



**FOOD SECURITY STATUS AND IMPACT OF CLIMATE SMART PRACTICES ON  
MAIZE PRODUCTIVITY IN ADAMAWA STATE, NIGERIA:  
A PROPENSITY SCORE MATCHING APPROACH**

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**ABSTRACT**

The study examined the food security and impact of climate smart practices maize productivity using a propensity matching approach. The specific objectives were to; describe the socio-economic characteristics of maize farmers; assess the food security status, estimate the costs and returns from maize production, determine the impact of climate smart practices on output and income, and describe the constraints faced by maize farmers in the study area. A multi stage sampling techniques was employed to select 206 maize farmers for the study. Data were collected using well-structured questionnaires and analysed using descriptive statistics, household dietary diversity score (HDDS), gross margin analysis, and Propensity matching score (PSM). The results shows that maize production was male dominated (66.99%), access to formal education (83.50%), active productive age (36.90%), and well experienced. The intercropping with legumes (94.0%) was the most common climate practices among maize farmers in the study area. The result shows that majority (81.0%) of the maize farmers in the study area have good dietary diversity score, which implies that most of them were food secured. Maize production was profitable in the study area with the return on investment of 3.32. The study concludes that adoption of climate smart practices among maize farmers is capable of increasing their productivity in terms of output and income and also resulted to favourable food security level in the study area. There is a need for extension agents to guide farmers on the best periods to cultivate maize and right climate smart practices to adopt in the study area.

**Keywords:** Food, Security, Impact, Climate-Smart, Productivity

**INTRODUCTION**

The backbone of most developing nations like Nigeria remains agriculture, despite the fact the country generates high gross domestic production from crude oil. According to Ahmadzai *et al.*, (2021) agricultural sectors plays a significant role in reduction of poverty as it is the means of livelihood for more smallholder rural dwellers. Agriculture is still a viable sector globally, but climate change is one issues which disrupts rural small scale farmers due to most of the depending on natural resources like rainfall, experience high poverty status, and inadequate knowledge to adopt improved strategies (Tofu *et al.*, 2022). Climate change is not only having impact on agriculture alone, it now cuts across other sectors which have led to loss of forest resources such as deforestation activities, high temperatures, and sea level increase as well. (Bolan, *et al.*, 2024). According to Ojo *et al.* (2024) one of the leading threat to global agriculture is climate change with effects such changes in rainfall pattern, high disease and insect attacks on crops, and changes in food security status of farming households. National Aeronautics and Space Administration, NACA (2020) also reported that global temperature had been on the increase since 1975 at an estimate of 0.05 °C for the past few decade, this had contributed to the depletion of the ozone layer leading to global warming. To curb this global menace, there is combined efforts by Government, individuals, and business around different countries. The aim of these efforts was to device a means where agriculture can adapt to current climate change in form of strategies leading a improved food security across the globe. One key concept that had since emerged is the climate smart agriculture. This ideal was developed by the



Food and Agriculture organization which had been accepted by several developmental institutional globally (Food and Agriculture Organization, 2013).

Climate smart agriculture helps to identify different strategies to mitigate climate change effects and increase food security status of farmers. The adoption of climate smart practices will promote food stability with the aim of keeping the environment safe from pollution. Furthermore, adoption of climate smart agriculture through cost effective practices such as use of organic manure crop rotation, use of legume crops, zero tillage, and others are thus needed to create a resilience system and educate small scale farmers with the with the needed strategies to mitigate climate changes effects on agricultural production (Mthethwa, *et al.*, 2022). The core objectives of climate smart agriculture are development of resilience practices to manage effect of climate change, promotion of increase output and profitability level for farmers, and limit emission of greenhouse gases, these core objectives tends to enhance food security development on a long run (FAO, 2022). Dietary demands of ever growing population and climate change can be addressed through the climate smart objectives. A major grain crop in sub-Saharan Africa is maize. Among the top producers of the commodities in Africa is Nigeria. Based on FAOSTAT (2016), the nation produces over 10% of the world's maize. A significant amount of fertilizer is consumed by the crop; according to a 2013 World Bank report, 16 kilogrammes of fertilizer were used for every hectare of arable crop grown in Nigeria. By using more productive agricultural techniques, the requirement for better soil nutrient management must be increased. There is need to emphasize the importance of soil fertility management as a means of improving agricultural productivity (USDA, 2014). Climate change practices is the solution to boast decline in soil fertility to promote increase output and income, thereby leading to national food security. Climate smart practices according to Ojo *et al.* (2024) includes mulching, use of improved seeds, crop rotation, mixed cropping, earning from non-farm income, and, land nutrient management. Despite effort efforts globally to support farmers to promote food security and agricultural productivity in Nigeria, past studies on climate smart practices such as (Ojo *et al.* 2024; Wahab, *et al.* 2020, Onyeneke, 2018, and Tihamiyu *et al.* 2017,) had limited their focus on the use of climate smart among farmers, and do not investigate the impacts on food security status and also household income and output. The choice of agricultural practices adopted during the crop production like maize largely depends on the method of production used by the farmer. Thus there is need to analyse the food security status and impact of climate smart practices on the income and output of maize farmers.

