods are used to gather, arrange, summarize, describe, analyze, and display a variety of numerical, qualitative, and quantitative data [2]. They are applied to convey numerical descriptions in a comprehensible format. Based on their straightforward statistical formulations, they are favoured. The statistical method of multiple regression is used to determine the associations between several variables. As opposed to other approaches, they are typically favoured because they place greater attention on the link between a dependent variable and one or more independent variables (predictors). The food security status of a chosen or recognized population may be expressed using the food security index, a dynamic quantitative and qualitative scoring methodology [4]. It displays the gaps in/surpluses in food security for a population, sample, or group of individuals while considering their current access to, affordability with regard to, usage of, and stability with regard to, food into account. The main reason it is favoured over other approaches is that it clearly displays, without bias or omission, the genuine or actual indices of people with access to food and those without it.

2. Materials and Methods

2.1. Study Area

One of the states in Southeast Nigeria, Ebonyi State, is where the study was conducted. Due to its agrarian culture and extensive crop farming, the state was chosen. Abakaliki, Afikpo-North, Afikpo-South, Ebonyi-Central, Ezza-North, Ezza-South, Ikwo, Ishielu, Ivo, Izzi, Ohaukwu, Ohaozara, and Onicha are the thirteen Local Government Areas that make up Ebonyi State. The state's population was estimated at 2,176,947 people in 2006 by the National Population Census Commission in Abuja [12]. Benue State, Enugu State, Cross River State, and Abia State, are all its neighbors. The entire land area is approximately 5,533 km^2, and its coordinates are 6 °10' 40.7028" and 7 °57' 33.4296." [13].The state has two distinct seasons, the rainy and dry, in a tropical environment. The dry season lasts from November to March, whereas the rainy season lasts from April to October. The state has a 28 ^{o}C average temperature and 17% of it is covered in precipitation. The area's vegetation is primarily rainforest, which supports the development of food and cash crops such as rice, maize, yam, cassava, oil palm, cocoa, cowpea, sweet potato, cocoyam, plantain, banana, melon, bambara nut, breadfruit, groundnut, and numerous vegetables and fruit trees.

2.2. Sample Selection

For sample selection, a multi-stage sampling technique was used. Three local government areas (LGAs) were purposively picked from Ebonyi North, Ebonyi South, and Ebonyi Central, totaling nine LGAs. The focus on intensive food crop production was the basis for the deliberate selection of these LGAs. In the second stage, three communities were chosen at random from the LGAs, totaling 27 communities. In the third stage, 4 villages were picked at random from the communities giving 108 villages. The final stage had 2 food crop farmers chosen to bring about 216 food crop farmers. The state agricultural development agency provided the list of the registered farmers who grow food crops, which served as the sample frame.

Table 1. Method of Sample Size Selection

Structural Zones	LGA	Communities	Villages	Food Crop Farmers
Ebonyi North	3	3	4	2
Ebonyi South	3	3	4	2
Ebonyi Central	3	3	4	2
Total	**9**	**27**	**108**	**216**

2.3. Data Collection

For the study, primary data was gathered. The researchers created the survey tool (questionnaire), which was used to collect data. Only 191 of the questionnaires were deemed useful for data analysis. Others were discarded as a result of mistakes and missing data found. A pilot survey was however carried out in the chosen LGAs prior to the real data collection in order to standardize the questionnaire and establish its reliability and content validity. Information obtained was standardized, coded, and placed into an excel spreadsheet.

2.4. Data Analysis and Model Specification

Descriptive statistics, the food security index, and the ordinary least squares multiple regression approach were used to evaluate the data gathered. The mean, frequency distribution, and percentage are all components of descriptive statistics. Descriptive statistics examine the characteristics of food crop producers' demographics, the various crop outputs generated, the levels of food production, and the restrictions affecting the development of sustainable food crops and food security. Farmers who grow food crops have their food security conditions examined by the food security index. The model compares the daily per capita calorie consumption of households to the suggested daily per capita calorie needs of families. The food security index model is specified as follows;

$$FS_I = \frac{F_{CFDPCCI}}{P_{DPCCR}} \tag{1}$$

Where

FS_I = Food security index

FCF_{DPCCI} = Food crop farmers's daily per capita calorie intake

P_{DPCCR} = Prescribed daily per capita calorie requirement

Furthermore, food insecurity gap index (FIGi), food surplus gap index (FSGi) and the head count ratio (HCR) were equally estimated thus;0

$$Hf_i = \frac{X}{Z} \quad (2)$$

$$Hf_s = \frac{y}{Z} \quad (3)$$

$$FIG_i = \frac{1}{X}\sum_i^X = 1 \quad \text{where } D_i = \frac{C_{i-R}}{R} \quad (4)$$

$$FSG_i = \frac{1}{Y}\sum_i^Y = 1 \quad \text{where } D_i = \frac{C_{i-R}}{R} \quad (5)$$

Where;
Hfs = Head count index for ith food crop farmer with access to food
Hfi = Headcount Index for ith food crop farmer without access to food
FIG_i = Food insecurity gap index
FSG_i = Food surplus gap index
X = Number of families without access to food
Z = Total number of food crop farmers in the sample
Y = Number of food crop farmer with access to food
Di = Daily calorie intake for ith food crop farmers
Ci = Daily food item calorie intake per person
R = Prescribed daily caloric intake for each person.

