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EFFECT OF CLIMATE SMART AGRICULTURE ON FOOD SECURITY STATUS OF ARABLE CROPS FARMERS IN NIGER STATE, NIGERIA

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Abstract
The study was conducted to examined the effect of climate smart agriculture on food security status of arable crops farmers in Niger state, Nigeria. Multistage sampling technique was used to select 150 respondents for the study. The data collected were analyzed using descriptive statistics such as mean, percentage, frequency distribution and inferential statistics such as ordered probit regression F-G-T Model and binary probit regression. The study revealed that majority of the arable crop farmers in the study area had average age of 48 years and married with an average household size of 6 persons. Furthermore, most of the respondents had formal education, with an average of 8 years of formal education, less than average had access to extension services and while membership of cooperative was low. The study also revealed that rotational grazing ($\bar{X}$ =7.09), planting of cover crops ($\bar{X}$ =6.76), planting of drought resistance varieties ($\bar{X}$ =6.57), use of compost and mulch ($\bar{X}$ =6.54) and capturing and storing water ($\bar{X}$ =6.35) were the water management strategies CSA adopted. Also, the use of green manure ($\bar{X}$ =3.32), no-till or zero tillage practice ($\bar{X}$ =3.16) and agro-forestry ($\bar{X}$ =3.04) were the conservative CSA strategies adopted. Similarly, the soil and land management CSA strategies adopted include; afforestation ($\bar{X}$ =6.28), ploughing land in direct direction ($\bar{X}$ =5.94), crop rotation ($\bar{X}$ =5.91) and shifting cultivation ($\bar{X}$ =5.94). the result also shows that level of education, complexity of CSA, access to government support, family labour, relative advantage of CSA and compatibility of CSA were the significant factors influencing adoption of climate smart agricultural technologies in the study area. Furthermore, the result shows that more than half (52.1%) of the arable farmers were food secure. Hence it was recommended that the arable farmers should be encouraged to sustain adoption different CSA practices to enhanced their agricultural productivity.

Key words: climate smart, food security, Arable crop and Adoption

INTRODUCTION

Agriculture plays a vital activity in the regional and economic development of the country, which has depreciated over the past decade due to the dominant functions of the crude oil in the economy. Nigeria has adequate natural resources to increase the production of crops to meet the nutritional value and availability of food for consumption, which increase the population in the country. Agriculture increases the foreign exchange from agricultural export earning to finance import of capital goods (Adebayo and Ojogu, 2019). One of the greatest challenges that humanity has ever faced is climate change. An event that causes floods, drought, and damage farmer's livelihoods by affecting weather patterns, ecosystem, water supplies, food security, settlements and human health (Food and Agriculture Organization (FAO), 2019). Climate and agriculture are strongly interconnected universal processes and therefore, variations in climate change influence agricultural activities by increasing the amount of greenhouse gas emissions which have a lot of prospective effects on plants and may have indirect threats on herbivores and all other food chain members. On the other hand, there is a growing concern that climate change will seriously affect the ability to meet the food demands of about 10 billion world population come 2050 (Ideki, 2019). which is a significant reason why experts are promoting climate-smart-agriculture. The region most vulnerable to climate change are the developing countries especially the African countries, which are characterized by a high level of poverty, subsistence food production, and land degradation problems. This is because their economics depends to a large extent on agriculture and they have inadequate capital for adopting and implementing the right measures.

The concept of Climate smart agriculture (CSA) refers to an approach to developing the technical, policy, and investment conditions to achieve sustainable agriculture development for food security under climate change (FAO, 2019). The climate smart agriculture approach is vital as it contains three scopes of sustainable development which are mutually addressing ecosystems management, food security and climate change challenges. Climate smart agriculture include proven practical techniques like; mulching, inter cropping, crop rotation, agro-forestry, conservation of agriculture and water management. Usage of CSA-practices by farming households either in combination or in isolation can lead to increase agricultural productivity, improve adaptation to climate change, and reduce mitigation costs for greenhouse gas emissions. However, efforts to promote CSA in African are proceeding at the policy level, as African leaders endorsed the inclusion of CSA in the New Partnership for African's Development (NEPAD) program on agriculture and climate change to improve food security in the region (Zongmore *et al.*, 2016).

