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ANALYSIS OF THE EFFECTS OF CLIMATE-SMART CROP PRODUCTION PRACTICES ON FOOD SECURITY AMONG CROP FARMERS IN BORNO STATE, NIGERIA

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Abstract

The study assessed effects of climate-smart crop production practices on food security among crop farmers in Borno State, Nigeria. The objectives of the study were to identify climate-smart crop production practices used by farmers; examine food security status of crop farmers; and determine the effects of climate-smart crop production practices on food security among crop farmers. Multi-stage sampling procedure was used in selecting 344 sample crop farmers. Descriptive and inferential statistics were used to analyze the data obtained. Results on climate-smart crop production practices of respondents depend on agro-ecological zone. The cross-cutting practices used include multiple cropping, mulching/use of cover crop, use of improve varieties of crops, early planting, increase application of fertilizer and zero/minimum tillage. The results on food security status revealed that only 45% 26.1%, and 10% of the respondents from Guinea, Sudan, and Sahel Savannah respectively are food secured. The coefficient of climate-smart crop production practices revealed positive and significant ($P \leq 0.05$) to food security of the respondents, implying that the higher the number of climate-smart crop production practices used by farmers, the better off their food security. The study concludes that farmers struggle to implement various smart crop practices peculiar to their agro-ecology and such practices had significant effects on food security. The study recommends that localize early warning information to be disseminated to farmers before the onset of rainy season and financial resources to be provided to farmers to ease implementation of climate smart crop practices.

Key words: Climate-Smart, Crop production practice, Food Security, Borno State

Introduction

The term climate change refers to an observed change in climate which is attributed directly or indirectly to human activities which alter the composition of the global atmosphere, and which are in addition to natural variability observed over comparable time periods (IPCC, 2007). Climate change is also a term that refers to major changes in temperature, rainfall, snow or wind patterns lasting for decades or longer, by both human made and natural factor (National Oceanic and Atmospheric Administration, NOAA, 2017). Various causes of climate change have been put forward, both natural and artificial. Climate change is caused by long term influence which are responsible for change in climate of the ice age to warmer time and also short-term change which are responsible for present climate change resulting from the accumulation of greenhouse gases (GHGs) due to human activities. Rising global average temperature is associated with widespread changes in weather patterns. Scientific studies indicate that extreme weather events such as heat waves and large storms are likely to become more frequent or more intense with human-induced climate change. The impact of climate change could be positive or negative (Melillo and Terese, 2016) and it exert its impacts on all work of live such as health, agriculture, world economy, transportation, security, rise in sea level, natural ecosystem and melting of glacier. De Acquah and Onumah (2011) reported that climate change poses a serious threat on environment, agricultural production and food security of most developing countries. Nigerian agriculture is among the hardest hit by climate change (Parry *et al.,* 2004; Mendelsohn & Massetti, 2017). The country's climate projections predict a rise in temperature of 1.1 to 2.5 °C by 2060 and an increase in the number of extreme heat days to 260 by 2100 compared with 10 days in 1990 (USAID, 2019). Studies have also documented increased variability in rainfall, dry spells and increased irregularity in the amount of precipitation once the rainy season sets in (Adejuwon & Odekunle 2006; Ayanlade *et al.,* 2017; Abatan *et al.,* 2018). This has resulted into poor performance of the agricultural sector making it unable to produce sufficient food for the growing population. The impact of climate change could be reduced through the use of Climate-Smart Agriculture (CSA) practices.

Climate-Smart Agriculture, as presented by FAO at the Hague Conference on Agriculture, Food Security and Climate Change in 2010, contributes to the achievement of Sustainable Development Goals (SDGs). CSA integrates the three dimensions of sustainable development (economic, social and environmental) by jointly addressing food security and climate challenges (FAO, 2013). CSA is composed of three main pillars: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; reducing and/or mitigating greenhouse gases emissions, where possible. The use of CSA among farmers is hindered by factors such as level of awareness, cost, climate financing, and sustainable policy (Adesina & Loboguerrero, 2021).

