ANALYZING THE DETERMINANTS OF SMALLHOLDER FARMERS' ADOPTION OF CLIMATE-SMART AGRICULTURE (CSA) USING A CENSORED REGRESSION MODEL

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ABSTRACT

The adoption of Climate-Smart Agriculture (CSA) has been recommended by Food and Agriculture Organization, (FAO), if smallholder farmers must survive eminent food insecurity in the face of uncertain climatic shocks. There is a need to investigate and understand the significant factors driving the adoption of CSA if its diffusion must increase. The study estimated the socioeconomic, institutional and technology-specific factors influencing farmers' adoption of climate-smart agricultural practices (CSAP) in Akwa Ibom State, Nigeria. In order to achieve its objective, the study made use of primary data obtained by means of a structured questionnaire. A multi-stage sampling procedure was used to select 250 respondents for the study. The data collected were analyzed using descriptive statistics and tobit regression model. The tobit regression result showed that farming experience, years of education, farm size were socioeconomic factors influencing the adoption of CSA; membership in a social group was an institutional factor influencing the adoption of CSA practices; and access to information on climate change was a technological factor that influenced farmers' adoption of CSA in the study. Based on the findings, the study recommends the need for government and agricultural institutions to invest in the education and training of farmers to further promote the adoption of CSA. It is also recommended that farmers should prioritize membership in social groups and cooperatives for an increased access to shared resources, knowledge sharing, and collective bargaining power for credit and other farm inputs.

Keywords: *Climate-smart agriculture (CSA), Climate-smart agricultural practices (CSAP), adoption, Tobit regression, farmers, Nigeria.*

INTRODUCTION

The economy of many African countries is predominantly driven by agriculture, and more than 70 percent of her population are smallholder farmers who live in rural areas. In Nigeria, agriculture also drives the economy serving as a means of livelihood, food security and a boost to economic growth. (Fawole and Aderinoye-Abdulwahab, 2021). According to National Bureau of Statistics (NBS, 2022), this sector employs approximately 70 percent of the country's labour force and simultaneously contributes about 27 percent to the country's Gross Domestic Product (GDP). Thus, the importance of this sector cannot be undermined. Inspite of the huge relevance of the Nigerian agricultural sector, it is undoubtedly threatened by climate change and these threats are evident in increased crop failures ensuing from erratic climate shock incidents which are apparent but not limited to drought and flooding. In addition to these, obvious changes in fluctuating rainfall patterns and increasing temperatures which have negatively impacted agricultural production and food systems is also no longer news (Etim *et al.,* 2019; Daniel and Firafis, 2021). All of these have resulted to an increased risk of food insecurity and severe livelihood hardship of many rural poor who rely on farming for food and income (UNFCCC, 2014), decreased crop yields, land degradation, and water scarcity, among others (Otitoloju *et al.,* 2023).

Increasing the awareness of smallholder farmers on climate change and also employing innovative adaptation measures are critical for mitigating the negative effects of climate change (Khonje *et* *al.,* 2018; Warinda *et al.,* 2020). In order to address the challenges posed on agricultural production by the changing climate, and in support of the Paris Agreement on climate change, the concept of Climate Smart Agriculture (CSA) was developed and introduced by Food and Agriculture Organization, FAO. (FAO, 2018, IPCC, 2019). CSA presents a compendium of answers to climate change, agricultural productivity and food security. It aims at tackling three main objectives: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; and reducing and/or removing greenhouse gas emissions, where possible (FAO, 2016; Onyeagocha *et al.,* 2018; Cordovil *et al.,* 2020). CSA provides the tools for evaluating the implication of different technologies and practices to national development and food security objectives under the site-specific effects of climate change. Thus, its overall aim gears towards supporting efforts from the local to global levels for sustainably using agricultural systems to achieve food security for all people at all times, integrating necessary adaptation and capturing potential mitigation (Kifle, 2021).

Ciat (2015) and Food and Agriculture Organization, FAO (2015), refer to climate-smart agricultural practices (CSAP) or technologies as different production techniques combined as an integrated approach to complementing each other to maximize profit. Although, Schaller *al.,* (2017) argue that climate-smart agricultural practices are not necessarily new production technologies, rather they are any production practice or technology which contribute to mitigating climate change and its negative impact on food systems. Tabe-Ojong *et al.,* (2023) opines that CSA is built on existing knowledge, technologies, and the principles of sustainable intensification, hence the need to recognize the significance of cultural ecology and indigenous knowledge systems. Literature suggests that farmers are using several agricultural innovations developed from indigenous knowledge or introduced technologies to improve their adaptive capacity to climate change and variability. Some of these practices are ex ante, meaning they are based on pre-informed climatic events, others are ex post measures adopted after a climatic event has been realized (FAO, 2019).