World Health Organization and United States Committee on International Nutrition recommend consuming a minimum of 2100 kcal per adult equivalent each day. The baselines for establishing the food security line for the study were the Food and Agricultural Organization's 1800 kcal and the 2700 kcal National Average Calorie Need. As a result, families below the food security line are categorized as having insufficient access to food, while those above the line are categorized as having sufficient access to food. The criteria for food nutritional composition were once more used to determine families' daily per capita calorie consumption [14]. The calculated values of the different food ingredients were translated into kilograms, and those values were used to determine the calories. The household size was multiplied by the intake factor for age-sex groups to convert the anticipated daily caloric (energy) intake of the homes to adult equivalents. Ordinary least squares multiple regression technique analyzed factors influencing food crop production, and the effects of climate change on food security. The model is expressed as follows;

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9,) + ei \quad (6)$$

Where
Y = Output of vegetable crops (Kg)
X_1 = Age (X_1)
X_2 = Gender (Male 1, Female 0)
X_3 = Household size (No. of persons)
X_4 = Farm size (Ha)
X_5 = Education (No. of years spent in school)
X_6 = Farming experience (No. of years)
X_7 = Input price (Naira)
X_8 = Membership in cooperative (Member 1, otherwise 0)
X_9 = Extension contact (No. of visits)
X_{10} = Climate change (Affected =1, 0, otherwise)
ei = Error term

Again, Ordinary least squares multiple regression technique was expressed as;

$$Y = f(X1, X2, X3, X4, X5, X6) + ei \quad (7)$$

Where,
Y = Food security index (values)
X_1 = Temperature (^{0}c)
X_2 = Rainfall (mm)
X_3 = Number of rainy days (number of times)
X_4 = Evaporation rate (mm)
X_5 = Sunshine hours (hours)
X_6 = Relative humidity (%)
ei = error term

Note; the climate variables were captured using perception of the food crop farmers to changing climate since the exact information on climate variables are not domiciled with them. Though; the climate variables were expressed in their standard units. Thus binary values were deployed to extract the needed information as a proxy to climate variables; where the farmers were asked to indicate the trend of changing climate variables; that is whether the climate variables increased or decreased per time during the cropping period. (1 was assigned as increased while 0 was assigned as decreased).

3. Results and Discussion

3.1. Demographic Features of Food Crop Farmers

The demographic features of the food crop farmers are shown in Table 2.

Females made up 53.4% of the farming population. This suggests that women farmers in the state produced more food crops than their male colleagues. This appears to confirm the claim that female crop growers have dominated the production of food crops in Nigeria recently [15]. The domination of more women in agriculture was also aided by the debate about gender equality and related proposals. With a mean age of 47 years, most crop farmers were between the age ranges of 41 to 50. This suggests that the producers of food crops were young and within the range of their productive ages, and it also suggests that they were physically and mentally capable of carrying out the production of their food crops [16]. There is a reputation among young farmers for increased farm yields and productivity, which leads to higher farm revenue. Farmers who were married predominated the production of food crops by 72.3%, according to data on marital status. This suggests that the growers of food crops were responsible, mature individuals who were dedicated to the provision of food. The availability and supply of labor (family labor), which is used to boost outputs, is said to rise with marriage. The majority of farmers who raise food crops, 54%, went to secondary school, demonstrating that they were relatively well-educated to increase the yield of their crops [16]. The potentials of producers of food crops in general are reflected in education. It aids in the farmers' acquisition of the necessary expertise and comprehension of the principles of agricultural production that guarantee improved crop yields and productivity. Again, the average length of time spent farming was 18 years, suggesting that the farmers of food crops had enough experience to deal with any production-related constraints that may have been innate. Farmers with more farming experience are better able to put farm production principles into practice and are better equipped to use resources and farm inputs more effectively to increase crop production [17]. The average household size among agricultural growers was 7 people. This is a sizable space that might be used for growing food crops. High family sizes enhance the availability of farm labor and conserve time and funds that would have been used to employ more farm workers. 58% of the farmers who grew food crops had contacts in extension. This suggests that the crop growers had face-to-face interactions with extension personnel and must have applied the practical information acquired from such visits. Both in the short and long term, extension contacts serve as a vehicle for revolutions in food crop production. They offer food crop farmers realistic exposures and experiences on-site, which leads to a rise in food crop yields and farm revenue [18]. The majority of farmers growing food crops (58.6%) are members of cooperative societies, which increases their opportunity to benefit from and have access to agricultural farm inputs like enhanced planting materials, seedlings, fertilizers, and other agro-chemicals, which has the potential to increase food crop production. Around 2 hectares of farmland were farmed by the majority of food crop farmers, which may not be enough for large-scale production. The majority of the food crop producers had farms with sizes between 1.1 and 2.0 hectares, with a mean farm size of 1.8 hectares. Major crop production barriers include land scarcity and fragmentation, which hinder substantial food crop cultivation and support the modest farm income of farming households [7]. Again, the majority of farmers who grow food crops—65% of them—attested to the effects of climate change. This suggests that climate change affected these farmers' overall farm productivity and food output. The impact of climate change on food crop production in Nigeria has persisted and is now felt globally [19]. 56.5% of farmers growing food crops reported using government inputs, which suggests that less money was spent on purchasing better planting supplies. Increased food production and outputs are the results of improved planting materials.