To this end, the specific objectives of this study were:

i. describe the socio-economic characteristics of the arable crop farmers in the study area;
ii. examine the adoption level of CSA among arable crop farmers in the study area;
iii. determine factors influencing adoption of CSA among the arable farmers in the study area;
iv. determine the food security status of the arable crop farmers in the study area;

METHODOLOGY

This study was conducted in Lavun, Bosso and Mariga Local Government Areas (LGAs) of Niger state, Nigeria. Niger State was created out of the former North Western State and became a fully autonomous State on 3rd February, 1976, with headquarter at Minna. Niger State is in the North-central part of Nigeria and lies in between longitude 3^0 30^1 and 7^0 20^1 East of the Greenwich Meridian and latitude 8^0 20^1 and 11^0 30^1 North of the equator. The State presently comprises of 25 Local Government Areas (LGAs) and it is made up of three major ethnic groups which are the Nupe, Gbagyi and Hausa. However, the total inhabitants in the State are over 3,954,772 people during the 2006 population census. But, going by the annual population growth rate of 2.5% in Nigeria, the population of Niger State was projected to be 5,556,200 in the year 2016 (National Bureau of Statistics, 2018). Multistage sampling technique was used for this study. The first stage involved selection of one (1) LGA from each of the zones (I, II, III). In the second stage, three (3) villages was randomly selected from each of the selected LGA. The third stage involved the use of Yamanne formula to select sample size from the sample frame of each village as obtained from Niger State Agricultural and Mechanization Development Authority (NAMDA). Thus, a total of 150 registered arable crop farmers were randomly selected as respondents for this study.

Data were collected using semi-structured questionnaire and analysis was conducted using descriptive statistics (mean, frequency distribution, and percentage) and inferential statistics (Probit regression model and FGT model) to the analyse the determinant factors influencing adoption of CSA among the arable farmers and the food security status of the arable crop farmers in the study area were specified as follows:

Ordered Logit Regression

Ordered Logit regression analysis was used in the study to analyse objective III which is to determine the effect of climate smart agriculture on food security status of rural farming households.

$Y=(X_1, X_2, X_3,\ldots\ldots X_n)$……………………....(1)

$Y=X_1+B1x1+B_1X_2+\ldots.B_n X_n+e$…………………….(2)

Where, Y=Dependent variable

X_1- Xn = Independent variables

$Y=b_0+b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5+b_6X_6+b_7X_7+b_8X_8+b_9X_9+b_{10}X_{10}+b_{11}X_{11}+b_{12}X_{12}+e$

Where Y= Level of adoption (highly adopted=3, rarely adopted=2, Not adopted=1)

X_1= Age (in years)

X_2= Household size (total number of people in the house)

X_3= Level of education (number of years spent in school)

X_4= Marital status (married=1, otherwise=0)

X_5= Land ownership (owned=1, otherwise = 0)

X_6= Farm size (number of hectares)

X_7= Farming experience (number of years)

X_8= Extension visit (number of visits received)

X_9= Access to government support

X_{10}= Cooperative membership (member=1, otherwise = 0)

X_{11}= Farm income (in naira)

X_{12}= Access to credit (access = 1, otherwise = 0)

X_{13}= Complexity of CSA (yes=1, no=0)

X_{14}= Relative advantage (yes=1, no=0)

X_{15}= Compatibility of CSA (yes=1, no=0)

b_1- b_{15} = Coefficients of independent variable

b_0 = Constant term

e=error terms

FGT model

The analysis of food security incidence using FGT measure usually starts with ranking of expenditures in ascending order Yi _ Y, _ ... _; Yn

$P_\alpha = 1/N\sum_{i=1}^{a}(Zi-Yi/Zi)\alpha$

α = Non-negative food security aversion parameter, which can be measured for food security status, for food secure 1 and food insecure 0.