Even though the concept of CSA is new in Nigeria, and still evolving, various practices that make up CSA previously exist and have been employed by farmers to deal with different agricultural production challenges (Tiamiyu *et al.,* 2018). The literature highlights that farmers' adoption of CSA and its practices is low (Kifle, 2021; Tiamiyu *et al.,* 2018), and this however results from differences in farmers' culture, awareness, resource endowment, objective, preference and socioeconomic background (Maguza- Tembo*et al.,* (2017). There is a dire need to investigate and understand the significant factors driving the adoption of CSA practices if its diffusion must increase (Li *et al.,* 2024). Empirical studies of Apeh*et al.,* (2024), Gabriel *et al.,* (2023), Oyawole *et al.,* (2020), Oyawole *et al.,* (2019), Tiamiyu *et al.,* (2018) across Nigeria have shown that a number of CSAP or technologies have been adopted for increased agriculture output and reduction in greenhouse gas (GHG) emissions concurrently.

These include but are not limited to; Organic agriculture and integrated soil management, Crop rotation, Intercropping, Cover Cropping and Crop Diversification, Agroforestry, Drought-Resistant Varieties, Improved Irrigation Techniques, Integrated Pest Management (IPM) (Otitoju *et al.,* 2023). However, CSA practices to be adopted by smallholders vary with different agro-ecological zones in Nigeria.

Existing empirical results indicate that smallholder farmers' adoption of CSA is significantly affected by several group of factors namely; socioeconomic, farm characteristics, institutional, informational and technology awareness, social capital and climatic factors, psychological, practice/technology-related attributes, biotic/abiotic, systemic and policy factors (Gemtou *et al.,* 2023; Negera *et al.,* 2022). This study contributes to knowledge on CSA by providing empirical information on the factors influencing the adoption of CSA in Akwa Ibom State, Nigeria. The study focuses on three categories of factors being socioeconomic, institutional and technological factors. Ten CSA practices were identified among smallholder crop farmers in this study including; Crop rotation, Intercropping, Mulching, Organic manuring, Cover-cropping, Minimum tillage, Resistant varieties, Early maturing varieties, Irrigation and Changing planting dates and the factors influencing the adoption of CSA by farmers were analyzed using a censored regression model-Tobit.

MATERIALS AND METHODS

Study area

The study was carried out in Akwa Ibom State, located in the South-South geopolitical zone and South-East ecological zones of Nigeria. The State lies between 4°32" and 5°33" North latitudes, and 7°35" and 8°25" East longitudes. The estimated total area is 7,245,915 km^2, and has a shoreline of 129km on the Atlantic Ocean to the South. It shares borders with Cross River State to the East, Abia State to the North, and Rivers State to the West (Uwatt, 2000).

According to the 2006 census, the population of the State stands at 4,920,208, out of which 2,044,510 are male and 1,875,698 are female. The major ethnic groupings in the State are Ibibio, Anang, and Oron. Although Ibibio is the main language, there are variations in dialects within the State. The State is situated within the tropical rainforest zone with two major seasons; rainy season (May – October) and a dry season (November – April). Annual rainfall ranges between 2,400mm along the coast and 2,000mm, while the temperature varies between 29°C and 34°C throughout the year. The physical features directly influence the choice of crop cultivation and fishing as a means of livelihood. Following the 1997 agricultural zone structuring by the then Federal military government, the State is divided into six agricultural zones namely- Abak, Etinan, Eket, Uyo, Oron, and Ikot Ekpene. Akwa Ibom State is suitable for wildlife conservation, food crops farming, tree crop farming and livestock farming (Government of Akwa Ibom State, 2018).

Sampling technique and sampling size

A multistage sampling technique was employed for the selection of sample size for the study. In the first stage, 2 - Agricultural Zones (Uyo and Abak) were randomly selected from the list of the 6 Agricultural Zone in the State. The second stage involved a random selection of 5 farming communities / villages from each pre-selected Agricultural Zone, and in the last stage, 25 farmers were randomly selected from each selected village to give a sample size of 250 farmers for the study.

