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FACTORS INFLUENCING THE LEVEL OF USE OF CLIMATE-SMART AGRICULTURAL PRACTICES (CSAPs) IN SOKOTO STATE, NIGERIA

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Abstract: Climate-Smart Agriculture (CSA) is paramount to the success of farming activities today in the face of the menace of climate change. This study therefore investigated the frequency of usage of CSA and the factors influencing its level of usage in the Northern agricultural zone of Sokoto State. A well-structured questionnaire was used for data collection. The data used for the analysis were cross sectional data collected from 120 rural farming households in six (6) villages across two (2) local government areas. Descriptive statistics, Adaptation Strategy Use Index (ASUI) and ordered probit regression model were used for data analysis. Results indicated that the majority of the respondents were male (83.33%), married (83.33%), had Quranic education (73.33%), household size of 1−10 persons (58.33%), farming experience of 16–30 years (49.17%) and were between the ages of 46 and 60 (44.17%). Similarly, the practice of conservation agriculture was the most used CSAP in the study area, while the results of the ordered probit regression showed that years of education and membership of a social group were significant explanatory variables influencing the level of use of CSAP among the low user and high user categories at the 10% and 1% level of significance respectively, while access to credit significantly influenced only the low user category at the 10% level of significance. The study therefore concluded that CSAPs were being practiced at different levels in the study area with various factors influencing their usage, and it therefore recommended that the farming households be well enlightened by extension agents on the benefits of CSAPs.

Key words: Climate-Smart Agriculture, Adaptation Strategy Use Index, ordered probit and conservation agriculture.

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Introduction

Agricultural production is still the main source of livelihood for rural communities in sub-Saharan Africa, providing employment to more than 60 percent of the population and contributing about 30 percent of gross domestic product in this region (Nhemachena and Hassan, 2007). With likely long-term changes in rainfall patterns and shifting temperature zones, climate change is expected to significantly affect agricultural production, which could be detrimental to the region's food security and economic growth.

According to Intergovernmental Panel on Climate Change (IPCC) (2007), the relationship of agriculture to climate change is a topic of increasing interest. Worldwide agricultural production is expected to decrease under climate change projections, posing a threat to global food security. However, it is also important to note that agriculture contributes a significant amount of global emissions annually, which would increase with the intensification or expansion of production to meet higher demand. In addition, estimates attribute as much as 80% of global deforestation to agriculture (Kissinger et al., 2012 as cited by Elizabeth and Sophie, 2014). The IPCC 4th Assessment Report predicts that climate change could cause yields to decrease by as much as 50% in some highly vulnerable areas, including sub-Saharan Africa (Elizabeth and Sophie, 2014). According to this report "warming in Sub-Saharan Africa (SSA) is expected to be greater than the global average and rainfall will decline in certain areas. Also, cereal production growth for a range of crops in SSA is projected to decline by a net 3.2 percent in 2050 as a result of climate change". Ringler et al. (2010) have stated that under climate change, the largest negative yield impacts are projected for wheat followed by sweet potatoes. However, millet and sorghum yields are projected to be slightly higher under climate change, probably given their higher tolerance to higher temperatures and drought stress.

Steenwerth et al. (2014) opined that the term Climate-Smart Agriculture (CSA) was developed to represent a set of strategies that can help combat the above stated challenges of climate change by increasing resilience to weather extremes, adapting to climate change and decreasing agriculture's greenhouse gas (GHG) emissions that contribute to global warming. These strategies used by farmers are conceptualized in this paper as Climate-Smart Agricultural Practices (CSAPs). Therefore, "CSAP focuses on contributing to economic development, poverty reduction and food security; maintaining and enhancing the productivity and resilience of natural and agricultural ecosystem functions, thus building natural capital; and reducing trade-offs involved in meeting these goals". This stresses the need for farmers to adopt the use of CSAP, which will help in boosting agriculture to produce more on the same amount of land while adapting to a changing climate and becoming more resilient to the risk derived from extreme weather conditions, such as droughts, floods, high temperature and low rainfall (World Bank, 2011).

