



INTERNATIONAL JOURNAL OF

Organic Agricultural

RESEARCH AND DEVELOPMENT

*Advancing Sustainable Agriculture for
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VOLUME

21

SPECIAL ISSUE



MAY, 2026



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Organic and Climate-Smart Adaptation Strategies among Sweet potato Seed Producers in Ebonyi State, Nigeria: Sustainable and Innovative Practices

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ABSTRACT

Climate change poses significant threats to agricultural productivity in sub-Saharan Africa, particularly among smallholder farmers dependent on rain-fed systems. This study examined the adoption of organic and Climate-Smart Agriculture (CSA) strategies among sweet potato seed producers in Ebonyi State, Nigeria, with the aim of assessing their awareness and effectiveness in enhancing resilience, and estimate factors influencing adoption. A multi-stage sampling technique was used to select 60 seed producers, and data were collected using structured questionnaires and focus group discussions. Analytical tools included descriptive statistics, Likert scale analysis, multinomial logit regression, and correlation analysis. The results revealed that awareness of CSA and organic practices was universal, adoption varied widely across practices. Improved varieties and basic pest management practices recorded high adoption rates, while capital-intensive and technically complex practices such as irrigation systems and advanced nursery technologies had low uptake. Correlation analysis showed a strong positive relationship between integrated pest management and soil health practices, and negative associations between improved varieties and some other strategies. The multinomial logit results indicated that gender, age, household size, education, extension contact, and income significantly influenced adoption decisions. Notably, extension contact and income positively affected adoption, while farming experience showed a negative relationship with some practices, suggesting resistance to change among more experienced farmers. The study recommends improved access to credit, strengthened extension services, and targeted capacity-building programs to promote integrated and sustainable adoption of CSA strategies among seed producers.

Key words: *Smallholder farmers, Technology adoption, Sustainable intensification And Multinomial logit model*

INTRODUCTION

Climate change remains one of the most pressing threats to agricultural productivity, especially in sub-Saharan Africa, where smallholder farmers rely predominantly on rain-fed agricultural systems. In Nigeria, the agricultural sector already vulnerable due to low adaptive capacity and limited institutional support is experiencing escalating climate-related shocks, including erratic rainfall patterns, rising ambient temperatures, prolonged dry spells, and accelerated soil degradation (FAO, 2019). These stressors directly undermine seed quality, reduce germination rates, and compromise the long-term sustainability of seed production systems. Among the most affected are seed producers of vegetatively propagated crops such as sweet potato (*Ipomoea batatas*), a staple food and nutrition security crop widely cultivated across Ebonyi State, Nigeria.

In response to these compounding challenges, Organic and Climate-Smart Agriculture (CSA) has emerged as a transformative framework that simultaneously pursues three interlinked goals: sustainable productivity increases, climate change adaptation, and mitigation where feasible (Lipper *et al.*, 2014). Organic agriculture and agroecology offer complementary pathways to CSA by emphasizing biodiversity, soil health, closed nutrient cycles, and reduced reliance on synthetic inputs principles that align strongly with climate resilience (Altieri & Nicholls, 2017). In Ebonyi State, sweet potato seed producers have reportedly begun integrating a range of organic and climate-smart practices. These include the use of drought-tolerant and disease-resistant sweet potato varieties, organic mulching for soil moisture retention, farmyard manure and compost application for integrated soil fertility management, agroforestry

integration, and water harvesting techniques (Mugendi *et al.*, 2020). Such practices are not merely additive; they represent differentiated, context-specific adaptations that reflect local ecological knowledge, resource availability, and market constraints. The adoption of these strategies highlights the dynamic and innovative nature of seed producers' responses to climate variability.

