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Determinants of Climate-Smart Agriculture Uptake among Orange-Fleshed Sweet Potato (OFSP) Growers in Abia State, Nigeria

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Abstract
This study investigated the determinants of climate-smart agriculture (CSA) uptake among orange-fleshed sweet potato (OFSP) growers in Abia State, Nigeria. Using a proportional stratified sampling technique, data were collected from 179 respondents through structured questionnaire. Descriptive statistics described farmers' socio-economic profiles and climate change impacts, while a 3-point Likert type scale assessed perceptions of CSA practices. Principal Component Analysis (PCA) identified commonly adopted CSA strategies and key constraints, and Ordinary Least Squares (OLS) regression along with Z-tests were used to analyze socio-institutional factors influencing adoption and variations among farmer groups. Findings revealed that the majority of respondents experienced climate-related challenges, including increased rainfall (82.1%), higher temperatures (62.6%), prolonged drought (64.8%), and a generally hotter environment (59.8%). In response, farmers adopted soil management practices such as organic manure (0.6638), inorganic fertilizer (0.6068), and ridge/mound planting (0.4458), as well as crop-focused practices like improved varieties (0.6725) and altered planting dates (0.4165). Constraints to CSA uptake included high labor costs (0.4083) and limited access to extension services (0.5210). Regression results showed that farming experience, occupation, and location were negatively associated with CSA uptake, whereas income, training participation, and land ownership were positively and significantly related. The study recommended enhanced training and capacity building, improved access to credit and subsidized inputs, and effective implementation of land-use policies to strengthen CSA adoption and build resilience among OFSP farmers in the region.

***Keywords**: Climate-smart agriculture; Orange-fleshed sweet potato; Adoption determinants; Climate change adaptation; Smallholder farmers*

Introduction

Sweet potatoes offer a particularly significant potential for increasing food production and income of rural farmers thereby reducing poverty and improving food security level in Nigeria. Sweet potato (*Ipomoea batatas*) is a creeper of the Convolvulaceae family, originated from Central America and is widely grown throughout the world for both man and animal consumption (Tsegaye, Alemu, & Yilma, (2022). Sweet potatoes have varieties of varying colours including white, yellow, purple and orange fleshed (Oniah 2019). Of the entire varied flesh storage root colour (white, yellow, cream, brown, purple, pink) of sweet potato varieties existing, the orange fleshed sweet potato varieties (OFSP) are newly introduced in Nigeria and are so rich in vitamins. Orange fleshed sweet potato differs from other varieties of sweet potato due to its extremely rich and bio-fortified with beta-carotene, which the body converts into vitamin A. According to

Umeh and Okoye (2024) one small root (100 - 125 grams) of most OFSP varieties can supply the recommended daily dose of vitamin A for children under five years of age. It is gaining importance as the cheapest source of antioxidant having several physiological attributes like anti-oxidation, anti-cancer and protection against liver injury and is most suiting as bio-fortified crop to combat malnutrition in small and marginal farming community. The considerable potential contribution of OFSP to food-based approach to tackle the problem of vitamin A deficiency, as a major public health concern of the poorer sections have motivated many farmers into its production in the country particularly in Abia State.

However, like other crop farmers in the nation, orange fleshed sweet potato (OFSP) farmers faced climate change effect that negatively or positively affect their production and livelihoods. The adverse impacts of this climate change have increasingly become a challenge for sweet potato farmers in agricultural systems. Extreme climatic events such as frequent floods, heat-stress, heavy rain and droughts can substantially reduce crop yields (Aryal et al., 2018). Varied stakeholders are in agreement that managing these climatic events is important and the global population will have to deal with its consequences (IPCC, 2024). Rising temperatures and changes in rainfall patterns affect agricultural production with significant decline in crop and livestock production (Sharma & Ravindranath, 2019).

For sustainable food production, one of the important strategies is climate-smart agriculture (CSA) that can increase the resilience of agriculture to climate change through better adaptation - and by reducing agriculture's contribution to global warming.