The main objective of the study was to analyse the food security status and impact of climate smart practices among maize farmers in Adamawa State Nigeria, while the specific objectives are to:

- i. describe the socio-economic characteristics of maize farmers;
- ii. assess the food security status among maize farmers,
- iii. estimate the costs and returns from maize production,
- iv. determine the impact of climate smart practices on output and income
- v. describe the constraints faced by maize farmers in the study area.

## **RESEARCH METHODOLOGY**

### **Study Area**

The study was carried out in Adamawa State, Nigeria. The state is located the northeastern region of Nigeria, on the Greenwich Meridian, it is situated between latitudes 7° and 11° N and longitudes 11° and 14° E. Gombe State to the north-west, Borno State to the north, Taraba to the south and west, and the Republic of Cameroun to the east were its neighbours. Adamawa State's total land area is approximately 38,741 km<sup>2</sup>, and according to the 2006 National Population Commission data, its population is 3,168,101 million. Adamawa State estimated population for 2024 is 4,914,876 based on the 3.2% annual population growth rate for the entire country. The state receives 700 mm of rain on average in the northwest and 1600 mm in the south. January and February are the driest months, while August and September are the wettest. The minimum recorded temperature is 18°C, while the highest recorded temperature is 40°C. In the south, the average monthly temperature is 26.70 degrees Celsius, whereas in the northeast, it is 27.80°C. In the State, farming and rearing animals are the most common employment. Among the crops cultivated are vegetables, cowpeas,



groundnuts, rice, sorghum, maize, and cotton (Tashikalma *et al.*, 2014). There are twenty-one local government areas (LGAs) in the state. The Southern Guinea Savannah and the Northern Guinea Savannah are the two prominent vegetation zones in the state. The topography is made up of beautiful mountainous terrain with valleys for the rivers Benue, Gongola, and Yedzeram. This undulating terrain includes the highlands of Adamawa Mountain, Mandara, and Cameroun (Adamawa Agricultural Development Programme, AADP, 1996). The state experiences distinct dry and rainy seasons due to its tropical environment. April marks the start of the rainy season, which concludes in late October.

### Sampling Techniques

A multi-stage sampling technique was used in selecting the respondents. In the first stage three (3) local government areas were purposefully selected based on participation on climate smart practices project, which was implemented by a local government organization in partnership with the state agricultural development Programme (ADP). Based on the intensity of maize produced in each agricultural zone, three communities were chosen from each local government area for the second stage. A community census conducted in the research areas was used to create the sampling frame in the third stage. A total of 206 maize farmers were selected for the study. The Raosoft sample size calculator was used to determine the sample size for the study. The sampling consist of both adopters and non-adopters of climate smart practices in the study area

**Table 1:** Sampling of Maize Farmers in the Study Area

Local Government Areas	Communities	Sampling Frame	Sample Size
Gombi	Gombi	92	43
	Parijo	71	33
Guyuk	Bobini	60	28
	Parokayo	63	29
Fufore	Maraban Cigari	62	29
	Parada	63	29
Total		442	206

**Source:** Adamawa State, Agricultural development program, 2023

### Data Collection and Analysis

Data were collected through the administration of structured questionnaires and analyzed using descriptive statistics, household dietary diversity score, gross margin, and propensity score matching.

