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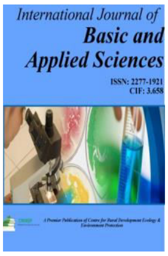

Research Paper

Socioeconomic Factors Affecting Farmers' Choice Of Climate-Smart Agriculture Practices Combinations By Small-Holder Crop Farmers In Imo State

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ABSTRACT

This study investigates the socioeconomic factors influencing smallholder farmers' choice of climate-smart agriculture (CSA) practice combinations in Imo State, Nigeria. As a nation heavily reliant on agriculture and natural resources, Nigeria faces growing threats from climate change, including declining productivity, food insecurity, and environmental degradation. Ironically, some farming practices continue to aggravate these climate-related challenges. Therefore, this research aimed to evaluate the socioeconomic characteristics of farming households and the determinants of their CSA practice choices. A multistage sampling technique was used, and data were collected from 337 food crop farming households. The analysis includes descriptive statistics and inferential and econometric models to identify key influencing variables. The socioeconomic characteristics showed that 57.9% of the respondents were male and 80.7% were married. The mean age was 55 years, and 50.4% of the respondent's attained secondary education, suggesting a relatively literate farming population. The econometric analysis highlighted several statistically significant determinants (at $P < 0.05$) of CSA adoption. Age (-2.98), marital status (-4.21), and household size (-3.38) negatively influenced CSA adoption. Older, married farmers with larger households were less likely to adopt a diverse range of CSA practices. Conversely, formal education attainment (4.453), specified training on CSA technologies (0.831), religious affiliation (8.252), scale of operation (3.905), and agroforestry engagement (2.808) positively and significantly influenced CSA practice choices. These findings underscore the importance of human capital development in driving CSA uptake. The negative association with age suggests that ageing farmers may lack the physical capacity, adaptive mindset, or technological exposure needed to embrace new practices. In contrast, the positive impact of formal education and CSA training points to the critical role of knowledge acquisition and capacity building. Educated farmers are more likely to understand the long-term benefits of CSA practices, such as improved productivity, resilience to climate shocks, and mitigation of environmental degradation. Religious affiliation and agroforestry practices also emerged as meaningful drivers, suggesting that community values and environmental stewardship influence behaviour. Similarly, larger farming operations provided the flexibility and scale needed to experiment with and adopt multiple CSA strategies.

1. Introduction

Agriculture is the backbone of Nigeria's economy, employing more than 70% of the population either directly or indirectly (World Bank Group, 2017). It serves as a primary source of food, income, and employment, while also providing raw materials for agro-based industries. Despite its pivotal role, the agricultural sector faces growing threats from environmental degradation and climate change. Unsustainable land-use practices, such as deforestation, overgrazing, and slash-and-burn agriculture, continue to degrade arable lands, rendering them less productive (Abdulahi, Fullen, &Oloke, 2016). Over the past six decades, climate change has become increasingly evident in Nigeria, with more frequent and severe disruptions in weather patterns, including erratic rainfall, rising temperatures, humidity fluctuations, and shifts in precipitation (IPCC, 2021). These changes have exacerbated food insecurity and agricultural vulnerability, particularly in

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Southeast Nigeria and Imo State (Abu, Okpe, &Abah, 2018). Agricultural practices, especially in market-oriented regions, have contributed significantly to climate change through activities such as excessive fertilizer use, deforestation, and methane emissions from rice paddies and ruminant livestock (Federal Ministry of Environment, 2014; Igberi*et al*., 2022). Southeast Nigeria, particularly Imo State, is at the forefront of these challenges, battling soil erosion, flooding, temperature variability, and an upsurge in pests and diseases. These adversities have heightened the risk of crop failures and declining yields, posing a grave threat to food production (Wouterse, 2017). While various mitigation strategies have been proposed (Ozor*et al*., 2012), the adoption of climate-smart agriculture (CSA) stands out as a holistic and effective response.

Climate-smart agriculture refers to a suite of farming practices, technologies, and innovations that aim to sustainably increase agricultural productivity, enhance resilience to climate shocks, and reduce greenhouse gas emissions (FAO, 2010; Nwajiuba, Tambi, &Bangali, 2015; Onyeneke*et al*., 2018). These include techniques such as conservation agriculture, agroforestry, water harvesting, crop diversification, and improved seed varieties. By integrating productivity, adaptation, and mitigation goals, CSA offers a strategic pathway to safeguard food security and improve livelihoods under a changing climate (Campbell *et al*., 2015).