The concept and adoption of these CSA approaches by farmers to sustainable agriculture are due to three major factors. These include increase climate change and events that worsens rain-fed agriculture, permanent changes in weather patterns which led to non- productivity at certain locations, and the need to reduce agriculture's contribution to greenhouse gas concentration in the atmosphere. Climate smart Agriculture is of no doubt an approach for transforming and re-orienting agricultural systems to support food security under the new realities of climate change. CSA has become an important adaptation and mitigation strategy to climate change (Ifeanyi-Obi, Issa, Aderinoye-Abdulwahab, Ayinde, Umeh and Tologbonse, 2022) and to provide food (such as OFSP) for the increasing population. Considering the significant roles of CSA and Orange Fleshed sweet potato (OFSP) in the rural communities of Abia State, there is the need to engage in its promotion, and study of this such becomes crucial, to analyze factors influencing adoption of climate smart agricultural practices among orange fleshed sweet potato farmers in Abia State. Study like this on climate adaptation can greatly provide knowledge that can help to reduce vulnerability to climate change effects by moderating potential damages, helping the OFSP producing rural communities cope with adverse consequences of climate change.

Objectives of the study

The specific objectives of the study were to;

i. describe socio-demographic and economic characteristics of the respondents,
ii. ascertain level of perception of OFSP farmers on the CSA practices in the study area;
iii. ascertain CSA practices commonly adopted among the OFSP farmers to cope with the natural hazards in the study area;
iv. identify constraints against the use of CSA practices among OFSP farmers.

Methodology

Study Area

This study was carried out in Abia State of Nigeria. Abia State with Umuahia as its capital has seventeen (17) Local Government Areas, three senatorial zones namely, Abia South, Abia Central and Abia North and many communities. It is one of the five states in the South East geo-political Zone of Nigeria.

Sampling procedure

The study adopted proportional stratified sampling procedure to select sample respondents. Sweet potato Production Association of Nigeria, SPAN, Abia State chapter has on record 1785 registered active members across different agricultural Zones of the State of which most of them were involved in OFSP production. Specifically, Aba, Ohafia and Umuahia are made of 501, 1080 and 204 members respectively. The study, however proportionately sampled 10% of these strata (50 from Aba, 108 from Ohafia and 21 from Umuahia) to give a total of 179 OFSP farmers for the study.

Measurement of Variables and Model Specifications
Socio-economic and institutional characteristics of respondents

The, socio-economic and institutional attributes of respondents which influence the adoption of CSA practices were described. In this study, the socio-economic characteristics that were considered are;

= age (years) as provided by the respondents
= educational level (years)
= marital status (married=1, single=0)
= Farm Income (Naira)
=household size (number of people eating from one pot)
= occupation (full time farming =1, part-time farming=0)
= farming experience (years)
= major cropping pattern (sole cropping=1, mixed cropping=2)
= mode of land ownership (Inheritance=4, purchase= 3, hire/lease=2, gift=1)
= Membership of social organization (yes=1, no=0)
= extension contact (number of times)
= previous training on CSA (yes=1, no=0)
= access to credit facilities (yes=1, no= 0)
= income per year from the farm (Naira)
= farm size (hectare)
= location of the farm
= Other source of income (farming=5 artisan=4, civil service=3, trading=2, others=1).

These variables were measured and analyzed from the responses of the respondents using frequencies, percentages and mean.

Level of perception of OFSP farmers on the CSA practices in the study area

Objective ii (the level of perception of OFSP farmers on the CSA practices) was realized using mean count. 3-Point rating scale of High (3), moderate (2) and Low (1) was used to achieve the mean. Variables with mean score of 2.0 (which is the average mean score of the likert level) and above implied that they were positive and in affirmative to the objective being measured, while factors with mean score of less than 2.0 are negative and rarely have influence on the objective being measured. To determine the mean likert level= $\sum X/N$. mean of each item was computed by multiplying the frequency of each response pattern with its appropriate nominal value and dividing the sum with the number of respondents to the items.