Nigerian agricultural sector contributes about 24% to the total annual GDP (Mohammed, 2025). The economic relevance of the agricultural sector is seen as a vital development tool for achieving the food self-sufficiency goal of the nation. However, despite the significant contribution of this food sub- sector in the economy, the problem of food insecurity, malnutrition and poverty are witnessed on the land attributable to the poor performance of the agricultural sector, which in turn creates food availability and accessibility problems at the household and national levels. The poor performance of agricultural sector has resulted to the inability of food production to meet up with the high demand as a result of the high population growth (Ben-Chendo *et. al*., 2018). Climate change has been one of the contributing factors to the poor performance of the agricultural sector in the country. To reverse the retrogressive growth of this important economic sector in the face of climate change, it is important to understand smallholder crop farmers' response to climate events and their investment in climate-smart practices. The decision to adopt a strategy depends on a farmer's knowledge of and confidence in the benefits of a strategy, the scale of his operation, the likely risk associated with not adapting and his financial ability to bear the cost associated with the strategy (Massetti & Mendelsohn 2018; Seo and Mendelsohn 2008). Lot of studies were conducted on effects of climate change on agriculture and determinants of climate-smart practices uptake. Little empirical evidence, however, exist on the effects of climate-smart practices on food security, particularly, among small scale farmer in Borno State. Therefore, this study looked at the nexus of climate-smart crop production practices and food security among farming households in Borno State, Nigeria. The specific objectives of the study were:

i. identify climate smart crop practices used by respondents;
ii. determine food security status of respondents; and,

iii. determine the effects of climate smart crop production practices on food security status of respondents.

Methodology

The study was conducted across the three agro-ecological zones of Borno State: Sahel Savannah, Sudan Savannah and Guinea Savannah (Fig. 1). As in many other regions of the Savannah, it is estimated that 80 percent of the population live in rural areas where the primary occupation is agriculture. It is also estimated that 80–90 percent of the population depends on agriculture for their livelihoods and food security (FAO, 2017). The majority of the population engages in small scale agriculture. Despite the huge agricultural potential of the region, the economic conditions of the people of Borno State are said to be worsen compared to other States. For instance, the poverty rate in the Borno has been estimated at 78%, the highest among the 6 regions of the country (FAO, 2017, Shettima *et. al*., 2026). This poor economic situation in the area is believed to be worsening recently as a result of the growing insecurity (*Boko Haram* insurgency) that is affecting the entire State and climate change. The later contributes to the dwindling socioeconomic and livelihood activities in the region (Shettima *et. al*., 2020).

The climate is characterized by alternate wet and dry seasons in response to the changes in pressure patterns, the rainy season in the state is associated with late onset and earlier cessation, the onset and cessation are also characterized by destructive storms which destroy life and property. The seasonal and latitudinal variations affect diurnal and seasonal temperature ranges, the highest maximum air temperature is recorded in the northern part usually areas north of latitude 9° and occur in March/April and minimum temperatures are recorded in December/January North of latitude 9°N. The region represents about 80% of the vegetation zones of Nigeria, experiencing lower rainfall and shorter rainy season and they make up the Savannah land. The region is made up of guinea Savannah, Sudan Savannah and Sahel Savannah agro-ecological zones (AEZs).