Method of data collection

The study made use of primary data obtained from crop farmers using well-structured questionnaire. Data was collected on the socio-economic characteristics of the farmers, climate smart agricultural practices used by farmers, and factors influencing farmers' adoption of climate-smart agricultural practices, and other climate change information.

Analytical technique

Tobit regression

The empirical model specifies adoption as a function of three groups of factors; (a) farmer characteristics(b) institutional specific factors, and (b) technology specific factors. The factors influencing adoption of climate-smart agricultural practices are estimated by examining their influences on the dependent variable. A multivariate threshold decision model, Tobit regression is hypothesized. Following McDonald and Moffit (1980) and as adapted by Udoh (2011), the Tobit regression model used in the study is expressed as:

$$V^*_j = B_T X_j + e_i \quad \ldots\ldots (1)$$

In the study, V^*_j= Adoption of CSA as a technology, (1 for yes and 0, otherwise); B_T = vector of unknown parameter; X_j= vector of explanatory variable; ei = error terms. The tobit regression model which is a hybrid of the discrete and continuous models was used to determine the influence of the explanatory variables on the probability of adopting CSA practices. The choice of the model as against the Logit or Probit is because, Tobit permits determining the intensity of use of a technology once adoption has taken place.

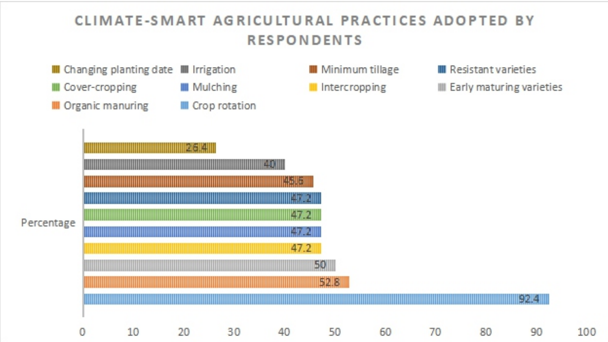
Hence the model is being re-written as X_1 = Age (years), X_2 = Sex (1 for male and 0, otherwise), X_3 = Household size (numbers), X_4 = Farming experience (years), X_5 = Education (years), X_6 = Farm size (hectares), X_7 = Farm income (naira), X_8 = Non-farm income (naira), X_9 = Membership in social group (1 for yes and 0, otherwise), X_{10} = Access to credit (1 for yes and 0, otherwise), X_{11} = Access to weather/climate information (1 for yes and 0, otherwise)

RESULTS AND DISCUSSIONS

Climate-Smart Agricultural Practices Adopted by Respondents

Figure1presents all climate-smart agricultural practices (CSAP) adopted by respondents in the study. It shows that crop rotation is the dominant CSAP (92.4 percent), organic manuring is the second most common CSAP (52.8 percent), and the use of early maturing varieties (50 percent) was third preferred CSAP. Intercropping, mulching, cover cropping and resistant varieties ranked as the fourth most preferred CSAP, while minimum tillage, irrigation, and changing planting date ranked fifth, sixth and seventh in their order of preference.

The result also indicated that various climate-smart agricultural practices were being employed in the study area, but at different levels of usage, which might be as a result of some factors influencing their level of usage. This may not be unconnected with the increased level of awareness of the respondents and the available information on climate-smart agriculture promoted by extension agents in the area. This result further showed that farmers are conscious of the effect of climate change on their farmlands and are therefore making deliberate efforts to mitigate its effects. Saadu *et al.,* (2024) also reported that crop rotation and application of organic fertilizers were the most commonly chosen CSA practices for coping with the effects of climate change among farmers. Kalu and Mbanasor (2023), report crop rotation as the most preferred CSAP in their study.



Source: Field survey, 2024
* Percentage cannot be added to 100 as a farmer can have more than one CSAP

Figure1: Climate-Smart Agricultural Practices Adopted By Respondents

Factors influencing farmers' adoption of climate-smart agriculture (CSA) in the study area

This section presents the factors influencing farmers' adoption of CSA practices using the Tobit regression model. These factors were grouped into 3; socioeconomic, institutional and technological factors. Eleven (11) explanatory variables were included in the model, and from the result, only five (5) were significant at different levels in relation to the dependent variable (adoption of CSA practices. The significant variables were: farming experience, years of education, membership in a social group, access to climate information and farm size.