Although several studies have acknowledged the benefits of CSA, critical gaps remain. Most prior research tends to generalize CSA adoption without disaggregating the socioeconomic factors that drive or hinder farmer engagement in specific combinations of CSA practices. Moreover, limited attention has been paid to the unique context of Imo State, where smallholder crop farmers face distinct climatic and socio-economic constraints. Existing studies also fall short in identifying the mix of CSA practices adopted by farmers and the underlying determinants of those choices. Addressing these research gaps is crucial to developing targeted interventions and policies that will enhance CSA adoption and effectiveness in the region.

Objectives of the Study

1. Examine the socioeconomic characteristics of smallholder crop farmers who engage in climate-smart agriculture (CSA) practices;
2. Isolate the factors affecting farmers' choice of CSA combinations in the study area.

2. Materials and methods

The study was conducted in Imo State, one of the South-East States in Nigeria. Imo State consists of twenty-seven (27) Local Government Areas (LGAs), grouped into three agricultural zones: Owerri, Okigwe, and Orlu. Owerri zone includes eleven LGAs, Okigwe zone consists of six LGAs, and Orlu zone contains ten LGAs. Imo State lies between latitudes 5° and 6°N and longitudes 7° and 8°E, bordered by Anambra State to the north, Abia State to the east, and Rivers State to the south. Imo State covers a total land area of 5,067.20 km^2 and has a tropical climate with clearly defined wet and dry seasons. The state experiences mean temperatures ranging between 27°C and 33°C and an average annual rainfall of about 2,000 mm. Humidity levels vary from 51% to 84%. Its topography is generally flat to gently undulating, with elevations ranging from 50 m to 300 m. The state is predominantly agrarian with rich tropical rainforest vegetation and significant food crop and livestock production. The study population comprised smallholder food crop farmers across the three agricultural zones of Imo State. These farmers are primarily responsible for the cultivation of food crops such as yam, cassava, maize, cocoyam, vegetables, and rice.

A multi-stage sampling procedure was adopted to ensure representation across the three agricultural zones. **In stage one,** two LGAs were randomly selected from each of the three agricultural zones, making a total of six LGAs. **In Stage two,** 20% of communities within each selected LGA were randomly chosen, making a total of 12 communities. **In stage three,** 20% of the farming households from each community were randomly selected, resulting in a sample size of 423. After data cleaning, 337 responses were used for analysis. Primary data was used for the study. Data were collected using a well-structured questionnaire administered through personal interviews. The questionnaire was divided into sections: the socio-economic characteristics of respondents and factors influencing their choices of CSA. Due to the low literacy levels and poor record-keeping habits of farmers, ADP extension agents were also consulted, and enumerators were trained for the collection of reliable data. Out of the 423 questionnaires distributed, 337 of the questionnaires were completed and deemed useful for analysis.Descriptive Statistics such as mean, frequency count, percentage, and a multivariate logistic model were used to achieve the objectives.

Model Specification

The Multivariate Logistic Model (MLM) is specified explicitly as follows

$$\text{Ln } Y = \text{Ln } \left(\frac{p}{1-p}\right) \quad \text{- - - (1)}$$

$$\text{Ln } Y = \text{Ln } \left(\frac{p}{1-p}\right) = b_o + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + b_5 x_5 + b_6 x_6 + b_7 x_7 + b_8 x_8 + b_9 x_9 + b_{10} x_{10} + b_{11} x_{11} + b_{12} x_{12} + b_{13} x_{13} + e$$

Where,

Y = use of CSA practice (Dummy variable, use of CSA practices in combination = 1, and use of CSA practice in isolation = 0)

P = Probability of use of CSA practices

Ln = natural logarithm function

b_0= constant

$b_1 - b_{11}$ = logistic regression coefficients

X_1 = mean income from food crop (₦)
X_2 = sex (Dummy variable, 1 for male, and 0 for female)
X_3 = Age of the farmer (years)
X_4 = Level of education (years)
X_5 = Households size (Number of persons)
X_6 = Farm size (Hectares)
X_7 = Farming experience (years)
X_8 = Social organization membership (Dummy variable, 1 for membership, and 0 for non-membership)
X_9 = Extension contact (Number of visits per annum)
X_{10} = Cost of soil maintenance (₦)
X_{11} = Capital (₦)
X_{12} = Number of CSA practices known to the farmer (Number of CSA practices)
X_{13} = Number of CSA practices available to the farmer (Number of CSA practices available).
Since P is the probability of CSA practices use in combination and (1 –P) is the probability of use of CSA practices in isolation, the ratio ($\frac{p}{1-p}$), known as the odds ratio, is the odds in favour of use of CSA practices in combination.