Meybeck and Gitz (2013) state that Climate-Smart Agriculture has the potential to provide 'triple wins', which include: (a) increased resilience to climate change; (b) reduced GHG emissions; and (c) improved food security. The importance of these benefits is as follows:

a. Agriculture is projected to be negatively affected by climate change, so adaptation is necessary;

b. Agriculture is a major contributor to annual global emissions, requiring mitigation of emissions; and

c. Agriculture is also important to the issue of global food security, which could be threatened if productivity levels are affected by climate change.

Following the Second Global Conference on Agriculture, Food Security and Climate Change in Hanoi in 2012, "Climate-Smart Agriculture Sourcebook" was published to further advance the concept with the intention of benefiting primarily smallholder farmers and vulnerable people in developing countries (FAO, 2013). In the work of Fanen and Olalekan (2014) on "Assessing the role of Climate-Smart Agriculture in combating climate change, desertification and improving rural livelihood in Northern Nigeria", they have found out that many smallholder farmers have inadvertently practiced CSA as part of their traditional farming system in Northern Nigeria. This study therefore seeks to identify the extent of use of CSAPs and also to determine the factors influencing their level of usage in the study area.

Materials and Methods

Study area

This study was conducted in Sokoto State. The state is located between latitude 11^0 3' to 13^0 5' N and longitude 4^0 to $5^0$15'E. The climatic condition of the state is semi-arid with two distinct seasons; the raining season lasting for 3−4 months from mid- May to mid-September and the dry season from October to early May. The State has a mean annual temperature of 34.9^{o}C. Farming is the major occupation of the people in the State. The major crops grown include millet, cowpea, sorghum, maize, rice and other vegetables such as amaranthus and spinach. The major livestock reared are cattle, sheep and goats (Maikasuwa and Ala, 2013).

Sampling techniques and sample size

The sampling technique used for this study is a multi-stage simple random sampling technique. The first stage included the purposive selection of Northern agricultural zone of Sokoto state. In the second stage, two (2) local government areas were randomly selected from the selected agricultural zone, while the third stage involved the random selection of six (6) villages from the two local government areas already selected. The last stage was the selection of a total of 120 respondents as used for this study.

Analytical techniques

Data collected for this research were analyzed using descriptive statistics, Adaptation Strategy Use Index (ASUI) for determining the frequency of use of CSAPs and the ordered probit regression model for determining the factors influencing the level of use of CSAPs. The ASUI will reflect the relative position (ranking) of each of the CSAPs identified in the study area in terms of their frequency of usage. The ASUI was adapted from Adesoji and Famuyiwa (2010) in Umunna et al. (2013). The frequency of use of the CSAPs was expressed using a four-point Likert scale, that is, 3, 2, 1, and 0 for frequently used, occasionally used, rarely used and not used respectively. The formula is as stated below:

$$ASUI = \frac{[(N_1 \times 3) + (N_2 \times 2) + (N_3 \times 1) + (N_4 \times 0)]}{M} \quad (1)$$

where:
N_1 = Number of farm households that frequently used a particular CSAP;
N_2 = Number of farm households that occasionally used a particular CSAP;
N_3 = Number of farm households that rarely used a particular CSAP;
N_4 = Number of farm households that did not use a particular CSAP;
$M = n \times 3$;
n = Total number of respondents.

Composite score

This was used to classify the farming households based on the level of use of CSAPs among the rural farming households in the study area. Respondents were made to respond to questions relating to the level of use of CSAPs. These practices included Conservation agriculture, Agro-forestry, Use of organic manure, Crop rotation, Crop diversification, Mulching, Use of wetland (Fadama), Planting of drought resistant crops, Planting of cover crops and Soil conservation techniques. A binary scale, that is, scoring 1 point for yes and 0 for no responses, regarding the use of any of these CSAPs, was used to rate their responses. If a respondent was asked 10 questions; such respondent would be scored a maximum of 10 points and a minimum of 0 points. The categorisation into high, medium and low users was achieved using a composite score as given below and as used by Salimonu, 2007 as cited by Adepoju et al., 2011).