Table 2. Demographic features of food crop farmers

Demographic features	Frequency	Percent
Gender		
Male	89	46.6
Female	102	53.4
Age		
21-30	33	17.3
31-40	49	25.7
41-50	91	47.6
51-60	11	5.8
Above 60	7	3.7
Mean age	47	
Marital Status		
Single	21	10.9
Married	138	72.3
Separated/Divorced	10	5.2
Widow/Widower	22	11.5
Education		
Primary	47	24.6
Secondary	103	53.9
University	10	5.2
None	31	16.2

Table 2 continued

Farming Experience		
1-10	29	15.1
11-20	114	59.7
21-30	37	19.4
31-40	9	4.7
41-50	2	1.0
Mean farming experience	18	
Household size		
1-4	91	47.6
5-9	98	51.3
10-14	2	1.0
Mean household size	7	
Extension contacts		
Yes	110	57.6
No	81	42.4
Cooperative membership		
Yes	112	58.6
No	79	41.4
Farm size		
0.1-1.0	61	31.9
1.1-2.0	115	60.2
2.1-3.0	15	7.8
Mean farm size	1.8	
Influence of climate change		
Yes	124	64.9
No	67	35.1
Accessed government inputs		
Yes	108	56.5
No	83	43.5

Source: Field data, 2021

3.2. Descriptive Statistics of Different Outputs of Food Crops Produced

The descriptive statistics of different outputs of crops produced was shown in Table 3.

The table shows that, among other root-tubers like yam, which produced 5110.31 kg, cocoyam, 3039.10 kg, and sweet potato, which produced 3041.95 kg, cassava production led the root-tubers. This shows how crucial and relevant cassava cultivation is to the state's whole local government regions. Due to its potential to provide food security and sustainability, cassava is known to be extensively grown [20]. This makes it unique among other tuber crops. Many farm households may rely on its production to provide food for domestic use as well as for business needs. At a mean output of 7991.20 kg, rice production significantly outperformed other staple crops like maize. Given that the state is the leading producer of rice in the nation, rice is without a doubt the most important crop farmed there. In essence, rice was grown and sold in practically every agricultural home in the state. Additionally, the state has flat land topography and fertile soils, both of which are favorable to and support the production of rice [21]. The fluted pumpkin, which has a mean output of 5800.23 kg, outperformed the other vegetables and fruits with a mean output of 4442.37 kg, followed by watermelon, 4402.16 kg, garden eggs, 3614.41 kg, okra, 3339.82 kg, green paper, 3098.02 kg, tomato, 2996.39 kg, waterleaf, 2591.21 kg, and cabbage, 2500.44. Some veggies may be more prevalent due to increased demand and increased nutritional value, which encourages their cultivation. Fruits and vegetables are abundant suppliers of vitamins and other nutritional elements needed for body development, improvement, and overall body building [15]. Because of their importance and relevance to the state, human intake cannot be discounted. With a mean output of 5166.98 kg, melon out-produced all other legumes in terms of food crop production, whereas groundnuts, cowpeas, and soy beans all came in below that mark. This demonstrates the state's melon crops' advantageous position. Overall, legumes improve soil fertility and constantly contribute to soil water conservation. Legumes are a great source of protein supplements that support body tissue growth and reproduction. Banana and plantain were two other noteworthy tree food crops that were grown, with mean outputs of 4302.03 kg and 3823.17 kg, respectively. At the nursery plantation, these two food crops, which are seasonal tree food crops, shade freshly, planted crops. They both serve as excellent vitamin sources and support healthy body development and tissue growth [10].Consuming bananas specifically aids in the battle against viral infections and other illnesses. Nonetheless, as seen by their high mean outputs, rice, cassava, maize, and fluted pumpkin were the most extensively grown food crops in the state. This further suggests that food crop growers are concentrating on these crops.