Y_i = The per capita income of its poor household.

n, = The total number of sample households,

q = The number of households below the food security.

Z = food security line.

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Arable crop Farmers

Age of the respondents: The result in Table 1; indicates that the mean age of the arable crop farmers was 48 years suggesting that they were still within the active and productive age, strong, energetic and full of innovative ideas that could be advantageous in the adoption of new technologies like climate smart agriculture (CSA). The age of farmers is an important factor to consider when analyzing their willingness and ability to adopt new technologies, as younger farmers may be more open to change and have the physical and mental capacity to adopt new technologies. This finding agrees with Ayanlade *et al*. (2017) who found that younger farmers were more likely to adopt new agricultural technologies than older farmers.

Marital status of the respondents: Table 1; also shows that the majority (83.3%) of arable crop farmers in the study area were married. This finding implies that most of the crop farmers in the study areas were married as family responsibilities which could enhance the adoption of CSA. Also, Married couples typically share resources and responsibilities. This could also be crucial for the adoption of CSA as it may require initial capital to adapt to new innovations. The combined resources and labour of a married couple could make it easier to experiment the CSA and absorb any potential risks associated with adopting the innovation.

Household size of the respondents: The result in Table 1, also reveals that more than half (56.7%) of the arable crop farmers had household size of 1 - 5 persons, with an average household size of 6 persons. This implies arable farmers in the study area had moderate household size. This follows National Bureau of Statistics household panel survey (2020) report that the national average household size in Nigeria in 2019 was 6 persons. The moderate household size observed among arable crop farmers in the study area could have enhance the adoption of CSA and enhanced food security because moderate household size may mean that farmers have a manageable number of dependents, allowing for more focused resource allocation and potentially making it easier to introduce and sustain changes in agricultural practices. This is consistent with the study of Yisa and Olufunke, (2019) who stressed that household size was a significant determinant of adoption of innovations.

Education status of the respondents: Table 1; reveals that majority (73.3%) of the arable crop farmers have formal education with an average of 8 years of schooling. This implies that the level of literacy among arable farmers in the study area was high. This high literacy level can enhance the adoption of climate-smart agriculture (CSA) practices which will invariably enhance food security status. More so, literacy and education levels can influence farmers' decision-making processes. Farmers with higher education levels may be more capable of analyzing information, evaluating risks and making informed decisions, including decisions related to the adoption of CSA which can enhance their food security status. This finding is consistent with the study of Olusegun *et al.* (2016) who found that education was a significant factor influencing farmers adoption of technologies.

Table 1: Distribution of respondent according to socioeconomic characteristics

Variable	Frequency	Percentage	Mean
Age			
30yrs and below	4	2.7	
31-60	129	86.0	48 years
above 60yrs	17	11.3	
Marital status			
Widow	11	7.3	
Divorced	9	6.0	
Single	5	3.3	

Married	125	83.3	
Household size			
1-5 persons	85	56.7	
6-10	43	28.7	6 Person
above 10 persons	22	14.7	
Formal education			
No	40	26.7	
Yes	110	73.3	
No of years spent in schooling			
0 (no formal education)	40	26.7	8 years
1-6yrs (primary)	20	13.3	
7-12 (secondary)	81	54.0	
above 12yrs (tertiary)	9	6.0	

Source: Field survey, 2023

Adoption level of CSA among arable crop farmers

The results in Table 2; present the adoption level of CSA technologies among rural farmers in the study area. Water use management shows Kendall's W^a of .072 with a Chi-Square value 108.158 suggesting a statistically significant level of agreement among respondents regarding the adoption of Climate-Smart Agriculture (CSA) technologies related to water use management. A Kendall's W value of 0.072 suggests a positive but relatively low level of agreement among respondents. While it indicates that there is some agreement beyond what would be expected by chance, the strength of the agreement is not very high. The water management strategies mostly adopted include; rotational grazing ($\bar{X}$ =7.09), planting of cover crops ($\bar{X}$ =6.76), planting of drought resistance varieties ($\bar{X}$ =6.57), use of compost and mulch ($\bar{X}$ =6.54) and capturing and storing water ($\bar{X}$ =6.35).