CSA practices commonly adopted among the OFSP farmers to cope with the natural hazards

The study listed anticipated CSA and updated during pre-survey and categorized the adoption, using 3-point scales of adopted (3), adopted and stopped (2) and never adopted (1) with the mean cut-off of 1.5. Hence, the study further categorized the practices using factorial component analysis to group the CSA practices into homogenous groups. However, Principal component factor analysis with varimax-rotation and factor loading of 0.40 was used. Variables with factor loadings less than 0.40 and variables that loaded in more than one factor were discarded following the study of Ashley *et.al.,* (2006).

$Y_1 = a_{11}X_1 + a_{12}X_2 + * * * + a_1nXn$ .... (3.1)
$Y_2 = a_{21}X_1 + a_{22}X_2 + * * * * + a_2nXn$…………………………………………………. (3.2)
$Y_3 = a_{31}X_1 + a_{32}X_2 + * * * * + a_3nXn$……………………………………………………. (33)
$Yn = an_1X_1 + an_2X_2 + * * * + anX_n$

Where,
$Y_1, Y_2 \ldots Yn$ = observed variables / CSA practices
$a_1 - an$ = factor loadings
$X_1, X_2, \ldots Xn$= unobserved underlying factors in CSA grouping.

The CSA were listed and categorized based on the five listed CSA groups which might be found in the study area.

CSA 1= Soil Related Management SRM (eg. Proper tillage, planting on the flat, use of manure/compost,

use of fertilizer, soil erosion control, afforestation, land rotation, planting on ridge/mound and planting on bed etc.);
CSA 2 = Crop Related Management CRM (e.g. use of improved variety, treating the vine before planting, use of quality planting materials, increase number of node cutting, crop rotation, plant spacing etc.);
CSA 3= Pest/Disease Related Management PDRM (use of IPM, application of pesticides, use of ash, use of neem, use of other crop attack, manipulation time of application, frequency of application etc.);
CSA 4 = Drought/Water Related Management DWRM (harvesting of water, manual application of water, irrigation application mechanical- drip, sprinkler, use of bed, mulching, planting under tree, planting near stream or river, watering in the evening/morning, etc.) and;
CSA5 = Post Harvest Related Management PHRM (harvest the vine before root, harvesting with fork, burying storage, cool dry storage, store in well-ventilated room, sore under the tree, store in the bar, use of ash in storage, use of dry leaves in storage, process to flour, process to juice, process to sallow, process to flakes others specify).

Constraints to adoption of CSA practices among the farmers

The constraints to the adoption of CSA practices among the OFSP farmers were analyzed using Factor component analysis (FCA). Principal component factor analysis with varimax-rotation and factor loading of 0.40 was used as in the case for objective ii. Variables with factor loadings less than 0.40 and variables that loaded in more than one factor were discarded.

Results and Discussion

Socio-economic and institutional characteristics of respondents

Results showed the mean household size of about 9 persons (SD= 3.32772), farming experience of about 12 years (SD=5.6634), N53, 498.1676 (SD=31154.5936) monthly income and 3.20 (SD= 0.9215) number of extension contacts. Many (60.90%) of the farms were located at rural area, than urban (36.90%) and semi-urban (2.20) with majority (67.00%) being male OFSP farmers than female (33.00%). More than half of the respondents were married (57.60%) than about 40.20% that were single and few (2.2%) divorcers. The study also found that majority (73.20%) of the OFSP farmers had tertiary education, participated in the training of CSA (90.30), members of cooperation (82.10%), practice mixed farming (91.10%) and ownership of land (88.80%). About 41.30% and 31.30% had access to irrigation and credit facilities with more than half (53.10%) of the farmers being into part time farming, than full timers (46.90%).

Perceptions of OFSP farmers on CSA practices

The study found high perception, that increase in rainfall affected CSA practices (3.05) as only rainfall related parameter with the mean score of 3.0 and above, the benchmark mean. The high perception on the effect of increase in rainfall on CSA practices maybe as a result of level of education and knowledge among the respondents on CSA practices. Aman et al. (2020) reported that increase in rainfall and extreme low rainfall in the dry season leads to flooding and a scarcity of water for production and life respectively.