High user = Between 10 points to (mean + S.D) points;
Medium user = Between upper and lower categories;
Low user = Between (mean – S.D) points to 0 point.

Ordered probit model

The ordered probit regression model was used to determine the factors influencing the level of use of CSAPs by the farming households in the study area. The various levels of CSAP usage (which is the dependent variable) were derived from the composite score. The ordered probit model is thus expressed:

$$Y_i^* = \chi'\beta + \varepsilon_i \qquad Y\mu í \tag{2}$$

where Y_i^* is the unobserved discrete random variable, x_i is the vector of independent variables, β is the vector of parameters of the regression to be estimated and ε_i is the vector of error term (Greene, 2003). Thus, Y_i, which is the observed ordinal variable, takes on the following values:

$$\begin{aligned} Y_i &= 0 \text{ if } Y_i^* \leq 0 \\ Y_i &= 1 \text{ if } 0 < Y_i^* \leq \mu_1 \\ Y_i &= 2 \text{ if } \mu_1 < Y_i^* \leq \mu_2 \\ Y_i &= 2 \text{ if } \mu_1 < Y_i^* \leq \mu_2 \\ Y_i &= J \text{ if } \mu_{J-1} < Y_i^* \end{aligned} \tag{3}$$

The dependent variable is Y_i = level of usage of Climate-Smart Agricultural Practices (2 = high user, 1 = medium user, 0 = low user).

The independent variables are:

X_1 = Age of household head (years);
X_2 = Gender of household head (D = 1 if male; 0 = otherwise);
X_3 = Marital status of household head (single = 1; married = 2; widowed = 3; divorced/separated = 4);
X_4 = Household size (number);
X_5 = Educational status of household head (years);
X_6 = Farming experience of household head (years);
X_7 = Farm size (hectares);
X_8 = Farm income (naira);
X_9 = Off-farm income (naira);
X_{10} = Membership of a social group (D = 1 if member; 0 = otherwise);
X_{11} = Access to agricultural credit (D = 1 if yes; 0 = otherwise);
X_{12} = Contact with extension agents (number);
X_{13} = Livestock ownership (D = 1 if owned; 0 = otherwise).

STATA version 13 was used for all the statistical analysis.

Results and Discussion

The results from Table 1 showed the socio-economic characteristics of the respondents. The majority of the respondents (44.17%) were between the ages of 46 to 60, which forms the active years of the farmers and therefore, they are strong enough to engage in agricultural practices. About 83.33% of the farmers are male, which is a common practice in North-western Nigeria, where women are only allowed to partake in activities like harvesting, winnowing, and processing of farm produce. About 73.33% of the respondents only had Quranic education followed by 12.50% with primary education. Quranic education is the prevalent form of education in Northern Nigeria, most especially among rural dwellers.

Table 1. Socio-economic characteristics of the respondents.

Variables	Frequency	Percentage (%)
Age		
16–30	13	10.83
31–45	50	41.67
46–60	53	44.17
61 and above	4	3.33
Gender		
Male	100	83.33
Female	20	16.67
Education		
No formal education	2	1.67
Quranic education	88	73.33
Primary education	15	12.50
Secondary education	11	9.17
Tertiary education	4	3.33
Marital Status		
Single	1	0.83
Married	100	83.33
Divorced/separated	2	1.67
Widowed	17	14.17
Household size		
1–10	70	58.33
11–20	47	39.17
21 and above	3	2.50
Farming experience		
1–15	29	24.17
16–30	59	49.17
31–45	29	24.17
46 and above	3	2.50
Total	120	100

Source: Field survey, 2016.

About 83.33% of the respondents were married, while about 58.33% had a household size of between 1 and 10, followed by 39.17% with a household size of 11 to 20 persons. A large household size is a source of family labour in rural Nigeria where farming is a major occupation. Results of the farming experience in Table 1 revealed that the majority of the rural farmers (49.17%) had farming experience of 16 to 30 years. Farming experience is very important in farming activities, as it helps the farmer in the area of proper farm management to maximize profit.