Socioeconomic factors

Farming experience

Farming experience had a positive and significant ($P \leq 0.05$) influence on the adoption of climate smart agriculture in the study. This implies that as the farming experience increases, the probability of adopting CSA practices increased by 0.0174. The marginal effect of 0.0225 indicates that an additional year of farming experience by a farmer will lead to an increase in adoption of climate-smart agricultural practices by2.25%. This is expected and could be because experienced farmers are supposed to have accumulated technical know-how over time and are in a better position to adopt new technologies. The result corroborates the findings of Adem (2019) and Zakaria*et al.,* (2020) who found that farmers' experience had a significant and positive effect on the intensity of climate-smart agricultural technologies adoption among farmers in Ethiopia and Northern Ghana respectively. Oyeneke (2017) also reported that farming experience had a positive effect across all the CSA practices identified in their research, demonstrating that experience increases the likelihood of adopting climate-smart agriculture. However, Faisal Salad *et al.,* (2021) argued that quite a lot of experienced farmers could become more comfortable and secure with the technologies which they have been practicing over time, and therefore refuse to adopt new ones.

Years of Farmers Education

Education level showed a positive and significant ($P \leq 0.05$) influence on the adoption of CSA. An increase in years spent in formal education, increases the probability of adopting CSA practices by 0.0237. The marginal effect of 0.1683 shows that each additional year spent in formal education, will lead to an increase in adoption of CSA by 16.8%.Midamba*et al.,* (2023) also found that education had a significant and positive effect on the adoption of sustainable agricultural practices in Uganda, attributing this to the skills, knowledge, and networking earned in school, and further explained how that educated farmers acquire more skills and networks than non-educated ones, which invariably leads to high adoption of the sustainable agricultural practices. A similar result is also reported by Faisal Salad *et al.,* (2021). Geda *et al.,* (2024) therefore asserting that education is crucial for stimulating adoption-related decisions.

Farm size

Farm size had a positive and significant ($p<0.01$) influence on the adoption of climate smart agriculture (CSA) in the study, implying that as farm size increases, the probability of adopting CSA increases by 0.0147. The marginal effect of 0.0190explains that for an additional hectare cultivated by a farmer, the probability of adopting CSA practices increased by 1.9%. This is because farmers with bigger cultivated farms have greater level of adoption, since they have higher opportunities of applying CSA practices in their fields. Abegunde (2020) and Wamalwa (2017) also reported a positive and significant relationship between farm size and the adoption intensity of climate-smart agricultural practices. The result from this study is similar and corroborates the findings of Midamba *et al.,* (2023) in northern Uganda, Feliciano (2022 in United Kingdom), Kwawu *et al.,* (2021) in Ghana, Wordofa *et al.,* (2021) in Ethopia and Mudashiru *et al.,* (2021) in Nigeria, who reported that having large portions of land increases the rate of adoption of agricultural technologies. However, in another study carried out in Ghana by Anang (2016), the coefficient of farm size was negative in relation to adoption, and it was argued that farmers with larger portions of land tend to incur high cost on adoption of the CSA practices, hence the less likelihood of adoption.

Institutional factors

Membership in a social group

Membership in a social group had a negative and significant ($P \leq 0.10$) influence on the adoption of CSA in the study. This implies that for each social group that a farmer belongs, the probability of adoption decreased by -0.1323. The marginal effect of -0.1711 indicates that for an additional social group that a farmer belongs, the probability of adopting CSA will decrease by 17.1%. This was contrary to apriori, although findings are in line with Obot and Obiekwe (2022) and Mulwa *et al.,* (2017) who also reported that membership in a farmer group negatively influenced adoption of improved production practices in Akwa Ibom State, and drought tolerant varieties in Malawi respectively. This result contradicts Teklewold *et al.,* (2019) and Wekesa (2018), who found that membership in farmer organizations increased the intensity of adopting CSA practices used by farming households in Ethiopia and Kenya respectively. Kaba and Emana (2024) also reported that membership to one additional farm-based association increased farmers' adoption decision of soybean production technology, explaining that when farmers participate more in social groups or cooperatives, they are likely to be informed about the technology which would in turn increase the likelihood of adoption.