Other variables such as; decrease in rainfall affect CSA practices (2.20), time of rain starts affect CSA (2.49), time of rain end affect CSA (2.04), and distribution pattern of rainfall affected CSA practices (2.23) had a low level of perception with mean score less than 3.00, benchmark mean. The study also found low perception among all variables as related to wind on; increase in wind speed (2.63), decrease in wind speed (2.16), changes in wind direction (2.62), more wind storm 2.88) and less wind storm (2.38) affect CSA practices with mean less than 3.00, the benchmark acceptable mean.

The study revealed (Table1) that variable such as; environment is hotter than before affect CSA practices (3.59), and high temperature affect CSA practices (3.13) were temperature related responses with high perception among the respondents in the study area with the mean score above benchmark mean of 3.00; while responses on environment is cooler than before affect CSA practices (2.18), and low temperature affect CSA practices (1.74) had mean scores below acceptable mean of 3.00 and therefore were lowly perceived by the farmers. However, the high perception on high and hotter temperature affecting CSA practices was in line with a prior expectation, since OFSP varieties mostly don’t adapted in harsh weather conditions. Aman et al. (2020) noted that when the temperature is very low or high and prolonged, it would be harmful for crop production.

Table 1: Level of Perception of OFSP Farmers on the CSA practices (Likert Scale Analysis)

Items	SA	A	U	D	SD	Mean
Rainfall						
Increase in rainfall affect CSA practices	26(130)	8(32)	123(369)	8(16)	14(14)	3.05
Decrease in rainfall affect CSA practices	8(40)	16(64)	8(24)	119(238)	28(28)	2.20
Time of Rain starts affect CSA practices	4(20)	44(176)	8(24)	103(206)	20(20)	2.49
Time of Rain end affect CSA practices	12(60)	12(48)	4(12)	107(214)	32(32)	2.04
Distribution pattern of rainfall affects CSA practices	16(80)	11(44)	12(36)	100(200)	40(40)	2.23
Wind						
increase in wind speed affect CSA	16(80)	32(128)	8(24)	115(230)	8(8)	2.63
decrease in wind speed affect CSA	8(40)	8(32)	28(94)	95(190)	40(40)	2.16
changes in wind direction affect CSA	12(60)	4(16)	107(321)	16(32)	40(40)	2.62
more wind storm affects CSA practices	4(20)	75(300)	40(120)	16(32)	44(44)	2.88
less wind storm affects CSA practices	4(20)	16(64)	40(120)	103(206)	16(16)	2.38
Temperature						
Environment is hotter than before affect CSA practices	107(535)	4(16)	16(48)	8(16)	28(28)	3.59
Environment is cooler than before affect CSA practices	12(60)	8(32)	40(120)	60(120)	59(59)	2.18
High Temperature affect CSA practices	18(90)	32(128)	91(273)	32(64)	6(6)	3.13
Low Temperature affect CSA practices	4(20)	20(80)	4(12)	60(120)	79(79)	1.74
Flooding						
No flooding affect CSA practices	4(20)	8(32)	79(237)	52(104)	36(36)	2.40
Low level of flooding affect CSA practices	12(60)	127(508)	8(24)	20(40)	12(12)	3.60
Frequent flooding affect CSA practices	123(615)	16(64)	24(72)	4(8)	12(12)	4.31
Drought						
Increase in drought period affect CSA	12(60)	129(516)	12(36)	20(40)	6(6)	3.68
Decrease in drought period affect CSA	4(20)	24(96)	4(12)	143(286)	4(4)	2.34
Grand mean						**2.71**

Source: Field Survey, 2023
Figures in Parentheses are the weighted frequencies
SA= Strongly Agree, A= Agree, U= Undecided, D= Disagree, SD= Strongly Disagree
Acceptable mean =3.00

In relation to flooding, the study found high perception among the OFSP farmers that low level of flooding affected CSA practices (3.60) and frequent flooding affected CSA practices (4.31) having had mean scores above benchmark mean of 3.00. This was an indication of high level of knowledge that flow of water cycle also affected by climate change. Khan (2018) reported that regular floods are considered essential for agriculture as it provide vital moisture and fertility to the soil by silt deposition but severe floods that occur in every 7-10 years, cause extensive damages to agriculture and other resource.
Among drought related responses; there was high perception among the respondents that increase in drought period affected CSA (3.68). This was expected as high perception was a clear implication that OFSP crop is a water-requirement crop that thrives in water-logged areas. According to Cao *et al*. (2022) and Satoh *et al*. (2022), severity and frequency of droughts have significantly increased (perceived), causing a marked reduction in crop production, considerable socio-economic losses in agriculture, and food security in the arid and semi-arid regions of developing countries.