Table 2 reveals the results of the perception of farmers on the impact of climate change on their farming activities in the past five years. The ability of farmers to perceive climate change is a vital requirement for their choice of CSAPs. The results indicate that the majority of the respondents (95.8%) affirmed that there had been an increase in temperature in the study area for the past five years. This confirms the existence of global warming, which has brought about an increase in temperature with a negative effect on crop production, while only 4.2% affirmed otherwise. Also, 70.8% of the respondents perceived an increased rainfall pattern in the past five years.

Table 2. Perception of respondents on a climate change impact.

Features of climate change	Increasing	Decreasing	No change
Change in temperature	115 (95.8)	5 (4.2)	-
Change in rainfall pattern	85 (70.8)	34 (28.3)	1 (0.8)
Effect of climate change on crop yield	Positive 33 (27.5)	Negative 84 (70.0)	No change 3 (2.5)
Effect of climate change on water supply	Improved 98 (81.7)	Worsened 22 (18.3)	No change -
Magnitude of drought	Mild 66 (55.0)	Moderate 53 (44.2)	Severe 1 (0.8)

Source: Field survey (2016).
Note: Figures outside the brackets are frequencies, while the ones in the brackets are percentages (%).

Rainfall/precipitation is a vital requirement for agricultural activity, but increased rainfall which results in flooding or soil erosion is detrimental to crop production. This result is in line with Gbetibouo (2011), who opined that over the years, temperature had been on the increase. But this differs from the work of Gbetibouo (2011), who opined that there had been a decrease in the rainfall pattern due to a climate change impact. Regarding the effect of climate change on crop yield, 70.0% of the respondents asserted that climate change had a negative effect on their crop yield, while 27.5% perceived a positive effect of climate change on their crop yield. About 81.7% of the respondents perceived an improved water supply in their environment as a result of climate change, and this is in accordance with the perception of the majority of the respondents on increased rainfall due to the effect of climate change, while 18.3% perceived a worsened water supply as a result of climate change. As for the magnitude of drought, 55.0% stated that the magnitude of drought in their farming environment was mild, while 44.2% perceived that the magnitude of drought was moderate. These findings affirmed that the farmers in the study area perceived the negative effect of climate change on their cropping activities and therefore the need to use CSAPs as a remedy to these problems.

Table 3 shows the results of the frequency of use of CSAPs. The results indicated which of the CSAPs was used most in ranking order in the study area. It may be noticed that the five (5) most used CSAPs in the study area included Conservation agriculture, Use of organic manure, Crop diversification, Use of wet land (Fadama) and Planting of drought and heat tolerant crops in descending order, while Agro-forestry is the least used CSAP in the study area. These results also showed that CSAP was being practiced in the study area, but at different levels of usage, which might be a result of some factors influencing their usage as shown in Table 4.

Table 3. Frequency of use of CSAPs by the respondents.

S/N	CSAPs	ASUI	Ranking
1	Conservation agriculture	0.9722	1st
2	Agro-forestry	0.1778	10th
3	Use of organic manure	0.9167	2nd
4	Crop rotation	0.2333	9th
5	Crop diversification	0.7139	3rd
6	Mulching	0.4111	6th
7	Use of wetland (Fadama)	0.4528	4th
8	Planting of drought and heat tolerant crops	0.4222	5th
9	Planting of cover crops	0.3444	8th
10	Soil conservation techniques	0.3694	7th

Conservation agriculture was the major CSAP in the study area. It involves minimum soil disturbance which reduces run-off and soil water loss. This is in line with the findings of Dumanski et al. (2006), who state that Conservation agriculture provides direct benefits to environmental issues of global importance. These include land degradation, air quality, climate change, bio-diversity and water quality. CSAPs should therefore be encouraged among farmers in order to lessen the effect/menace of climate change on crop production and also protect the eco-system.