Table 3. Descriptive statistics of different outputs of food crops produced

Food Crops	N0. of Farmers		Unit	Mean Output	Standard Deviation	Minimum Output	Maximum Output
	F	%					
Rice	191	100	Kg	7991.20	60.3710	350.00	8000.00
Cassava	191	100	Kg	6402.91	37.1601	250.00	7900.00
Cucumber	88	46.1	Kg	2591.21	23.0830	150.00	3500.00
Tomato	91	47.6	Kg	3098.02	38.1011	200.00	3650.00
Cabbage	67	35.1	Kg	2500.44	45.2941	100.00	3500.00
Watermelon	101	52.8	Kg	4442.37	39.2374	250.00	5000.00
Yam	189	98.9	Kg	5110.31	19.1957	300.00	5500.00
Coco-yam	123	64.4	Kg	3039.10	33.0962	250.00	4500.00
Okra	187	97.9	Kg	3614.41	48.1734	200.00	4200.00
Garden egg	104	54.4	Kg	4402.16	46.8414	150.00	4770.00
Green pepper	188	98.4	Kg	3339.82	69.7173	100.00	4669.00
Cowpea	152	79.6	Kg	3550.44	74.3334	200.00	4400.00
Maize	190	99.5	Kg	5903.49	56.1387	300.00	6609.00
Plantain	179	93.7	Kg	3823.17	57.6620	100.00	4500.00
Banana	170	89.0	Kg	4302.03	39.3022	100.00	4900.00
Sweet Potato	162	84.8	Kg	3041.95	48.5402	150.00	4050.00
Fluted pumpkin	191	100	Kg	5800.23	41.3162	200.00	6070.00
Waterleaf	139	72.8	Kg	2996.39	56.2292	250.00	3090.00
Soya bean	133	69.6	Kg	2809.90	42.0831	150.00	3500.00
Groundnut	138	72.3	Kg	3890.24	56.6002	200.00	4500.07
Melon	182	95.3	Kg	5166.98	71.2334	250.00	6000.00
Pineapple	108	56.5	Kg	2012.09	33.3300	100.00	3800.00

Source: Field data, 2021

3.3. Food Production Levels in the State

Food production levels in the state were shown in Table 4.

Table 4. Food production levels

Food production levels	Percent/Mean	Observation
Increasing	30.4% (2.4)	High
Decreasing	43% (1.9)	Low
Static	27% (1.2)	Unchanging

Source: Field data, 2021.

According to the table, 30.4% of farmers that grow food crops reported rising food production a level, suggesting that food production in the state is rising. The majority (43%), which indicates a sharp decline in food production in the state, indicated a declining level of food production. The poor yields of food crops grown in the state may provide some indication of this [22]. Moreover, poor agricultural policies combined with both internal and external causes, such as climate change, a lack of available land, and money, the high cost of planting supplies and hired labor, etc., might lead to a decline in the state's food supply. Also, roughly 27% of the growers of food crops reported a stable level of food output, suggesting that the state's food production remains constant. Nonetheless, it is clear that food production in the state is declining over time based on the high price of agricultural products in the state.