CSA practices commonly adopted among the OFSP farmers to cope with the natural hazards in the study area
Table 2 presents the Principal Component Analysis (PCA) on CSA practices commonly adopted among the OFSP farmers to cope with the natural hazards in the study area. The study showed that practices such as use of organic manure (0.6638), use of inorganic fertilizer (0.6068) and planting on beds/ridge/mounds (0.4458) were adopted CSA1 (Soil Related Management) practices by the respondents in the study area.

The use of organic and inorganic fertilizer found in the study might be attributed to the high chances of soil infertility leading to a decline in the quantity and quality of the crop as a result of continue farming on a particular soil. However, Aman et al. (2020) also reported that change in climate affect soil moisture, and frequency of drought or flood, and groundwater level in different areas also affect the soil nutrient leaving the soil helpless and poor. Soil fortification through addition of organic and inorganic materials is the best bet. This result might also be as a result of accessibility and affordability of organic and to extent inorganic materials by the farmers that led to the adoption.

Practices that reclaim productivity and restore carbon storage include: nutrient amendments, applying organic substrates such as manures and composts and reducing tillage and retaining crop residues; conserving water (Njuguna, 2020).

In line with the findings on planting on beds/ridge/mounds as adopted CSA practices in the study, Ferreira (2023) noted that the performance of a plant is greatly influenced by the way it is treated/planted as it grows, and many pathogens enter a host through an injury. Therefore, proper land preparation and looseness of the soil help OFSP to root and build up its food without obstruction.

For the CSA2, the study found planting improved crop variety (0.6725), changing planting dates (0.4165) and inter-cropping (0.7355) as the adopted CSA practices in the study area.

The Pest/Disease Related Management PDRM (CSA3) found to be adopted and practiced in the study area were; planting disease resistant varieties (0.8171) and use of terraces (0.4510). In corroboration with the study, Bennett et al. (2019) and Gollin et al. (2021) stressed that the key to mitigate climate changing problem is to involve in the development and dissemination of high-yielding and disease-resistant crop varieties to farmers. However, among the OFSP varieties, there are highly resistant and susceptible varieties to SPVD, and as well high yielding such as UMUSPO/1, 4 and 3. Climate-resilient crop varieties are a critical part of the climate-smart agriculture (CSA) approach with the potential to offer the triple wins of increasing productivity with ensuing welfare implications, building resilience to climatic shocks and reducing the emission of greenhouse gases (Ojong et al., 2023). However, the use of terraces adopted in the study explained the level of crop, soil and land protection the farmers employed to secure their farms.

Table 2. Principal Component Analysis (PCA) on CSA practices commonly adopted among the OFSP farmers to cope with the natural hazards in the study area