#### Model specification

#### Descriptive statistics

The descriptive tools employed includes mean, standard deviation, charts, frequency and percentages.

#### Household Dietary Diversity Score (HDDS)

The levels of food security among maize farmers were assessed using the household dietary diversity score. This form of metric shows how many different types of food or food groups people eat and how often they eat them. The result is a score that shows how diverse people's intake is; scores have been found to be significantly correlated with measures of caloric adequacy (IFPRI 2006). For analytical purposes and in order to establish program targets or goals, Coates *et al.* (2007) suggested using the mean score or distribution of scores.

#### Gross Margin Analysis

According to Saras *et al.*; (2023) gross margin (GM) is the difference between the total variable costs and the gross farm income. In subsistence farming, for example, where fixed capital makes up a relatively small percentage of the farming operation, gross margin is a very helpful metric. Costs that fluctuate according on output levels are known as variable costs.

Therefore;

$$GM = GFI - TVC \dots\dots\dots (1)$$

Where GM = Gross margin (₦)



GFI = Gross farm income (₦)

TVC = Total variable cost (₦)

### **Propensity Score Matching (PSM)**

The influence of climate smart practices on maize output and household income in the study area was determined using Propensity Score matching. A statistical comparison group is created using this non-parametric method, which models the likelihood of adopting climate smart practices based on useful aspects that the technology does not overtly highlight. In PSM, farmers that have implemented climate-smart practices are matched based on the projected probabilities (propensity scores) from an estimated Probit or logit model.

The estimation of average treated effect on the treated (ATT) is specified as follows

$$ATT = E\{H1/D=1\} - E\{H0/D=1\} \dots\dots\dots(2)$$

The problem with estimation of the equation (2) is that it is not observable. However, it is probable to appraise equation (2) by replacing  $E\{H1/D=1\}$  with  $E\{H0/D=0\}$ -as follows

$$ATT = E\{H1/D=1\} - E\{H0/D=0\} \dots\dots\dots(3)$$

Equation (3) valuation is a skewed measurement of the causal influence of climate-smart practices. Controlling observable factors ensures that the adoption of climate-smart activities is random and unrelated to the outcome variables, i.e., the constrained independence hypothesis is satisfied. This leads to the modelling of a more reliable estimation.

$$P(z) = \Pr \{D=1/Z\} = E \{D/Z\} \dots\dots\dots(4)$$

$$ATT = E\{H1-H0/D=1\} \dots\dots\dots(5)$$

$$ATT = E\{E\{H1-H0/D=1, P(2)\} \dots\dots\dots(6)$$

$$ATT = E\{E\{H1/D=1, P(Z)\} - E\{(H0/D=0, P(Z))/D=0\} \dots\dots\dots(7)$$

where D is adoption (1 for climate smart farmers and 0 otherwise), Z is the vector of explanatory factors, and H1 is the value of the outcome for adopters of climate smart practices, and H0 is the value of the outcome for non-adopters of climate smart practices. The study adopted two matching methods (Kernel Based Matching and Nearest Neighbour Matching Radius Matching) rather than just one to guarantee the impact on farmers using climate-smart practices is robust.

## **RESULTS AND DISCUSSION**

### **Socio-economic Characteristics of Maize Farmers in the Study Area**

The results in Tables 2 revealed that 36.9% of the respondents fell between the age bracket of 31-40 years while 25.2% and 24.3% were between the ages of 41-50 and 21-30 years with a mean age of 39 years. This implies that respondents in the study area are in their active age to participate in maize production. These findings are consistent with those of Adebayo *et al.* (2021), who found that the average age of maize farmers in Niger State, Nigeria, was over 35 years. A significant household size in the study area was recorded with a mean household size of 6 persons. Majority (57.77%) of maize farmers had household size of between 2-6 persons while 36.41% and 5.83% had 7-11 and 12-16 persons, respectively. The results also revealed that 33.98% maize farmers had farming experience of between 21-30 years while 29.13%, 20.87%, 11.17% and 4.36% had 1-10, 11-20, 31-40 and 41-50 years of maize production, respectively with a mean of 10 years. This shows they have enough experience in maize farming activities in the study area. This finding agrees with Yahaya *et al.* (2020) where they observed that most of maize farmers in Kaduna state had farming experience above 1 year, which shows enough experience to adopt new practices in the study area.