3.4. Food Security Status of Food Crop Farmers

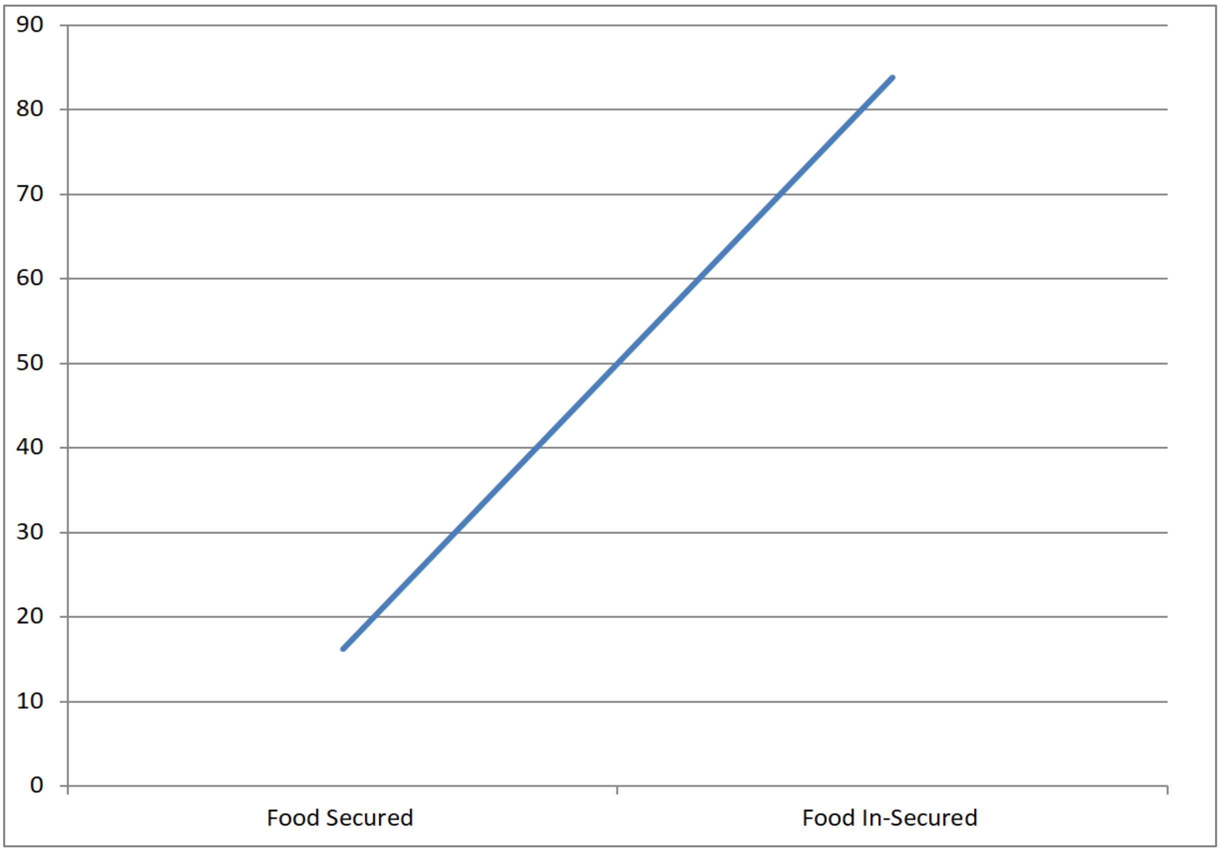
The food security status of food crop farmers is shown in Table 5.

Table 5 provides information on the farmers' level of food security. The result shows that 16.2% of farmers who grow food crops were food secured, compared to 84% of the food crop farmers who were not secured. This suggests that while the majority of farmers who raised food crops were not secured, a smaller percentage of them were. As opposed to the latter, the former might be attributed for their preferences for agricultural credits, subsidized agricultural inputs, and early access to climate change information [23]. The result is further represented in figure 1. Comparatively, there were 31 out of 160 households experiencing food insecurity, which indicates a 516 percent rise in food insecurity among food crop farmers in the state. This increase may be attributable to both internal and external farm restrictions. The average household size of food crop producers who were in control of their food supply was 3.0, while it was 4.0 for those who were not. This has major implications for the state's food security because households with larger families or households experience more food insecurity [24]. In comparison to the 2.46 value derived from the families without access to food, the estimated mean food security score for the household with food security was 4.21. This indicates that families with access to food had a higher food security score than those without it, which had a lower value. The state's adverse agricultural and economic policies might be the cause of the low food security score [20]. Additionally, this suggests that the state's food insecurity has increased by 58.4% in absolute terms. Food crop farmers with and without food security had respective mean household daily calorie intakes of 14572.00 and 1222.01, as well as respective mean household per capita daily calorie intakes of 15504.40 and 1199.96. The average daily calorie consumption per capita for families with food access was 14572.00 and 15504.40 kcal, above the minimal daily calorie requirements of 2100 kcal and 2700 kcal suggested by the WHO, USCIN, and FAO, respectively, thus indicating good food security. While the average daily calorie intake for households without access to food was 1222.01 and 1199.96 kcal, this was less than the minimum daily calorie requirements of 2100 kcal recommended by the WHO and USCIN, 1800 kcal by the FAO, and the national average calorie requirement of 2700 kcal, indicating a lack of food security in the state. These findings also suggest that crop farmers with access to food consumed the recommended daily caloric intake of 2100 kcal by the WHO and USCIN, 1800 kcal by the FAO, and the national average caloric requirement of 2700 kcal as opposed to the food crop farmers without food access who were unable to consume the recommended daily caloric intake. The estimated values of the food insecurity gap index for food crop farmers who had access to food and otherwise were 0.66 and 4.23, respectively. This suggests that households with access to food had a marginally lower food insecurity gap index than their counterpart who with an exceeding index of 423%. Similarly, the food surplus gap index showed that households with access to food had a high index value of 2.24 and a marginal index of 0.79 compared to households without access to food indicating that the former was much better off than the latter. The food surplus/insecurity gap indicator, which gauges the degree of departure from the food security line, reveals that households with access to food surpassed the calorie need by 339%, while households without access to food fell short of the calorie requirement by 19%. This is a significant gap between the state's food crop producers. The large difference might indicate that families with access to food outnumber those without [25]. The results also showed a head count ratio of 4.4 for food crop producers who had access to food and 22.8 for those who do not.