CSA	CSA1	CSA2	CSA3	CSA4	CSA5
Planting improved crop variety	0.1480	**0.6725**	0.0362	0.1599	0.0433
Planting a greater number of node cuttings	-0.0981	0.2006	0.3804	0.2212	-0.2543
changing planting dates	-0.1040	**-0.4165**	0.0239	0.2158	-0.0469
Use of crop rotation	0.5370**	0.1319	0.8360**	0.0378	0.0019
Moving to a different site	0.5587**	0.1757	0.0257	-0.2248	0.8003**
Inter-cropping	0.1181	**0.7355**	0.2406	-0.0907	0.2518
Water harvesting	-0.2110	-0.1152	0.0473	**0.8258**	0.1532
Use of irrigation water	-0.0807	0.0317	-0.0947	0.0080	-0.2105
Use of organic manure	**0.6638**	0.3025	-0.0358	-0.0732	0.2827
Planting shade trees on crop land	-0.2979	0.4202**	-0.0406	0.5194**	-0.1709
Use of mulching	0.0399	0.3869	0.3351	**0.6570**	0.2306
Planting disease resistant varieties	0.3644	0.2614	**-0.8171**	0.1096	0.0803
Using information from weather forecast/announcement	-0.3175	0.361	0.2614	0.2170	0.0283
Efficient use of pesticides	0.3889	-0.1003	0.5290*	0.4097*	0.0212
Using organic fertilizer	**-0.6068**	-0.1316	0.4319	-0.1613	-0.0142
Planting cover crops	0.1295	-0.0018	0.5128**	0.4301**	0.2306
Use of compost material	0.3779	0.2439	-0.1059	0.01230	0.2492
Use of biochar	-0.1702	-0.0032 -	--0.0827	--0.1890	0.0258
Use of terraces	0.1138	-0.1455	**0.4510**	0.2570	-0.1230
Use of life/plant barrier	0.6444**	0.5525**	0.4331**	-0.2043	0.2933
Use of zero tillage	0.2328	-0.0935	0.0845	0.4164	0.0866
Planting on beds/ridge/mounds	**0.4453**	-0.3370	-0.2180	-0.0660	0.1814
Curing before harvest	0.0674	-0.2815	-0.2029	0.4064	**-0.7042**
Store in a well-ventilated area	0.1221	0.0171	-0.1650	0.3082	**0.4789**

Use of ash/leave in storage	0.2689	0.1458	0.1008	-0.0273	-0.2536
Process to other product form	0.1304	-0.2022	0.2082	0.2258	**0.8640**

Source: Field Survey, 2023

CSA 1= Soil Related Management, CSA 2 = Crop Related Management CRM, CSA 3= Pest/Disease Related Management PDRM, CSA 4 = Drought/Water Related Management DWRM, CSA5 = Post

Harvest Related Management PHRM

In support of the findings, Njuguna (2020) noted that farmers employed various ways to secure water resources in rural areas and practice rainwater management and harvesting system. The aforementioned study also observed that harnessing of rain or groundwater for agricultural or domestic use has been in practice in agricultural zone area of the country. Ibrahim (2018) confirmed the results and identified several water-harvesting technologies as Zai pits, retention ditches, road runoff harvesting, rock catchment harvesting, roof catchment harvesting, and construction of ponds, dams, and water pans, among others. The high performance on the use of mulching was in accordance with the findings of Abdulraheem et al. (2021), who observed that the farmer uses mulching as an organic material not only to add manure to the soil but also for soil and water nutrient retention, which will help to reduce pest/disease incidence. Ferreira (2023) also noted that mulching not only retain water but prevent excess water which reduces the amount of air in the soil, prevents good root development, and increases susceptibility to root-rot diseases.

Furthermore, due to high perishability of OFSP and post-harvest losses, farmers adoption of curing before harvesting, storing in a well-ventilated area and value addition have been reported by several studies (Okoye et al., 2021; Mitra et al., 2012).

Constraints to the use of CSA practices among OFSP farmers

The study also presented the results on varimax-rotated factors militating against the use of CSA practices among OFSP farmers in the study area In Table 3. Three (3) factors from the results were extracted based on the response of the respondents. Only variables with factor loading of 0.30 and above at 10% overlapping variance as indicated by Ashley *et al.,* (2006) were used in naming the factors. Variables that loaded more than one factor as in the case of variables 2 and 7 were discarded, while variables that had factor loadings of less than 0.30 were not used following Enete and Amusa, (2010). This procedure was adopted in grouping the variables into three major factors as: Factor 1= Eco-financial constraints, Factor 2 = Socio-Infrastructural constraints and Factor 3 = Techno-Institutional constraints.