Ojoko *et al.,* (2017) explains that social groups which could also be farmers' cooperative society play a very important role in the education of their members, and that farmers belonging to such groups are easily enlightened and exposed to new farming technologies that will help boost agricultural production.

Wekesa (2018) added that group membership provides access to credit and extension which are important ingredients to adoption of CSA technologies, with reason being that through group interactions, members get to exchange ideas, handle farm demonstrations and also get connections to dissemination of important research findings.

Technology characteristics

Access to information on climate change

Access to information on climate change had a positive and significant ($P \leq 0.05$) influence on the adoption of CSA in the study. This result implies that an increased access to climate information will lead to an increase in the adoption of CSA by 0.1330. The marginal effect of 0.1719 indicates that an access to additional climate information by a farmer will lead to an increase in adoption of CSA by 17.2%. Findings were in line with Ojo *et al.,* (2023) who found the coefficient of access to climate information to be positive and statistically significant with the adoption of CSA among smallholder farmers in Osun State, and hence posited that the adoption of CSA increases with increased access to climate information. Etim *and* Ndaeyo, (2020) also supported the fact that farmers with access to information about climate change were more likely to adopt CSA practices earlier and faster than farmers with less access to climate change information. Thus, implying that farmers with access to environmental information have a higher probability to adopt knowledge, skills and processes that would lead to transformed behaviour in support of an ecologically sustainable environment.

Table 1: Tobit model estimation for factors influencing farmers' adoption of climate-smart agriculture (CSA)

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Variables	Coefficient	Standard error	P value	Elasticity of probability of adoption	Marginal effect
Constant	−0.6193	0.4979	0.2136		
Age	0.0056	0.0087	0.5199	0.0023	-0.0030
Sex	−0.1075	0.1541	0.4852	-0.0441	-0.0570
Household size	−0.0678	0.0592	0.2519	-0.0278	-0.0359
Farming experience	0.0425	0.0125	0.001 **	0.0174	0.0225
Years of education	0.3176	0.1339	0.0177 **	2.3719	0.1683
Average farm income	5.1550	6.3518	0.4170	0.0032	0.0042
Average nonfarm income	2.9782	5.6879	0.6005	0.0196	0.0253
Membership in social group	−0.3229	0.1671	0.0534 *	-0.1323	--0.1711
Access to credit	0.3034	0.3114	0.3299	0.1243	0.1608
Access to climate information	0.3244	0.1373	0.0181 **	0.1330	0.1719
Farm size	0.3622	0.8501	0.000 ***	0.0147	0.0190

Log likelihood =-258.3378
Wald $chi^2(12)$ = 12.03381
Prob>chi^2 = 0.5123
Number of observation = 250

*,**,*** signifies significance at 10, 5 and 1% respectively

Source:Field survey, 2024

CONCLUSION

This study focused on socioeconomic, institutional and technology specific factors-affecting smallholder farmers' adoption of climate-smart agriculture (CSA) in Akwa Ibom State, Nigeria. Findings conclude that farmers' farming experience, farm size, years of education are the socioeconomic factors influencing the adoption of CSA, while membership in farmers' social group is an institutional factor influencing CSA adoption, and access to climate information is a technology specific factor influencing farmers' adoption of CSA in the study area. These variables highlight the complexity of factors influencing CSA and underscore the need for targeted interventions to enhance adoption and diffusion of CSA in the study area. The knowledge of these factors were necessary in the formulation of agricultural policies which will fast-tracked the dissemination of CSA practices at the local level in the long-run.

RECOMMENDATIONS

The results from the study have important policy implications**.** Policymakers should specifically consider socioeconomic, institutional, and technology-specific factors that significantly influence CSA adoption. Firstly, since experienced and well-educated farmers are more likely to adopt and implement CSA practices more effectively, this suggests a need for an investment in education and training for farmers which can further promote the adoption of CSA and other sustainable agricultural practices. Secondly, the study recommends the necessity to encourage the formation and strengthening of farmer social groups such as farmer unions, agricultural cooperatives, and farmer collaboration groups to ease knowledge sharing and collective action. Farmers should join farming groups and cooperatives for an increased access to shared resources, knowledge, and collective bargaining power for credit and other farm inputs. Lastly, given that the availability of climate information plays a crucial role in the adoption of CSA practices, access to timely and up to date climate data and information which can improve farmers' decision-making processes regarding CSA is highly recommended.

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