Rotational grazing involves systematically moving livestock between different pasture areas. The high mean score suggests its widespread adoption as a water management strategy. This practice is beneficial because it prevents overgrazing, allows for natural pasture recovery, and minimizes soil erosion. By rotating livestock, farmers can optimize forage utilization, maintain healthy pasture ecosystems, and reduce water stress on specific areas. This follows the study of Ema and Hons (2018) who reported that rotation grazing is one CSA strategies adopted by farmers to mitigate against effects of climate change.

The planting of cover crops involves cultivating specific crops to cover and protect the soil during non-growing seasons. The high mean score indicates widespread adoption, and this practice offers multiple benefits for water management. Cover crops reduce soil erosion, enhance water infiltration, and improve soil structure. They act as a protective layer, preventing water runoff and promoting groundwater recharge. Additionally, cover crops contribute to weed control, nutrient cycling, and overall soil health. The adoption of drought-resistant crop varieties is crucial in regions prone to water scarcity. The high mean score reflects the recognition of the importance of planting crops resilient to drought conditions. Drought-resistant varieties can withstand water stress, ensuring better yields during periods of reduced rainfall. This strategy contributes to climate-smart agriculture by enhancing resilience to changing weather patterns. Farmers adopting drought-resistant varieties are likely to experience more consistent yields, improved food security, and reduced vulnerability to climate-related risks, emphasizing the practicality and effectiveness of this water management strategy.

Regarding risk Management, the estimated Kendall's W value of 0.015 for risk management indicates very low agreement among respondents in the study area regarding the adoption of risk management strategies. This value is close to zero, suggesting that there is minimal concordance or consensus among respondents in their practices or attitudes related to risk management. The low Kendall's W value implies that respondents have diverse or inconsistent approaches to risk management. There is little agreement in the adoption of specific risk management strategies, and practices may vary widely among farmers in the study area. The lack of agreement may stem from differing perceptions of risks within the farming community. Farmers may prioritize different types of risks or employ varying strategies based on their individual circumstances, experiences, or assessments of potential threats.

In terms of conservation practices, the estimated Kendall's W value of .358 indicates a moderate level of agreement among respondents regarding the adoption of conservation practices. The use of green manure ($\bar{X}$ =3.32), no-till or zero tillage practice ($\bar{X}$ =3.16) and agro-forestry ($\bar{X}$ =3.04) were the most conservative strategies adopted. The moderate adoption of green manure practices ($\bar{X}$ = 3.32) suggests a pragmatic acknowledgment of its benefits. Green manure, often involving legume crops, contributes to soil fertility through nitrogen fixation, adds organic matter for improved soil structure, suppresses weeds, and aids in erosion control. This practice aligns with sustainable farming by enhancing soil health and reducing the reliance on external inputs. Similarly, the moderate adoption of no-till or zero tillage practices ($\bar{X}$ = 3.16) reflects a practical recognition of its advantages. By minimizing soil disturbance and preserving crop residues, no-till practices contribute to soil conservation, water retention, energy savings, and carbon sequestration. This approach resonates with farmers seeking environmentally friendly and resource-efficient methods. The adoption of agro-forestry practices ($\bar{X}$ = 3.04) is moderately acknowledged among respondents. Agro-forestry, integrating trees with crops, supports biodiversity, soil conservation, climate resilience, and diversified income sources. The adoption underscores an appreciation for ecological diversity and the potential economic benefits of integrating trees into agricultural landscapes.