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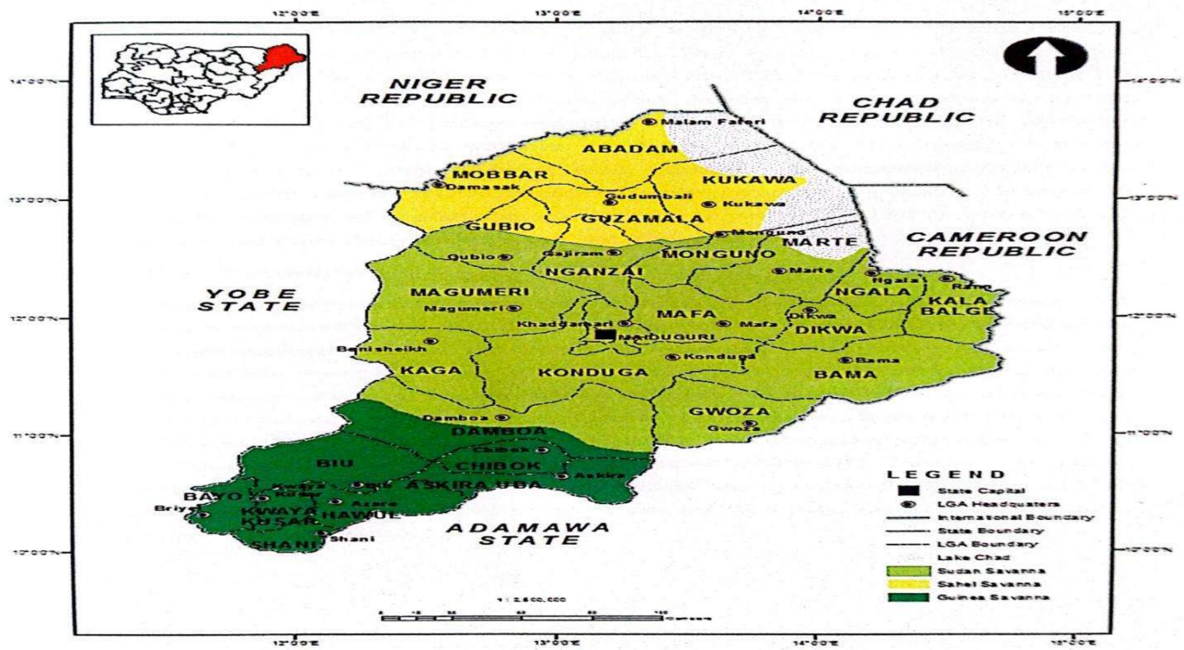

Fig. 1: Map of Borno State Showing Agro-ecological Zones
Source: Cartographic Unit, Department of Geography, University of Maiduguri

Qualitative and quantitative survey methods were used for the study. Using a mixed methodology helped to provide better information to address the stated objectives. The quantitative method was used to quantify the findings of the study while the qualitative method was used to develop a deeper understanding about the findings and provide recommendations that were useful for informed decisions. The data for the study were derived from both primary and secondary sources. Primary data were obtained from crop farming households.

Multi-stage sampling procedure was used in selecting sample respondents for the study. In the first stage, two (2) Local Government Areas (LGAs) were purposively selected based on the intensity of production from each agro-ecological zone of the study area, making a total of 6 LGAs. These include: Askira/Uba and Biu LGAs from Guinea Savanna; Jere and Mafa LGAs from Sudan Savannah; and Mobbar and Mongonu LGAs from Sahel Savannah agro-ecological zones. In the second stage, three communities were selected from each LGA purposively, based on accessibility to crop farming households, making the total number of eighteen communities. In the third stage, lists of crop farming households were obtained from crop farmers' association from each ward, 20% of the farmers were proportionately selected to give 344 sample respondents for the study. In addition, from each community, leaders of crop farmers' association of the selected crop were identified for Key Informant Interview (KII). In each community, Focus Group Discussion (FGDs) session was held with members of food crop associations of the various crop groups to validate information obtained from personal interview.

Table 1: Sampling Procedure

AEZ	LGA	Community	Sampling Frame	% Sample
Guinea	Hawul	Marama	380	38
		Ghuma	355	35
	Biu	Tum	382	38
		Biu	385	38
Sudan	Jere	Gungulun	382	38
		Dutsuman	460	46
	Konduga	Tungushe	250	25
		Malari	290	29
Sahel	Gubio	Gubio I	180	18
		Gubio II	190	19
	Mongonu	Gumsuri	90	09
		Askil	100	10
Total			**3,444**	**344**

Source: Compiled by Researcher, 2025.

Primary data were collected with the aid of *Kobocollect*, an electronic data collection tool. Enumerators were trained on the use of the *Kobocollect* tool in the different Agroecological zones of the study area. Computer Tablets and audio recorders were used for the data collection exercise. Descriptive statistics such as composite score analysis, food security scale and binary logistic regression model were used to analyzed objectives i & ii of the study.

Composite Score Analysis

The composite score was used in capturing CSA practices among farming households. A binary scale was used to represent the use of CSA practices by the farming households. Ten (10) CSA practices were identified in the study area. A practice was scored 1 if used by a respondent and 0 if not used by the respondent. A respondent based on the total number of CSA practices identified can only have a maximum score of 10 and a minimum of 1. The score generated was used as a proxy to represent CSA practices among the sampled farmers.

Binary Logistic Regression Model

The effect of CSA practices on household food security (obj. iii) was analysed using a binary logistic regression model.