Table 3: Varimax-Rotated Factors militating against the use of CSA practices among OFSP farmers in the Study Area

S/N	Constraining Variables		Constraints	
		Factor 1	**Factor 2**	**Factor 3**
1	High cost of labour	**0.4083**	-0.1718	0.1576
2	Inadequate capital	0.1158	-0.4880**	0.5481**
3	Price fluctuation of materials	0.0663	0.1820	0.0304
4	Procedures were difficult to understand	0.0215	0.0363	**0.6363**
5	Harvesting, processing and storing Technologies	-0.0407	**0.4750**	0.0193
6	Difficulty in applying technology	0.0683	-0.0288	-0.0699
7	Lack of technical support	0.4529**	0.4988**	0.6376**
8	Poor access to information from extension agents	0.1522	**-0.5210**	0.6125
9	Poor financial status of the farmers/processors	-0.2304	0.1147	0.0266
10	Poor product storage (short shelf life)	-0.1223	**-0.5769**	--0.0930
11	Irregular and weak government policies	0.1945	0.1930	**-0.4403**
12	Poor market structure	0.1234	-0.2379	**0.6943**
13	Poor knowledge of application	-0.3421	-0.0334	-0.2379
14	Cost of maintenance	-0.1767	0.1158	0.0365
15	Susceptible nature of OFSP to pest and diseases	0.3340	0.0154	**0.4379**

Source: Field Survey, 2023

Factor 1= Eco-financial constraints, Factor 2 = Socio-Infrastructural constraints, Factor 3 = Techno-Institutional constraints

The study identified only high cost of labour (0.4083) as eco-financial constraints against the use of CSA practices in the study area. Cost of farm labour plays an important role in the use of CSA practices and also identified as common constraints in agriculture due to high intensity of agricultural activities especially in peak production season Royo-Esnal and Valencia-Gredilla, 2018; Okoye et al, 2021). High cost of labour directly and indirectly affects the level of operation which has an implication on CSA practices and adoption. This is because the household bears the transaction costs of labor market participation in small scale farming.

The socio-infrastructural constraints (factor 2) found in the study were; harvesting, processing and storing technologies (0.4750), poor access to information from extension agents (0.5210), and poor product storage (short shelf life) (0.5769). This was an indication of poor infrastructural facilities and social access to essential facilities need to purse OFSP production and practice. In line with the results, Okoth (2019) noted poor storage, and processing facilities among sweet potato farmers and also further confirmed that poor storage and processing facilities are some of the major problems of agriculture in Nigeria. Institute Economic Affairs (2018) mentions that agricultural financial services include risk transfer strategies that a farmer can access which like insurance, contract farming and sources of agricultural capital are not well known to farmers due to poor communication system. More so, Okoth (2019) noted that the inconsistent and conflicting advice about CSA confuses the farmers even farther and also mentioned that responsive national regional markets should be encouraged to provide access to credit and financial schemes to enable farmers adopt new and emerging climate-smart technologies and as well market their products.

However, the study showed that; procedures were difficult to understand (0.6363), irregular and weak government policies (0.4403) and poor market structure (0.6943) were the techno-Institutional constraints militating against CSA adoption and practices in the study area. This result was in similarity with the findings of Ekunwe et al. (2018) who identified similar problems among okra farmer in their study.

Test of Hypothesis

Socio-economic and institutional factors have no statistically significant relationship on the adoption of climate smart agricultural practices among OFSP farmers.

The regression analysis (Table 4) identified the semi-log model as the best fit, with an R^2 value of 0.5897, indicating that 58.97% of the variation in CSA adoption was explained by the independent variables. The F-statistic was significant at the 1% level, confirming the model's robustness.

Among socio-economic factors, farming experience and occupation were negatively significant at the 10% level. Unexpectedly, experienced farmers were less likely to adopt CSA, possibly due to a preference for traditional methods, while less experienced or younger farmers were more open to innovation—consistent with findings by Ngigi et al. (2022), who noted that younger and less experienced farmers tend to be more adaptive to climate innovations. Full-time farmers, being more reliant on agriculture, showed greater willingness to adopt CSA than part-time farmers.

Farm income had a positive and significant influence at the 5% level, supporting studies by Tesfaye et al. (2021) that income increases the capacity to invest in inputs, technology, and labor required for CSA. Similarly, participation in training, access to credit, and land ownership were highly significant and positively influenced CSA adoption, echoing findings by Ajayi et al. (2023), who emphasized the importance of institutional support in driving CSA uptake among smallholders.