Table 2; Adoption level of CSA among rural farmers in the study area

CSA strategies	Mean	Rank
Water use and management		
rotational grazing	7.09	1st
planting of cover crops	6.76	2nd
planting of drought tolerant crops	6.57	3rd
use of compost and mulch	6.54	4th
capturing and storing of water	6.35	5th
construction of sub surface drainage	6.32	6th
Kendall's W[a]	.072	
Chi-Square	108.158	
Risk Management		
used of improved farm machinery	2.59	1st
use of fertilizer	2.53	2nd
use of improved seed	2.52	3rd
conservation tillage practices	2.36	4th
Kendall's W[a]	.015	
Chi-Square	6.527	
Conservation agriculture practices		
use of green manure	3.32	1st
no-till or zero tillage practice	3.16	2nd
agro forestry practice	3.04	3rd
direct planting seedling	2.92	4th
practices of conservation tillage	2.56	5th
Kendall's W[a]	.358	
Chi-Square	34.559	

Source: Field survey, 2023

Factors influencing adoption of climate smart agriculture

The results of the ordered logit regression on the factors influencing adoption of climate smart agriculture revealed that The Pseudo R^2 value of 0.4603 suggests that the model explains approximately 46.03% of the variance in the dependent variable, which, in this case, is the adoption of CSA practices. The LR chi^2 (13) statistic is significant at the 1% probability level, indicating that the overall model is statistically significant. The coefficient of level of education (.19207), access to government support (.0329), family labour (.0730), relative advantage of CSA (.8728) and Compatibility of CSA (.1710) were all positive and statistically significant at vary probability level. This implies that on average a unit increase in any of the variable will leads to increase in the adoption of CSA in the study area. The positive and statistically significant coefficient for the level of education suggests that higher levels of education among farmers in the study area are associated with increased adoption of Climate-Smart Agriculture (CSA). This relationship can be attributed to the fact that educated farmers may have better access to information on modern agricultural practices, including CSA technologies. This is similar to the study of Yisa *et al.* (2019) who reported that education had direct relationship with adoption of technologies. The positive and statistically significant coefficient for access to government support suggests that farmers who have better access to government assistance are more likely to adopt CSA practices. Government support can manifest in various forms, including financial incentives, training programs, and subsidized access to resources. Farmers with easier access to these support mechanisms are likely to overcome potential barriers associated with the adoption of CSA, such as initial costs and knowledge gaps. Government interventions that specifically target and promote CSA practices, along with effective communication channels to disseminate information and resources, can contribute to increased adoption.

The positive and statistically significant coefficient for family labour indicates that an increase in the utilization of family labor is associated with higher CSA adoption. Family labour plays a crucial role in farm operations, and its positive influence on CSA adoption can be attributed to several factors. When farmers engage family members in agricultural activities, there is a potential for increased labour availability, allowing for the implementation of labor-intensive CSA practices. Additionally, the collaborative nature of family labor fosters a shared commitment to sustainable farming practices. The positive coefficient suggests that promoting CSA adoption can be intertwined with strategies that enhance the involvement and awareness of family members in agricultural activities.

Table 3: Factors influencing adoption of climate smart agriculture

Variable	Coefficient	Standard error	z-value
Age	-.0294	.0177	-1.66
Household size	.0000217	.00043	0.05
Level of education	.19207	.0646	2.97***
Marital status	.0581	.0890	0.65
Farm size	-.0499	.0811	-0.62
Access to extensions services	-.2172	.2403	-0.90
Complexity of CSA	-.5331	.2123	-2.51**
Annual income	.0509	.0621	0.82
Access to government support	.0329	0189	1.74*
Family labour	.0730	.0185	3.95***
Access to local market	.2810	.1888	1.49
Relative advantage of CSAT	.8728	.2409	3.62***
Compatibility of CSAT	.1710	.0560	3.05***
Constant	-2.1466	.9672	-2.22**
LR chi2(13)	64.87		
Prob > chi2	0.0000		
Pseudo R2	0.4603		
Log likelihood	-92.192054		

Source: Field survey, 2023

The highly positive and statistically significant coefficient for the relative advantage of CSA indicates a strong association between perceived benefits and increased adoption. Farmers who perceive CSA practices as advantageous are more likely to adopt them. The relative advantage encompasses economic, environmental, and social benefits. Economic advantages may include improved yields, reduced input costs, and access to premium markets. Environmental benefits may involve enhanced soil health, water conservation, and biodiversity preservation. Social advantages may include improved resilience to climate change and increased community well-being.