The explicit logistic regression model is expressed as

$$I_i = B_o + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 + e \text{ ----------3.1}$$

Where:

Ii = Probability that a farmer is food secure (1 food secure household, 0 otherwise)

B_o = intercept

X_1 - X_7 = Explanatory variables

B_{1} - B_7 = Estimated coefficients e = The base of the natural logarithm

A logistic model is better expressed in odds and log of odds to simplify explanations on the parameter coefficients. The odds ratio explains the ratio of the household's likelihood of being food secure (Pi) to being food insecure (1—Ii). Ii1

The explanatory variables used include:

X_1 = Age (yr)

X_2 = CSA Practice (Composite score)

X_3 = Income Level (No.)

X_{14} = Household Size (No.)

X_{15} = Crop Produced (No.)

X_5 = Education Level (Yr)

X_7 = Farm Size (ha)

The following were climate-smart agricultural goals set by FAO (2013) and their respective practices:

(a) Increasing Agricultural Productivity and Incomes on Sustainable Basis

i) Diversifying cropping practices ii) Crop rotation iii) Mixed farming iv) Usage of wetland FADAMA v) High yielding cultivators vi) Agroforestry vii) Adjusting of planting date.

(b) Adoption and Building Climate Change Resilience

i) Planting drought-resistant varieties ii) Relocation from climate risk iii) Multiple cropping iv) Recycling of waste products v) Improvement in farmers' management skills vi) Agro-forestry vii) Zero tillage viii) Diversifying cropping practices

(c) Reducing Greenhouse Gas Emission

i) Conservation tillage ii) Cover crop iii) Application of organic and inorganic fertilizers iv) Agro-forestry v) Usage of wetland FADAMA

This implies that only farmers observed to be practicing climate-smart production practices that cut across two main objectives of climate-smart agriculture were considered user of climate-smart agriculture. This means that partial users or farmers using a practice achieving one objective of CSA as stated by FAO (2013) were not considered as users of CSA practices in this study.

Results and Discussion

Climate Smart Agriculture (CSA) Practices Used by Crop Farmers

The result on farm level CSA practices by crop farmers in the three agro-ecological zones is presented in Table 1.

Table 1: Distribution of Respondents based on CSA Crop Production Practices Used

CSA Crop Production Practices	Sudan Savannah (n= 138)		Guinea Savannah (n=149)		Sahel Savannah (n=56)	
	Frequency*	**Percentage**	**Frequency***	**Percentage**	**Frequency***	**Percentage**
Multiple Cropping	125	90.58	130	87.25	40	71.43
Application of Chemicals	52	37.68	45	30.20	26	46.43
Early Planting	110	79.71	33	22.15	42	75.00
Application of Fertilizer	20	14.49	104	69.80	30	53.57
Mulching/use of Cover Crops	65	47.10	50	33.56	25	44.64
Use of New Crop variety tolerant to new climate regime	85	61.59	130	87.25	38	67.86
Application of Organic Manure	32	23.19	18	12.08	26	46.43
Irrigation Supplementation	5	3.62	6	4.00	7	12.5
Zero/Minimum Tillage	35	25.36	75	50.34	47	83.93
Agroforestry	15	10.87	50	33.56	00	0.00

Source: Field Survey, 2025.

* Frequency based on Multiple Responses

In Sudan Savannah agro-ecological zone, the result revealed that 90.58% of the respondents used multiple cropping as CSA practice, 79.71% practiced early planting, 61.59% used new crop varieties tolerant to new climate regime and 47.10% of the respondents employed mulching and use of cover crops as CSA practice. The result on CSA practices adopted by farmers in guinea savannah agro-ecological zone revealed that (87.25%) of the respondents practiced multiple cropping and new crop varieties tolerant to new climate regime respectively, 69.80% of the respondents practiced increased use of fertilizer and 50.34% employed zero/minimum tillage. In Sahel agro-ecological zone, major CSA practices include early planting (75.00%), multiple cropping (71.43%), use of new crop variety tolerant to new climate regime (67.86%), and increased application of fertilizer (53.57%). The use of multiple cropping or crop diversification is considered as a tradition for smallholder farmers as reported by many authors (Enete *et al*., 2011; Mohammed, *et al*., 2014). The practice, however, has been intensified as a result of climate change. Multiple cropping is aimed at spreading climate risk over two or more crop enterprises (adaptation) as climate factors affect crop enterprises differently. This is because different crops have different level of resilience to climate variability; hence planting many crops could ensure that farmers get some output in the face of extreme climate situation (increased productivity). The result is in with observation of Tekeste (2021) who reported that farmers practiced inter-cropping using cereals and legumes in Siyadebrina District, Ethiopea.