**Table 2:** Qualitative Socio-economic Characteristics of Maize Farmers (n=206)

Variables	Frequency	Percentage	Mean
<b>Age (Years)</b>			39.00
20-30	50	24.3	
31-40	76	36.9	
41-50	52	25.2	
51-60	16	7.8	
61-70	12	5.8	
<b>Household size (Persons)</b>			
2-6	119	57.77	6.00
7-11	75	36.41	
12-16	12	5.83	
<b>Farming Experience(years)</b>			
1-10	60	29.13	10.00
11-20	43	20.87	
21-30	70	33.98	
31-40	23	11.17	
41-50	9	4.36	
<b>Annual Income (Naira)</b>			
100,000-200,000	84	40.78	110,500
201,000-300,001	26	12.62	
302,000-400,001	38	18.45	
402,000-500,001	34	16.50	
502,000-600,001	24	11.65	

**Source:** Field Survey, 2023

The results in Table 2 further revealed that 33.01% of the maize farmers were women while majority (66.9%) were men. This demonstrates that male-dominated maize production enterprise in the study area while the female counterparts concentrated on other areas of the maize value chain. Such results are consistent with those of Abdullahi *et al.* (2020), who found that males dominated maize production farming in Kano State, Nigeria. Less than half (44.17%) of the maize farmers had secondary education while 28.16% and 11.7% attended primary and higher institutions. This finding shows that maize farmers were well-educated and capable of implementing innovative climate-smart practices. In addition, majority (75.24%) of the maize farmers had contacts with extension agents, whereas 24.75% do not. The results also showed majority (87.37%) of the maize farmers were members of cooperative society, while 12.62% were not. Maize farmers who are part of a cooperative are more likely to adopt new technologies compared to their counterparts in the study area. The above findings is in line with that of Olatinwo *et al.* (2022), they discovered that majority of farmers in Kwara state belong to cooperative society in the study area. The result further shows that most (64.08%) adopted the use of climate smart practices while (35.92%) do not adopt the use of these practices in the study area.



**Table 3: Qualitative Socio-economic Characteristics of Maize Farmers (n=206)**

Variable	Frequency	Percentage
<b>Sex</b>		
Male	138	66.99
Female	68	33.01
<b>Level of Education</b>		
Quranic	34	16.50
Primary	58	28.16
Secondary	91	44.17
Tertiary	23	11.17
<b>Membership of Cooperative</b>		
Member	180	87.37
Non-Member	26	12.62
<b>Contact with Extension Agents</b>		
Contact	155	75.24
No Contact	51	24.75
<b>Climate smart practices adoption</b>		
Adopters	132	64.08
Non-adopters	74	35.92

**Source:** Field Survey, 2023

#### **Climate Smart Practices adopted by Maize Farmers in the Study Area**

The results in Table 4 presents the distribution of climate-smart practices adopted by maize farmers. The results revealed that most (94.0%) of the respondents adopted intercropping maize with legumes as climate smart practices. The process involved ways to increase soil fertility and boost maize yield, and legumes, like cowpea and groundnut, were cultivated with maize. The use of organic manure (87.0%) was another practice adopted which suggests that the farmers were using organic manure in the form of cow dung and chicken droppings in the study area. Other practices adopted by the maize farmers were improved seeds (79%), minimum/zero tillage (45%) and crop residue retention. The result agrees with the findings of Saadu *et al.* (2024) where they discovered that crop rotation, mixed farming and diversity of crop practices were among the climate smart practices adopted by farmers.