3. Results and Discussions

Socio-Economic Characteristics of Small-Holder Crop Farmers in Imo State. The farmers' socio-economic characteristics of the farmers is presented in Table 1

Table 1: Socioeconomic characteristics of smallholder crop Farmers in Imo State

Sex	Frequency	Percent	Mean	Total
Male	195	57.9		
Female	142	42.1		
		100.0		**337**
Age (Year)			**55 years**	
Less than 30	7	2.08		
30 – 39	18	5.34		
40 – 49	72	21.36		
50 – 59	126	37.39		
60 – 69	101	29.97		
70 and Above	13	3.86		
		100.0		**337**
Marital Status				
Single	26	7.72		
Married	276	81.90		
Widow/Widower	35	10.39		
		100.0		**337**
Formal Education Level				
No Formal Education	21	6.23		
Non-Formal Education	7	2.08		
Primary Education	97	28.78		
Secondary Education	170	50.45		
Tertiary Education	42	12.46		
		100.0		**337**
Household Size				
1 – 5	15	4.45		
6 – 10	151	44.81		
11 – 15	106	31.45		
16 – 20	22	6.53		
21 – 25	43	12.76		
		100.0	**12 persons**	**337**

Source: Field Survey Data Analysis, 2024

Table 1 shows the results of the socioeconomic characteristics of smallholder crop farmers in Imo State. The findings reveal that farming in the area is male-dominated, with men comprising 57.9% of respondents compared to 42.1% female participants. This gender imbalance reflects entrenched socio-cultural norms where women are often sidelined in agricultural decision-making and resource allocation. Joshi and Kalami (2019) collaborated on this by stating that although both genders participate in farming, roles are typically gender-specific. Men usually perform more physically demanding tasks such as ploughing and yam staking, while women handle planting, weeding, and harvesting activities, often carried out close to the home due to domestic obligations. Contrary to these trends, Pierotti*et al*. (2022) reported a female labour majority in South-West Nigeria. National statistics show that women constitute 36% of Nigeria's farming population, and 55% of farms involve at least one female farmer. Despite this, policies and interventions tend to marginalize women, reinforcing male dominance in farming. Nonetheless, women remain crucial in post-harvest processing, food preparation, and animal husbandry, often showing higher allocative efficiency (Ehirim*et al*., 2016). The result goes on to show that the mean age of farmers is 55 years, implying an ageing demographic. Notably, 37.4% fall within the 50–59 age bracket, 30% are aged 60–69, and only 28.8% are between 30–49 years. This ageing trend is concerning, especially as younger individuals increasingly opt for quicker-income ventures like motorcycle (*okada*) transport or urban jobs. Sulaiman and Abdul-Rahim (2018) link this ageing trend to elevated CO2 emissions due to reliance on fuelwood. Adekemi (2019), analyzing LSMS-ISA data, noted that just 9.69% of farmers are youths, raising concerns over succession planning and long-term sustainability of CSA practices. Marital status data show that 80.7% of respondents are married, 11.6% are widowed, and 7.7% are single. While high marriage rates suggest the potential for family-based labour, they can also present constraints. Larger families mean more hands for farming, but also increased consumption needs, which can undercut profits. Ehirim (2016) observed that these domestic pressures often reduce the economic viability of small-scale agriculture. For women, especially marital dynamics can impede participation in CSA, with limited decision-making autonomy despite their labour contributions. Education shows that 6.2% of farmers have no formal education, 2.1% have informal training, 28.8% completed primary education, and 50.4% attained secondary education. The relatively high literacy rate is promising for CSA adoption, as better-educated farmers tend to understand, embrace, and disseminate innovative techniques. Abegunde et al. (2020) identify education as a key enabler of CSA uptake, while Ojoko*et al.* (2017) argue that educational initiatives bridge the knowledge gap essential for climate adaptation. Finally, the mean household size shows 12 members per farmer. Most households (44.8%) consist of 6–10 members, followed by 31.5% with 11–15 members. Only 4.5% reported having 1–5 members. Larger households may offer the advantage of abundant farm labour, potentially increasing productivity. Yet, increased household consumption can erode potential gains. Kalu and Mbanasor (2023) maintain that in underdeveloped agricultural contexts, large household sizes bolster labour supply. However, Agbenyo (2022) cautions that household size alone does not guarantee adoption of CSA practices unless coupled with strategic training and engagement.