Early planting is an age-long practice by crop farmers. The main trust of the strategy is to ensure that critical growth stages do not coincide with the harsh climate condition usually experienced at the end of the wet season (adaptation). Farmers reported that as soon as the rainy season starts, they sow their crops. The strategy, however, requires re-sowing, as not all the seeds germinate as a result of moisture deficiency in the soil at the beginning of the raining season. This will ensure also appreciable yield is obtained by farmers (increased productivity). Majumder *et a*l. (2024) reported that majority of farmers in climate vulnerable coastal areas of Bangladesh used early planting. Mulching/use of cover crops is aimed at conserving moisture content of the soil. Couple with soil characteristics, the rainfall regime in the Sudan and Sahel Savannah is scanty, therefore, farmers resort to adopt the strategy in order to conserve the little moisture in the soil by covering the soil either with cover crops (cowpea, groundnut) or some non- crops materials (thatch, farm waste). This will ensure that soil surface is not directly exposed to the sun radiation thereby minimizing the rate of evaporation (adaptation). When crops get adequate moisture, crop performance will be enhanced thereby ensuring better returns (increased productivity). Egeru *et al*. (2022) reported the use of mulching as one of the main CSA practices in Nakasongola District, Uganda.

The use of new crop varieties tolerant to new climate regime has been practiced by farmers in all the agro-ecological zone of Borno State. New crop varieties such as maize, cowpea and soybean are promoted by International Institute for Tropical Agriculture (IITA), International Fund for Agricultural Development (IFAD) and government agencies in the State. This paved way for farmers to adopt it as a CSA strategy to climate change. The main trust of using new crop varieties could be two folds: grow fast to meet up the shortened wet season (adaptation) and yield high to ensure that farmers get income in the face of climate change (increased productivity). Tekeste (2021); Erekalo and Yadda (2023) also reported the use of new crop variety as a CSA practice in Ethiopea. The use of chemical as a CSA strategy is gaining ground among farmers, evidenced from the result of the study. Chemical such as herbicides application is a substitute for labour in farm business. Considering the cost of labour in farm operations and the adverse effects of climate change on crop production, farmers lessen the cost of labour using chemicals as CSA strategy hence reduced cost of crop production (adaptation) leading to increased profitability of farm business (increased productivity). Agroforestry ensures integrating trees into crop farming systems. Crop farmers can reap multiple benefits that help combat climate change. Such benefits include carbon sequestration (mitigation); soil conservation, biodiversity boost, improved water cycles and increased resilience (adaptation). For crop farmers, agroforestry can be a game-changer, improving soil fertility, reducing climate-related risks, and opening new income streams (e.g., timber, fruits, or nuts). The use of organic fertilizer by crop farmers helps reduce greenhouse gas emissions (mitigation); improves soil health and increases crop yields (increased productivity). It's a cost-effective way to promote sustainable agriculture (adaptation).

Food Security Situation among Respondents

The result on food security situation of the respondents in the different agroecological zones of the state is presented in Table 2. The result reveals that only *45*% 26.1%, and 10% of the respondents from Guinea, Sudan, and Sahel Savannah are food secured respectively. This result implies that majority of the respondents are food insecure. Low food security situation across the three agroecological zones of the state could be attributed to low crop yield occasioned by climate change, ravages of insecurity (*Boko Haram*) in the State and inadequate institutional support. The result concurred with that of Shettima *et al*. (2020) who observed that only 23% of the households ravaged by *Boko Haram* insurgency in Northeast, Nigeria were food secured.

Table 2: Food Security Situation of the Respondents based on Agroecological Zones (n = 344)

Sudan Savannah (n =138)		Sahel Savannah (n= 56)		Guinea Savannah (n = 150)	
Food Secure no. %	Food Insecure no. %	Food Secure no. %	Food Insecure no. %	Food Secure no. %	Food Insecure no. %
36 (26.1)	102 (73.9)	10 (17.9)	46 (82.1)	45 (30.0)	105 (70.0)

Source: Field Survey, 2025.