Table 5. Food security status of food crop farmers

Food security status	Food secured Households	Food-in-secured Households	Pooled
Percentage of food crop farmers	16.2	83.8	100
Number of households	31	160	91
Mean of household size	3.0	4.0	7.0
Mean food security index/ Std. Dev.	4.21 / (1.27)	2.46 / (0.78)	6.7/(2.05)
Mean households daily calorie intake (kcal)	14572.00	1222.01	15794.01
Mean households per capita daily calorie intake (kcal)	15504.40	1199.96	16704.36
Food insecurity gap index	0.66	4.23	4.89
Food surplus gap index	2.24	0.79	3.03
Food surplus/insecurity gap index	3.39	0.19	3.58
Head count ratio	4.4	22.8	4.1

Source: Field data, 2021



Note: X axis represents the food security status of food crop farmers and Y axis represents food-secured and in-secured households.

Figure 1. Graphical representation of food crop farmers with food access and otherwise

3.5. Factors Influencing Food Crop Production

The factors influencing food crop production was shown in Table 6.

The table displayed the findings of multiple regression on how socioeconomic variables affected the state's output of food crops. The lead equation, the double-log functional form offered the greatest fit and was selected because it produced the highest values of the coefficient of multiple determinations (R^2), the maximum number of significant variables, and the F-value. The R^2 of 0.910 showed that the socio-economic factors fully explained 91% of the overall fluctuations in the endogenous variable. Age had a negative significant coefficient, indicating that as growers of food crops get older, crop production declines. The outcome further suggests that younger food crop producers predominate in the state compared to older farmers. Given that productive ages provide high outputs and productivity, age is found to be a significant factor of food crop production [2]. The household size of producers of food crops was positive and significant; indicating that any increase in household size will result in higher production. High home size heavily influences the availability and quantity of family labor, which is a requirement for higher food production. The positive and substantial coefficient of farm size suggests that crop yield grows vis a vis with the size of a farmer's farm. The size of the farm has a significant impact on crop production since it affects how much food crops are grown and the type of effective agricultural techniques adopted [7]. Education was positive and substantial, suggesting that a 1% increase in the level of education among producers of food crops will translate into a 1% improvement in agricultural yields. The knowledge and comprehension of farmers of food crops is improved through education, enabling them to strengthen their agricultural operations and incorporate new cultivation practices and procedures [22]. The farming experience was considerable and beneficial, suggesting that any improvement in the farmers' level of farming expertise will translate into an equivalent rise in the yield of food crops. Experience in farming improves the technical and financial efficiency of food crop production, increasing food yields and revenue [19]. Extension contacts were both positive and important inferring that any increase in the number of extension interactions with farmers who grow food crops will improve food crop output by 315%. Extension connections are renowned for generating first-hand experience and disseminating fresh and/or enhanced farming technologies, both of which are essential for boosting food production [14]. The improvement of food crop producers' technical experience, knowledge, and abilities is made possible through extension connections geared at boosting food output. Climate change was unfavorable and substantial, which suggests that a 1% increase in it will similarly result in a 239% decline in the yield of food crops. This demonstrates further how climate change causes harm in agriculture and food production. Climate change causes a severe and destructive impact on food production leading to reduced crop yield and earnings [26].

Table 6. Factors influencing food crop production and food security

Variable	Linear	Semi-log	Double-log	Exponential
Constant	201.262	2.1302	81.1205	3.2028
	(1.201)	(3.101)***	(1.102)	(2.220)**
Age (X_1)	-3.3320	-3.3221	-6716.1	-4.4201
	(-2.242)**	(-1.400)	(-3.836)***	(-1.249)
Gender (X_2)	-324.103	-5.1029	-6707.1	-4.8875
	(-2.413)**	(-0.141)	(-0.800)	(-3.577)***
Household size (X_3)	541.002	3.2006	3365.0	2.2051
	(1.311)	(1.111)	(2.439)**	(1.207)
Farm size (X_4)	4101.10	2.2015	5504.32	4.4025
	(1.319)	(4.009)***	(3.701)***	(1.322)
Education (X_5)	640.256	3.9329	6089.9	5.2039
	(2.220)**	(1.323)	(3.501)***	(4.014)***
Experience (X_6)	611.602	9.1015	6392.1	4.0501
	(1.442)	(3.904)***	(4.560)***	(1.330)
Input price (X_7)	-402.16	-4.3391	-170.612	-3.9405
	(-1.739)	(-0.015)	(-0.332)	(-1.045)
Membership in cooperative (X_8)	-4083.12	-4.2196	-7.3752	-3.2198
	(-1.801)	(-1.301)	(-1.403)	(-3.740)***
Extension contact (X_9)	5.7297	7.9330	3.1542	3.5401
	(1.221)	(1.073)	(2.710)**	(1.431)
Climate change (X_{10})	-45.4561	-0.9944	-23.9341	-34.7701
	(-2.567)**	(-1.883)	(-4.527)***	(-0.093)
R^2	0.771	0.882	0.910	0.709
F- ratio	24.76***	37.18***	74.08***	23.69***