The results of the ordered probit model which showed the factors influencing the level of usage of CSAPs in the study area are as shown in Table 4. The Log likelihood of -98.2285 with a p-value of 0.0000 revealed that the model as a whole was statistically significant. The estimated cut-off points (μ) showed that the categories were ranked in an ordered way of $\mu 2>\mu 1>\mu 0$. The dependent variables were low user (Y = 0), medium user (Y = 1) and high user (Y = 2). The marginal effect estimates indicated that years of education of the respondents and membership of a social group were the significant explanatory variables that influenced the usage of CSAPs among the low user and high user categories in the study area at the 10% and 1% level of significance respectively. Access to credit also influenced the usage of CSAPs among the low user category. On the other hand, none of the explanatory variables significantly influenced the medium user category. Education is a vital tool for knowledge acquisition.

Table 4. Ordered probit regression model for the factors influencing the level of use of CSAPs.

		Low user			Medium user			High user		
Variable	Coefficient	SE	P-value	ME	SE	P-value	ME	SE	P-value	ME
Age of household head	0.0003895	0.00599	0.983	-0.0001243	0.00047	0.983	-9.68e-06	.00645	0.983	0.000134
Gender of household head	0.1501062	0.3662	0.893	-0.0494465	0.01829	0.969	-0.0007127	.34931	0.886	0.0501592
Marital status	-0.3988126	0.17456	0.466	0.1272876	0.02282	0.664	0.0099127	.18755	0.464	-0.1372003
Education	0.0553309	0.01056	0.095*	-0.0176598	0.00274	0.616	-0.0013753	.01141	0.095*	0.019035
Household size	0.0498417	0.01141	0.163	-0.0159078	0.00252	0.623	-0.0012388	.01233	0.164	0.0171466
Farm income	6.04e-07	0.0000	0.694	-1.93e-07	0.0000	0.753	-1.50e-08	0.0000	0.694	2.08e-07
Off-farm income	1.02e-06	0.0000	0.824	-3.25e-07	0.0000	0.845	-2.53e-08	0.0000	0.825	3.50e-07

Table 4. Continuation.

		Low user			Medium user			High user		
Variable	Coefficient	SE	P-value	ME	SE	P-value	ME	SE	P-value	ME
Farming experience	0.0072622	0.00645	0.719	-0.0023178	0.00062	0.769	-0.0001805	.00696	0.720	0.0024983
Membership of a social group	0.7728677	0.0835	0.003***	-0.2466735	0.03679	0.602	-0.01921	.08905	0.003***	0.2658835
Variable	Coefficient	SE	P-value	ME	SE	P-value	ME	SE	P-value	ME
Access to credit	0.5249819	0.08503	0.074*	-0.1520597	0.04492	0.396	-0.0381006	.12216	0.120	0.1901603
Contacts with extension officer	-0.1326864	0.04082	0.300	0.0423491	0.00682	0.629	0.003298	.0436	0.295	-0.045647
Livestock ownership	-0.5798643	0.11561	0.197	0.1493095	0.12282	0.567	0.0703809	.23446	0.349	-0.2196904
Total farm size	0.0158766	0.00441	0.251	-0.0050673	0.00079	0.617	-0.0003946	.00468	0.243	0.0054619
Cut 1	-0.5295117									
Cut 2	0.682739									

The more educated a farmer is, the easier he or she adopts modern technology/innovations. This is in line with the studies of Mamudu et al. (2012), who stated that educated members of the farming household would easily adopt modern agricultural production technologies and strategies. Therefore, the usage of CSAPs and their propagation among rural farmers depend on this factor.

Another important factor that influenced the use of CSAPs in the study area was being a member of a social group, for instance, farmers' cooperative society. Social groups play a very important role in the enlightenment of their members. Farmers who belong to such groups are easily enlightened and exposed to new farming technologies that will help boost agricultural production. Probably most of the farmers in the study area became aware of CSAPs through the social group they belong to.

Access to credit was also a vital tool that will enable a low user of CSAPs to rise up to being a high user. When farmers are given access to credit, it will enable them to acquire more technology which might be expensive to purchase. This agrees with the findings of Amao and Ayantoye (2015), who opined that access to credit in the form of loanable funds (soft loans) can be used to expand production through the purchase and use of modern improved inputs.