Determinants of Choice Combination of CSA Practices by Small-Holder Crop Farmers

The factors that determines the choice combination of CSA practices among small-holdercrop farmers in the state is presented in Table 2

Table 2: Multivariate Probit Result of Choice Combination of CSA Practices by farmers

Variables	Parameter Estimates Productivity and Food Security		Adaptation and Resilient		Mitigation	
	Coefficient	/t-value/	Coefficient	/t-value/	Coefficient	/t-value/
Intercept	6.556*	2.00	4.776**	3.22	0.022**	4.41
(Std. Errors)	3.278		1.483		0.005*	
Age	-0.10*	2.08	-0.079*	1.98	0.100	2.08
(Std. Errors)	0.048		0.040		0.048	
House hold Size	-0.008	0.18	-0.033	1.33	-0.01	1.67
(Std. Errors)	0.045		0.025		0.006	
Education	0.267**	2.72	0.007*	2.09	-0.468*	1.99
(Std. Errors)	0.098		0.003		0.235	
Experience	-0.178	0.56	0.502	1.87	-0.367	1.92
(Std. Errors)	0.318		0.268		0.191	
Marital status	-0.214*	2.19	0.111**	2.45	0.931	1.34
(Std. Errors)	0.098		0.045		0.694	
Sex	-0.291*	2.006	0.897	0.521	0.175	0.141
(Std. Errors)	0.145		1.720		1.240	
Scale of operation	0.867*	2.206	0.716**	3.14	0.325*	2.26
(Std. Errors)	0.393		0.228		0.144	
CSA Training	1.786	1.805	0.068**	3.09	2.262*	2.02
(Std. Errors)	0.989		0.022		1.121	
Agro-Forestry Management	1.841**	3.01	0.109*	2.18	0.954**	2.44
(Std. Errors)	0.611		0.050		0.391	
Income	-0.622**	3.00	-0.901**	3.41	-0.445	1.98
(Std. Error)	0.207		0.264*		0.225*	
Religious Affiliation	0.445	1.85	0.034*	2.13	0.143**	3.19
(Std. Error)	0.241		0.016		0.046	
CSA Awareness	0.012	1.448	0.26*	1.992	0.802*	2.110
(Std. Error)	0.017		0.519		1.692	
Functional /Diagnostic Statistics						
Chi- Square			68.0078*			
Log Likelihood			-165.4997			
Observations			337			

*Source: Field Survey Data Analysis 2024 Legend: P< 0.05 = * and P < 0.01 = ***

Table 2 presents the results of the functional parameters estimating the determinants of Climate-Smart Agriculture (CSA) practice combinations among arable crop farmers in Imo State. The chi-square value of 68.008 and the negative log-likelihood of -165.50 are statistically significant at the 5% level (P < 0.05), indicating that the model has a good fit. In other words, the explanatory variables collectively have strong explanatory power over the likelihood of CSA practice adoption. This confirms the appropriateness of the model specification and validates its ability to explain farmers' decisions across the three CSA pillars: productivity enhancement, resilience building, and climate change mitigation.

Age has a negative and statistically significant relationship with CSA adoption across the three pillars. The absolute t-value exceeds the critical threshold of 1.96, confirming that age negatively influences the likelihood of choosing CSA practices. This suggests that as farmers get older, they are less likely to adopt CSA combinations aimed at improving productivity, building resilience, and mitigating climate change. This finding is consistent with the reality on the ground: older farmers often lack the energy, technical know-how, and willingness to embrace new technologies compared to younger, more agile counterparts.

Formal education attainment is positively significant across most CSA pillars, particularly productivity and resilience. However, it shows a somewhat counterintuitive negative relationship with climate change mitigation practices. This could imply that while education boosts understanding and application of CSA practices in general, some mitigation-specific interventions, like increasing vegetative cover or carbon sequestration techniques, are either less emphasized in formal curricula or are less immediately rewarding. This gap underscores the importance of targeted extension education and farmer field schools to promote mitigation-oriented CSA knowledge.

Sex (gender) also emerges as a determining factor. The results indicate that being male significantly reduces the likelihood of choosing CSA practices aimed at productivity and food security. However, sex does not significantly influence adoption in the areas of resilience and mitigation. This suggests that while women are actively involved in decisions that enhance productivity, they may be less engaged with practices related to climate adaptation and mitigation, possibly due to restricted access to resources, decision-making authority, or information in these domains. Scale of operation, training on CSA, and awareness of CSA all have positive and statistically significant effects on the likelihood of adopting CSA practices across all three pillars. This aligns with expectations: farmers who cultivate larger plots are more likely to perceive the benefits of CSA, especially when they have received training and are more aware of its advantages. Information and empowerment matter a lot.

Religious affiliation is positively associated with the adoption of adaptation and mitigation practices, but not with productivity-oriented choices. This could reflect religious teachings or community norms that emphasize stewardship of the environment, particularly in faith-based rural communities. It's a cue that faith groups could be influential partners in scaling CSA adoption.

4. Conclusion

The study concludes that socioeconomic variables significantly shape smallholder farmers' decisions regarding CSA practice combinations. Advancing CSA adoption in Imo State requires targeted interventions: educating and training younger farmers, enhancing institutional support, and leveraging community structures. Making farming attractive and profitable for educated youth could catalyze the broader adoption of CSA and contribute to sustainable food systems.

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