**Table 4: Climate Smart Practices adopted by Maize Farmers in the Study Area**

Climate Smart Practices	Frequency	Adoption rate	Percentage (%)	Ranking
Intercropping with legumes	194	0.94	94.0	1 <sup>st</sup>
Use of organic manure	179	0.87	87.0	2 <sup>nd</sup>
Use of improved maize climate smart seeds	163	0.79	79.0	3 <sup>rd</sup>
Minimum / Zero tillage	93	0.45	45.0	4 <sup>th</sup>
Crop residue retention	74	0.36	36.0	5 <sup>th</sup>
Crop rotation	38	0.18	18.0	6 <sup>th</sup>

**Source:** Field survey, 2023    \*\*Multiple response was allowed\*\*

#### **Food Security of Maize Farmers in the Study Area**

The availability, accessibility, stability, and utilization of food are the main pillars of food security. Food insecurity is the state in which a household is unable to achieve these four requirements (FAO, 2018). Table 5 showed the distribution of maize according to food security status. The findings revealed that the majority (81.0%) of the maize farmers in the study area have good dietary diversity scores, indicating that most of them were food secure; (13.0%) had medium dietary diversity scores, indicating that they were moderately food secure; and only 6.0% had low dietary diversity scores, with a mean score of 9.0, indicating that few of them were food insecure. The result therefore shows that high dietary diversity score among the maize farmers that they were food secure in the



study area. The result corroborates with Musab *et al.* (2019) who observed that the (60.3%) of groundnut adopters in Katsina State, were food secured.

**Table 5: Food Security Status of Maize Farmers in the Study Area (n=206)**

Household Food security Status	Number of households	Percentage	Mean
Good dietary diversity	167	81.0	9.0
Medium dietary diversity	27	13.0	
Low dietary diversity	12	6.0	

**Source:** Field Survey, 2023

### Costs and Returns of Maize Production in the Study Area

Table 6 shows the cost and returns from maize production in the study area. Profitability is determined by the connection between total returns and total production costs incurred during the course of a firm. The total variable cost (TVC) for maize in the study area was estimated to be ₦145,900. The estimated labour cost was ₦40,000, which accounts for 27.42% of the total variable cost. The estimated cost of fertilizer was ₦45,000, which made up 30.84% of the total variable cost. The cost of harvesting the maize produce was estimated to be ₦20,000, and accounts for 13.71% of the total cost of production, while the cost of herbicide was estimated to be ₦12,000 and accounts for 8.22% of the cost of production. The cost of transportation was estimated to be ₦10,900 and accounts for 6.79% of the total variable cost in the study area. The gross margin (GM) from the production of maize in the study area was ₦484,100, while and the total revenue (TR) was ₦630,000. Nevertheless, the return on investment (ROI) was 3.32 this means that for every naira spent in maize production, 2.32 naira was realized. According to these findings, maize production is a lucrative business in the study region. This finding agrees with Yahaya *et al.* (2020) who discovered that maize production was a profitable venture in Kaduna State, Nigeria.

**Table 6: Average Costs and Returns of Maize Production in the Study Area (one hectare)**

Items	Quantity	Unit price(₦)	Total cost (₦)	Percentage (%)
<b>Variable Cost</b>				
Cost of inputs				
Maize seeds(kg)	20	350	7000	4.80
Fertilizer-inorgnise (kg)	150	300	45,000	30.84
Fertilizer (organic)-truck	4	3000	12,000	8.22
Agro-Chemicals(litres)	4	3000	12,000	8.22
Labour (mandays)	8	5000	40,000	27.42
Harvesting	5	4000	20,000	13.71
Transportation (naira)	30	330	9,900	6.79
<b>Total Variable Cost (TVC)</b>			145,900	
<b>Returns</b>				
Average yield(kg/ha), (100kg)	3000			
Average selling price(kg)	210			
Total Revenue(TR)	630,000			
Gross margin (TR-TVC)	484,100			
R.O.I	3.32			