Source: Field data, 2021.

***, **, * significant at 1%, 5%, and 10%

3.6. Effects of Climate Change on Food Security

The effects of climate change on food security was shown in Table 7.

Given the amount of significant variables, greatest F-value, and best R^2, the double-log functional form was selected. The endogenous variable's overall changes could be entirely explained by the observed climatic variables, according to the R^2 value of 0.864, which was 86%. The model's fitness was further demonstrated by the F-value of 86.01. The fact that the temperature was negative and substantial suggests that a rise in temperature lowers the food security of the family. Increasing soil pathogen formation brought on by rising temperatures spawns agricultural pest insects reducing crop yields, income, and sustainable yields and resulting in food insecurity [12]. High temperatures impair the reproductive and developmental phases of crop seedlings, which diminish plant height and root expansion and result in subpar growth and yields. Rainfall was negative and substantial, suggesting that too much rain reduces the food security of food crop farmers. By soil erosion, water erosion, water-logs, and percolation, excessive rainfall can pose a threat to crop cultivation and have a catastrophic impact on root and shoot growth [23]. Heavy rainfall damages field crops that have already been planted, lowering their yields and market prices and resulting in the start of food insecurity. Flooding happens as a result of extreme rainfall intensity, which also drastically lowers agricultural outputs and exacerbates food poverty in the state [25]. The number of precipitation days was negative and statistically significant, suggesting that a rise in the number of rainy days lowers plant yield and outputs by heavily flooding arable fields and eroding away upper vegetative soils, which causes food shortages [13]. It also makes soils less productive and infertile by lowering their nutrient concentrations and budget composition. A rise in the number of rainy days also encourages the establishment and development of several plant diseases, leading to an increase in crop disease infestations and decreased crop productivity [9]. Sunshine hours were favorable and substantial, suggesting that a 1% increase in sunlight hours would boost food security by 739 percent. Sunlight is essential for the growth and development of crops and promotes the photosynthetic activities of agricultural plants, which produce sustainable yields and outputs. The importance of sunlight in crop production cannot be overstated, especially during photosynthesis, the process by which plants and other autotrophic organisms convert light energy, often from the sun, into chemical energy utilized to manufacture plant carbohydrates and activate the microbial activity of soil organisms [18]. The energy required by plants to convert carbon dioxide and water into the carbohydrates and oxygen required for plant development is provided by sunlight. Moreover, photosynthesis-produced carbohydrates promote crop vegetative and reproductive development as well as crop biomass production, which increases food output [17]. Relative humidity was positive and substantial, suggesting that a 1% rise in relative humidity will lead to a comparable improvement in food security of roughly 211%. Relative humidity raises the moisture content of farmlands, especially during dry seasons, leading to a rise in food crop production and sustainable yields [26]. In addition to encouraging plant water relations (transpiration), relative humidity also encourages plant leaf growth and improves photosynthesis, crop pollination, and soil aeration. It encourages seed germination and growth and improves soil moisture availability, which ultimately increases food production.

Table 7. Effects of climate change on food security

Variable	Linear	Semi-log	Double-log	Exponential
Constant	4713.01	33.1213	13.7434	18.9088
	(1.201)	(4.418)***	(1.570)	(1.622)**
Temperature (X_1)	-4.1030	-7.4039	-4101.82	-3.0911
	(-3.091)***	(-3.941)***	(-2.671)**	(-1.592)*
Rainfall (X_2)	-932.051	-7.0094	-401.318	-40.583
	(-3.112)***	(-0.481)	(-4.050)***	(-1.450)
Number of rainy days (X_3)	-45.9120	-5.1102	-3903.05	-7.7113
	(-1.313)	(-0.211)	(-3.001)***	(-0.304)
Evaporation rate (X_4)	-2012.22	-3.5115	-4104.17	-3.9045
	(-1.451)	(-1.813)*	(-1.309)	(-4.925)***
Sunshine hours (X_5)	32.852	15.9121	73950.41	7.7013
	(1.450)	(1.338)	(3.770)***	(0.402)
Relative humidity (X_6)	205.931	4.8015	2113.88	3.3092
	(2.013)**	(1.206)	(4.501)***	(1.909)
R^2	0.608	0.700	0.864	0.821
F- ratio	25.09***	13.90***	86.01***	18.24***

Source: Field data, 2021.