Guinea Savannah's food security situation is relatively better compared to other agroecological zones of the state, mainly due to its more favorable agricultural conditions. The region's fertile land and access to water resources make it suitable for farming, allowing households to grow crops like sorghum, millet, and cowpea. In addition, guinea Savannah zone has seen relatively less conflict compared to the Sahel and Sudan zones, which has allowed farming activities to continue with fewer disruptions. This stability has enabled farmers to maintain their livelihoods, contributing to improved food security thereby reducing vulnerabilities (Mohammed, 2021). However, challenges persist, including climate change impacts, such as droughts and erratic rainfall, which affect crop yields. Moreover, the region still faces economic and infrastructure challenges, limiting access to markets.

Sahel Savannah's high food insecurity incidence stems from a mix of factors. The region's harsh climate, with frequent droughts and sandy soils, makes farming tough. But beyond that, *Boko*

Haram insurgency affects the zone harder, displacing farmers, destroyed farms, and disrupted humanitarian aid. Also, poor roads and markets make it hard to access food or sell produce.

Climate change affects food security through rise in temperature, changing rainfall patterns, and extreme weather events that impact on crop yields. This translates to less food availability especially in vulnerable areas, rise in food prices, making it harder for people to afford leading to more malnutrition and hunger, especially among kids and the poor. In Borno State, these impacts are worsen as a result of droughts, desertification, and other natural resources degradation stressing food systems. Marzban *et al*. (2023) observed that climate change has made it very difficult to achieve food security goals. This is because average temperature of the earth is about 1 °C warmer than previous decades. In this regard, temperature is expected to rise between 2 and 4 °C for decades to come. The number of climate shocks such as severe heat stress, drought, and floods will increase and continue (Eslami, 2021).

The *Boko Haram* insurgency has had a devastating impact on food security in Borno State, Nigeria. The conflict has led to a significant decline in agricultural production, with crop production dropping by 82% for sorghum, 67% for rice, and 55% for millet between 2010 and 2015 (UNDP, 2018). This has resulted in widespread food insecurity, with over 3.8 million people facing critical food insecurity and 7.7 million in need of life-saving humanitarian assistance. The insurgency has disrupted farming activities, destroyed infrastructure, and forced farmers to flee their lands. Many farmers have abandoned their farms, leading to a shortage of food and increased prices. The conflict has also disrupted markets, making it difficult for people to access food items.

Inadequate institutional support has worsened food insecurity in Borno State. Weak governance, limited funding, and poor coordination have hindered effective responses to food crises. Bashir and Mohammed- Sani (2025) identifies corruption, patronage politics, and weak institutional frameworks as key governance failures undermining Nigeria's food security. Humanitarian aid often falls short of needs, agricultural support for farmers is limited and infrastructure like roads, irrigation infrastructure and storage facilities are lacking. In a state already affected by conflict and climate shocks, this institutional gap leaves communities more food insecure.

Effects of Climate Smart Agriculture (CSA) Practices on Food Security

Result on the effects of climate Smart agriculture (CSA) practices on food security is presented in Table 3. Results revealed that the coefficient of age, CSA practices, income level, farm Size, household size and education level were positive and significant and affecting the food security of farmers in the study area at varying levels of significance.

Table 3: Effects of CSA practice on Food Security

Variable	Coefficient	Standard Error	Z- value
Age	1.240503	0.349134	3.55*
CSA Practices	2.210000	0.790412	2.80**
Income Level	0.360084	0.142314	2.53**
Household Size	0.347231	0.184023	1.89**
№ of Crops Produced	0.884212	0. 541100	1.63NS
Education level	1.873584	0.521646	3.59**
Farm Size	0.125047	0.060683	2.06**

Source: Field Survey, 2025.

** Significant at 5%; * Significant at 10%; NS No Significance

Result on age implies that the higher the age of farmer, the better the food security of the household. Age exposes farmers to the access to resources such as inputs and information with which farmer utilizes to achieve food security. Often young farmers are more energetic and open to new technologies but might lack resources or land access. Older farmers have more experience but might struggle with labor-intensive work or adapting to climate changes. Elderly farmers are more vulnerable to food insecurity if they can't farm effectively or lack support. In the study area, elderly farmers might face extra challenges amid conflict and climate stresses. Haddabi *et al.* (2019) contradict the result and observed that age is negative and significant influencing likelihood of being food secured. Young and energetic household heads are expected to cultivate larger farms compared to the older and weaker household heads.