The positive and statistically significant coefficient for the compatibility of CSA suggests that farmers who perceive CSA practices as compatible with their existing farming systems and values are more likely to adopt them. Compatibility involves the alignment of CSA practices with the socio-cultural and economic context of farmers. Practices that fit seamlessly into existing farming routines and align with local customs are more likely to be adopted. The positive coefficient indicates that fostering a sense of compatibility through targeted extension services, community engagement and participatory approaches can enhance CSA adoption. The coefficient of Complexity of CSA (.533) was negative and statistically significant at 5% probability level. This suggests that, on average, an increase in the perceived complexity of CSA practices is associated with a decrease in their adoption in the study area. Farmers may interpret complexity as an indicator of increased difficulty or challenges associated with implementing CSA practices. If farmers perceive CSA practices as overly complex or difficult to understand, they may be hesitant to adopt them, especially if they anticipate challenges in implementation, management, or resource requirements.

Food security status of arable crop farmers

Result in Table 4; reveals that above average (52.13%) of the arable crop farmers were food secured. Suggesting that a substantial portion of arable crop farmers have achieved a level of financial stability and predictability in their income which can be attributed to the adoption of CSA technologies. The incidences of food security as indicated by head count ratio was 0.479% suggesting that 52% income securities of arable crop farmers were not able to meet their recommended monthly allowance (RMAs) which is ₦30,420 per person per month. Also, the estimated values of the food security gap were 0.213 this shows that 79% increase in income is required by the income insecure arable crop farmers to be income secured. Furthermore, the result shows that the severity of food security indices is 0.073 implying that 7.3% of the arable crop farmers were extremely income insecure. This is in agreement with the study of Tsado and Bodaga, (2018) who agree in their separate studies that income adoption of CSA technologies significantly improve the food security status of farmers.

Table 4: Food security status

Variable	Frequency	Frequency
food secure	98	52.13
food insecure	90	47.87
Total	188	100
Food security line / month	₦30,420	
Food security incidence	0.479	
Food security gap	0.213	
Severity of food insecurity	0.073	

Source: Field survey, 2023

Conclusion and Recommendation

From the findings, it can be concluded that the majority of the arable crop farmers in the study area were middle-aged and married with an average household size of 6 persons. Furthermore, most of the respondents had formal education, with an average of 8 years of formal education, less than average had access to extension services and while membership of cooperative was low. It can also be concluded rotational grazing, planting of cover crops, planting of drought resistance varieties, use of compost and mulch and capturing and storing water were the water management strategies CSA adopted. Also, the use of green manure, no-till or zero tillage practice and agro-forestry were the conservative CSA strategies adopted. It was therefore recommended that;

i. The study revealed that CSA adoption help to attain food security, it was therefore, recommended that the farmers should be encouraged to sustain adoption different CSA practices to enhanced their agricultural productivity. This can achieve through awareness campaigns by extension agent and targeted support programmes by State Government.
ii. Level of education was found to have direct influence adoption of CSA among arable farmers, therefore, the study recommended that the state government should implement and support education and training programmes for arable crop farmers. The support should be focused on providing relevant agricultural education, including Climate-Smart Agriculture (CSA) practices.
iii. Efforts should be made by the State and Local Government to improve the quality of education provided in rural areas. This can be achieved through the provision of more educational facilities and resources, the recruitment and training of more qualified teachers, and the introduction of practical skills training programme that are relevant to the needs of the farmers.

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