**Source:** Field survey, 2023

### Impact of Climate Smart Practices on Output and Income of Maize Farmers in the Study Area

A logistic regression of maize adoption status on the predictor factors was used to generate the propensity score, which is the expected probability of adopting the climate smart. Prior to determining the causal influence of climate-smart practices on adopters and non-adopters, the two primary tenets of PSM were assessed. To make sure the common support assumption is satisfied, the matching process quality was evaluated. In terms of distributing covariates evenly amongst adopters and non-adopters, the propensity score estimation procedure was successfully specified. The output productivity performance of the maize adopters of climate smart practices was substantial at 5%,



according to the nearest neighbour matching data (Table 7). This suggests that adopting climate-smart practices had the intended impact on the yield of maize produced by adopters in the research area. The maize yield for (adopters) who adopted climate smart practices was likewise significant at 10%, with a mean difference of 224.2, according to the matching results from the radius matching method and the stratification approach. The outcome also demonstrates that adoption of climate smart has had the intended impact on maize farmers' income. In order to achieve sustained food security and poverty reduction in the study area, the yearly farm income generated by the adoption of climate smart practices has the desired multiplier effect, which can help reinvest in additional farm and off-farm activities to generate more income. Based on the mean difference estimate of 3665.48, the matching findings from the radius matching approach and the stratification method showed that the maize income for (adopters) who embraced climate wise activities was substantial at 10%. Therefore, the findings indicated that climate smart practices among maize farmers in the study area are influenced by productivity performance in terms of output and income. This means that implementing climate smart practices can help achieve sustainable food security and poverty reduction by facilitating reinvestment into other farm and off-farm activities and producing the desired multiplier effect in terms of maize output. The result corroborates with Ibrahim *et al.* (2018) where they discovered that maize productivity in terms of output and income increase based on introduction growth enhancement of scheme in Katsina State, Nigeria.

**Table 7:** Impact of Climate Smart Practices on Output and Income of Maize Farmers in the Study Area

Matching Algorithms	ATT	Standard Error	T-value
<b>Output</b>			
Nearest Neighbor	341.705	180.502	1.89**
Stratified	224.2	183.46	1.22*
Radius	224.2	183.46	1.22*
<b>Income</b>			
Nearest Neighbor	-7693.12	75379.25	-1.11*
Stratified	3665.48	63724.65	1.35*
Radius	3665.48	63724.65	1.30*

**Source:** Field Survey, 2023

### Constraints Associated with Maize Production in the Study Area

Poor climate conditions, such as drought and floods, were cited by 98.0% of the maize farmers as the major obstacles that affected production. The majority of the farms were destroyed by floods, which also had an effect on the amount of harvest that was obtained from maize production. Inadequate information about climate smart practices (27.0%) was the second and most significant barrier among maize farmers. This knowledge hindered the farmers' ability to increase their level of productivity. The third and most significant limitation affecting maize farmers in the study region was inadequate capital. the most of farmers in the area lack access to credit facilities, which further hinders maize output. The additional limitations (16.0%) that maize growers had to deal with were pastoralists, theft, and conflicts within the rural areas. The findings are consistent with that of Abdullahi *et al.* (2021), where they observed that the main challenges affecting maize producers in Kaduna State, Nigeria, were pests, and diseases, and inadequate capital.

**Table 8:** Constraints Associated with Maize Production in the Study Area

Constraints	Frequency	Percentage	Ranking
Poor climatic condition	200	98.0	1 <sup>st</sup>
inadequate knowledge on climate smart practices	45	27.0	2 <sup>nd</sup>
Inadequate capital	40	24.0	3 <sup>rd</sup>
Pests and Diseases	37	22.0	4 <sup>th</sup>
Others (Pastoralist conflict, theft)	27	16.0	5 <sup>th</sup>

**Source:** Field Survey, 2023

\*\*\* Multiple response was allowed\*\*\*





## CONCLUSION AND RECOMMENDATION

The maize farmers adopted the use of climate smart practices, males predominated in maize production, but those that implemented practices were able to secure their sustenance. The maize enterprise was profitable with the use of climate smart practices. The study concludes that adoption of climate smart practices among maize farmers is capable of increasing their productivity in terms of output and income and also resulted to favourable food security level in the study area.

- i. There is a need for government and other financial institution to provide credit support to farmers to enhance more income and profitability in maize production in the study area.
- ii. There is a need to for government and non-governmental organization to encourage more women participation in maize production to augment the male farmers within the enterprise.
- iii. There is need for extension agents to guide farmers on the best periods to cultivate maize and right climate smart practices to adopt in the study area.

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