Location also showed a negative but significant relationship at the 1% level, suggesting rural farmers were more likely to adopt CSA than their urban counterparts—likely due to their stronger dependency on agriculture and direct exposure to climatic risks (Temesgen, 2020) and Khatri-Chhetri et al., 2021).

These findings collectively reject the null hypothesis and affirm that socio-economic and institutional factors significantly influence CSA adoption. Policy efforts should therefore focus on enhancing access to credit, training programs, secure land tenure, and income-generating opportunities to foster CSA adoption among OFSP farmers.

Table 4: OLS Regression Estimates of Socio-economic and institutional factors influencing adoption of climate smart agricultural practices among OFSP farmers

Variables	Linear	Exponential	Double Log	Semi-Log +
Sex(X_1)	1.5716	0.1012	0.0804	1.2051
	(1.14)	(1.72)	(1.42)	(0.91)
Age (X_2)	0.0148	-0.0003	-0.0031	0.6241
	(0.35)	(-0.15)	(-0.04)	(0.38)
Marital Status (X_3)	0.1069	0.0217	0.0601	-0.2144
	(0.06)	(0.27)	(0.07)	(-0.11)
Education qualification (X_4)	-0.7863	-0.0371	-0.0329	0.7206
	(-1.36)	(-1.50)	(-1.33)	(-1.25)
Farming experience (X_5)	-0.1704	-0.0062	-0.0707	-1.9294
	(-1.71)*	(-1.45)	(-1.67)*	(-1.94)*
Cooperative (X_6)	0.9141	-0.1610	-0.0119	1.1015
	(0.42)	(-0.17)	(-0.13)	(0.51)
Occupation (X_7)	-3.3773	-0.1298	-.1286	-3.3916
	(-2.23)*	(-2.01)*	(-2.02)*	(-2.28)*
Income (X_8)	0.00004	1.99e-06	0.08109	1.8182
	(2.46)*	(2.82)**	(3.04)**	(2.91)**
Extension contact (X_9)	2.4624	0.0509	0.0135	1.8044
	(1.07)	(0.52)	(0.14)	(0.82)
Training (X_{10})	-23.1693	-0.6916	-0.7017	23.5657
	(-7.49)	(-5.25)***	(-5.38)	(7.72)***
Credit (X_{11})	-12.1216	-0.4595	-0.4001	10.9512
	(-6.74)***	(-6.00)***	(-5.75)***	(6.73)***
Land (X_{12})	-8.664	-0.2245	-0.2757	9.6708
	(-4.14)	(-2.52)*	(-3.20)**	(4.79)***
Irrigation (X_{13})	0.2501	0.0057	0.0053	0.2149
	(0.24)	(0.13)	(0.12)	(0.21)
Location (X_{14})	6.4151	0.2320	0.1947	-5.6004
	(2.60)*	(2.21)*	(1.86)*	(-2.29)*
Contact	59.9201	4.3024	3.7439	45.7613
	(10.43)***	(17.59)***	(8.06)***	(4.21)***
F-cal	16.19	8.44	8.74	16.84
R-squared	0.5802	0.4186	0.4273	0.5897
Adj R-squared	0.5443	0.3690	0.3784	0.5547

Source: field survey, 2022
***, ** and *** are significant at 10%, 5% and 1% level of probability respectively.**
+ = lead equation

Conclusion

This study revealed that most of the OFSP farming households in the study area experienced climate change in various forms. Some of them include: increase in the amount of rainfall, early starts of rain than it used to be, changes in wind direction and wind storm. In other to mitigate these experiences, the farmers were found to practice some of the CSA such as use of organic manure, use of inorganic fertilizer and planting on beds/ridge/mounds as soil related management; planting improved crop variety, changing planting dates and inter-cropping as the adopted crop related management.

Factors such as farming experience, occupation and location of the farmers, farm income, and participation in training, access to credit and ownership of land or access to land were found significantly influencing adoption of CSA in the study area and beyond. The study therefore called for policies and strategies aimed at strengthening the existing OFSP farmers through providing intensive training and building of synergy among partners. Also, considerable policy support and capacity enhancement is needed for climate smart agricultural practices including access to information, land and credit to empower the farmers' needs.

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