CSA practices plays an important role in achieving food security of farmers. The result implies that the higher the number of CSA practices use by farmers, the better the households' food security. One of the pillars of CSA is increase productivity. If productivity is enhanced, food security can be achieved. By focusing on sustainability and resilience, CSA helps to protect the environment and ensure farmers adapt to climate change impacts such droughts and erratic rainfall. CSA practices such as inter-cropping and conservation tillage boost productivity, drought-tolerant crops and agroforestry help farmers cope with climate stresses, efficient water management and soil conservation support long-term food production. This result concurred with that of Victor *et al*. (2022) who observed that CSA practices have positive effects on households’ food security in South Africa. Teklu *et al*. (2024) also observed that CSA practices such as crop residue management, compost, and agroforestry have significant effects on improving household's food security by 21.3%, 13.6% and 16.6% respectively.

Result on level of income implies that the higher the level of income of respondents, the better food security of the households. Income level has a direct impact on food security for farming households. Low-income households struggle to afford food, often relying on limited farm produce. Middle income households' better access to food but might still face challenges like price shocks. Higher income households are better food secure because they are exposed to more food options, ability to invest in farming, and buffer against food crises In Borno State, low-income level households are vulnerable to food insecurity, especially amid conflict, inflation and climate stresses. Pearl (2024) observed that income level of farmers affects their food security in Rias Village, South Bangka Regency. Result on household size on food security implies that the higher the household size, the better the food security of the household. Small households might have more food per person, but labor can be limited. Large households have more labor for farming, but food has to stretch further. Many dependents can strain food resources. Generally, large farm size May mean more farm labour that will ensure food security of households.

Result on education level implies that the higher the education level, the better the food security of households. Education exposes farmers to information and financial services necessary for meeting households' food security. With higher education, farmers make informed decisions on farming practices, adopt new technologies, and access better markets, while lower education limits access to information on improved farming methods, climate resilience, and financial services. In the study area, farmers with more education tend to have better food security outcomes. Kodjo and Kwami (2023) observed that education level has positive effect on respondent's food security. This means that the probability that the individual is food secure increases if he or she has a higher level of education. This result can be explained by several channels. First, education may allow the individual to access food and nutrition information necessary for the individual to be food secure. Second, education can enable the individual to access well-paid jobs. Also, education helps the individual to be more productive; this is a crucial link for the individual to be food secure if he/she lives especially in rural areas: this is the productivity effect. Finally, education allows the individual to have a solid social capital. This constitutes the last resort for the individual and therefore allows him to escape from food insecurity.

Result on farm size implies that the larger farm size the better the household food security. Households with small farms might struggle to produce enough food, especially if soil is degraded. Medium farms households can meet household needs and maybe sell surplus, while large farms households are more likely to produce enough food and generate income. To some extent, in the face of climate change, farm size is immaterial. This is because if natural calamity befalls, it often leave farmers with big farm size and huge investment with big loss. Ruslan and Prasetyo (2023) found that the farm size has a positive impact in lowering the likelihood of experiencing moderate or severe levels of food insecurity among agricultural households. The study also found that agricultural households with a higher probability of being food insecure are characterized by having higher members of households, relying only on agricultural activities.

Conclusion and Recommendations

The study concludes that climate-smart production practices affects food security in the study. Crop farmers have being implementing various climate-smart practices at the farmers' disposal to reduce the effects of climate change on food production, thereby enhancing their food status.

The study recommends the following:

i. localize early warning information to be disseminated to farmers to enable them adjust and plan farm operations.

ii. financial resources to be provided to farmers so that farmers can implement more climate smart practices.

iii. institutional support such as social protection programs to be provided to farmers. These include livelihood support, insurance, cash transfer and public works. This will ensure farmers practice number of climate smart crop practices for enhanced food security.

iv. measures to protect environmental resources for sustainably to be taken. Measures such as afforestation/reforestation strategies, agroforestry among others.

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