***, **, * significant at 1%, 5%, and 10%

3.7. Indicated Constraints Impeding Food Crop Production and Food Security

The indicated constraints influencing sustainable food crop production and food security was shown in Table 8.

Table 8. Indicated constraints impeding food crop production and food security

Indicated Constraints	Frequency	Percent
Inadequate and lack of capital	191	100
High cost of input materials	191	100
Inadequate farming lands	172	90.0
Poor extension access and services	104	54.4
Land fragmentation	190	99.5
Problem of storage/processing facility	178	93.2
High rate of rural migration	171	89.5
Inadequate information concerning climate change	191	100
Pests and disease attacks	191	100
High cost and low availability of labor supply	180	94.2

Source: Field data, 2021

The table shows that 100% of the producers of food crops expressed complaints about lack of funding, high input material costs, insect and disease assaults, and a lack of knowledge about climate change. This suggests that the producers of food crops saw these restrictions as their most troubling and difficult production challenges, negatively affecting food security [27]. Farmers of food crops have long been concerned about capital since it governs and controls other production parameters [28]. As most rural farmers lack the financial means to purchase such expensive inputs, extensive crop cultivation is discouraged, which affects food crop yield and food security. Pest and disease assaults on planted crops degrade agricultural output, reducing crop yields and increasing family food insecurity [29]. Farmers frequently fall prey to such information failures, resulting in countless distortions to farming operations. This leads to major interruptions and deficiencies in farming. Likewise, over 90% of farmers that grow food crops cited inadequate farming grounds, land fragmentation, a lack of storage or processing space, high costs, and a scarcity of skilled personnel. Due to the decreased efficacy and efficiency of food crop cultivation, inadequate farming areas provide a significant threat to food production and food security [30]. Food insecurity in households that cultivate food crops is made worse by the fragmentation of the land, which makes it impossible to cultivate food crops intensively and extensively. Short-term and long-term issues with storage and processing facilities hinder the effective storage of food and the efficient processing of agricultural products, which affects the availability and supply of food. Due to high labor rates or charges, producers of food crops find it more difficult to get hired labor, which significantly reduces their ability to produce crops effectively and efficiently. Similarly, a lack of labor supply might be caused by the movement of youths to cities in quest for white collar jobs, which threatens food security [31]. The high rate of rural migration (89.5%) and the subpar extension access and services (54.4%) were two additional prominent documented restrictions limiting the development of food crops and compromising food security. The high incidence of rural-urban migration reduces the local labor force or farm workforce as they migrate to urban areas in pursuit of better pastures, leaving the farm in the hands of elderly employees whose strength is insufficient. Again, because of poor extension access and services, it is difficult for farmers of food crops to obtain new and better cultivation techniques, which has a detrimental impact on food crop output and food security [32].

4. Conclusions and Recommendations

Due to external causes related to climate change, food production in Nigeria has continued to decline, aggravating food security there, according to several reports. The study's conclusions revealed that food crop producers were generally married, experienced, well-educated, and within their prime working years. Rice, cassava, maize, and fluted pumpkin were the most commonly farmed crops, with greater mean yields and farmer populations. A little over 30.4% of farmers who grow food crops said that the state's food production level was rising, while the majority, 43.3%, said it was declining. The estimated food security index for the homes with access to food was 4.21 compared to 2.46 for the households without access to food. While 84% of farmers who grow food crops lacked access to food, only 16.2% of them did. This suggests that the majority of food crop producers lacked the security of food whereas a smaller proportion of them had access to food. The food surplus gap index again showed that families that were food secure had a high index value of 2.24 and a marginal index of 0.79. Age and climate change had a detrimental impact on food crop output, but other factors including household size, farm size, education, farming experience, and extension connections had a beneficial impact. Food security was influenced favourably by daylight hours and relative humidity, but adversely by climate factors including temperature, rainfall, and the frequency of wet days. Constraints on food production and security include a lack of funding, high input costs, pest and disease outbreaks, and incomplete climatic data. In order to prevent negative future effects, the research advised farmers to embrace the diversity of climate change and persistently look for early warning signs and information on climate change. To revive the state's declining food production levels, the government should enact benevolent food production policies. Moreover, to help alleviate their challenges, boost food production, and combat climate change, relevant agriculture authorities should offer food crop producers grants, credits, input subsidies, and information on the issue.

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