The marginal effects of all the variables influencing the three categories of 'low user', 'medium user', and 'high user' are as shown in Table 4. As it can be seen from Table 4, among the low user and medium user categories, age of household head, gender of household head, years of education of household head, household size, farm income, off-farm income, farming experience, membership of a social group, access to credit and total farm size were all negatively related. The negative sign implies that an increase in all these variables will cause the farmers who are low users and medium users of CSAPs to increase their usage of CSAPs. Regarding the high user category, on the other hand, all the above stated explanatory variables were positively related. This positive sign implies that as these variables increase, there will be a boost in the usage of CSAPs among the high user category in the study area.

Conclusion

The most used CSAPs in the study area in order of ranking were Conservation agriculture, Use of organic manure, Crop diversification, Use of wet land (Fadama) and Planting of drought and heat tolerant crops. A number of factors influenced the extent of use of these CSAPs among the three categories of users in the study area. The significant factors included years of education of the respondents, membership of a social group and access to credit, which all had a negative signed marginal effect on the low user category. This implies that if these factors are increased, the low user category will increase their usage of CSAPs. It is therefore recommended that farmers should be encouraged to join one or more farmer social groups, which would expose them to agricultural innovations. Also, the farmers should be well educated and enlightened by extension services on the benefits of CSAPs in agricultural production, which are the panacea for reducing the negative impact of climate change on their farming activities.

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FAKTORI KOJI UTIČU NA NIVO KORIŠĆENJA KLIMATSKI PAMETNIH POLJOPRIVREDNIH PRAKSI (CSAPs) U DRŽAVI SOKOTO, NIGERIJA

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R e z i m e

Klimatski pametna poljoprivreda (engl. *Climate-Smart Agriculture* – CSA) najvažnija je za uspeh poljoprivrednih aktivnosti danas, uprkos opasnosti od klimatskih promena. Ovo istraživanje je ispitivalo učestalost primene klimatski pametne poljoprivrede i faktore koji utiču na njen nivo upotrebe u Severnoj poljoprivrednoj zoni države Sokoto. Dobro strukturiran upitnik korišćen je za prikupljanje podataka. Podaci koji su korišćeni za analizu bili su podaci preseka stanja sakupljeni od 120 seoskih domaćinstava iz šest sela iz dve oblasti lokalne samouprave. Deskriptivna statistika, indeks korišćenja strategije adaptacije (engl. *Adaptation Strategy Use Index* – ASUI) i naručeni probit regresioni model korišćeni su za analizu podataka. Rezultati su pokazali da je većina ispitanika muškog pola (83,33%), u braku (83,33%), steklo versko obrazovanje (73,33%), veličine domaćinstva 1–10 članova (58,33%), poljoprivrednog iskustva 16–30 godina (49,17%) i starosti između 46 i 60 godina (44,17%). Pored toga, konzervacijska poljoprivreda je bila najviše korišćen metod u ispitivanoj oblasti, dok su rezultati regulisane probit regresije pokazali da su godine obrazovanja i članstvo u nekoj društvenoj grupi značajno važne promenljive, koje utiču na nivo upotrebe klimatski pametnih poljoprivrednih praksi među kategorijama „niskih" i „visokih korisnika" na nivoima značajnosti od 10% odnosno 1%. Pristup kreditu je značajno uticao samo na kategoriju „niskih korisnika" pri nivou značajnosti od 10%. Istraživanjem se zaključuje da su klimatski pametne poljoprivredne prakse korišćene pri različitim nivoima u ispitivanoj oblasti sa različitim faktorima koji utiču na njihovu upotrebu, pa se preporučuje da savetodavni agenti informišu poljoprivredna domaćinstva o koristima klimatski pametnih poljoprivrednih praksi.

Ključne reči: klimatski pametna poljoprivreda, indeks korišćenja strategije adaptacije, naručen probit i konverzacijska poljoprivreda.

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