While CSA has been extensively documented for staple grain crops, its application in vegetatively propagated seed systems particularly sweet potato seed production remains underexplored. Seed producers occupy a uniquely critical position in agricultural value chains, as the quality of planting material directly determines farm-level productivity, disease pressure, and household food security. Therefore, understanding how sweet potato seed producers in Ebonyi State are adapting to climate stresses through organic and climate-smart strategies is both a scientific priority and a development imperative. However, this study analyzed the effectiveness of key climate-smart and organic practices implemented by sweet potato seed producers in Ebonyi State in enhancing resilience to climate change, evaluated the socio-economic and institutional factors influencing the adoption of organic and climate-smart adaptation strategies, and examined the challenges and barriers to the implementation of these practices within sweet potato seed production systems.

Methodology

Study Area: The study was carried out in Ebonyi Nigeria, located in the southeastern geopolitical zone of Nigeria. Mean annual rainfall ranges from 1,500 mm to 2,000 mm, while average temperatures vary between 22°C and 32°C. The major occupation of the inhabitants is agriculture, including the cultivation of rice, yam, sweet potato, cassava, maize, and vegetables.

Sample size and selection technique: A multi-stage sampling procedure following purposive and random techniques were used to select 60 sweet potato seed producer, using a well-structured questionnaire and FGD. The level of awareness and adoption of organic and CSA adaptation and mitigation strategies and its effectiveness in enhancing resilience to climate change were analyzed using mean for likert scale analysis. The socio-economic and institutional factors influencing the practices of CSA strategies among seed entrepreneurs were estimated using multi-nominal regression, while correlation regression were used to estimate the relationship between OCSA practices.

The multinomial logit regression procedure. The dependent variable Organic and Climate Smart Practices (OCSA) was defined as IV= use of Improved Varieties practices, WMP= Water management practices, IPDMP= Integrated pest/Diseases Management practices, SNTP = Smart Nursery Type Practices, Soil Health Management Practices SHMP.

Probability of a farmer i's choice of source j was estimated using is expressed thus: $P_{ij} = e^{X_i\beta_j}$

$$\frac{e^{X_i\beta_j}}{\sum_{j=1}^4 e^{X_i\beta_j}} \quad \text{for } j = 1 \text{ to } 4 \dots\dots\dots(1)$$

$$\text{Prob } (Y_i = j/X_i) = P_{ij} = \frac{e^{X_i\beta_j}}{\sum_{j=1}^4 e^{X_i\beta_j}}, \quad \text{for } j > 1 \dots\dots\dots(2)$$

$$\text{Prob } Y_i = 1/X_i = P_{i1} = \frac{1}{1 + \sum_{j=2}^4 e^{X_i\beta_j}} \quad \text{for } j > 1 \dots\dots\dots(3)$$

Where, P_{ij} is the probability representing the i th farmer's chance of using seed type j , X_i represents a set of explanatory variables, e is the natural base of logarithms, and β_j are parameters to be estimated by MLE.

The model is explicitly modeled as:
 $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + u_1 \dots\dots (4)$

Where, X_1 = Sex (Male =1, Female =0), X_2 = age (years) as provided by the respondents, X_3 = academic qualification (Prof= 6, PhD=5, Msc =4, Bsc =3, Secondary =2, Primary =1), X_4 = marital status (married=1, single=0), X_5 = household size (number), X_6 = working experience (years) X_7 = membership of social organization (yes=1, no=0), X_8 = native of community (yes=1, no=0), X_9 = number of extension contact, X_{10} = Estimated Monthly income (Naira), e = error term.

Results and Discussions

Average Characteristics of the Farmers

Table 1 presents the socio-economic characteristics of the sweet potato seed producers and provides insight into their demographic and institutional profile. The results indicate that the producers are relatively mature, with a mean age of 48 years (SD = 10.53), suggesting that sweet potato seed production is dominated by middle-aged individuals who are likely to possess considerable farming experience and decision-making capacity. The average farming experience of 10 years (SD = 3.83) further confirms that the respondents are fairly experienced in agricultural production. The mean household size of approximately 5 persons implies moderate family labour availability, which can positively influence farm operations.

Monthly farm income averaged ₦479,100, although the wide income range (₦150,000–₦1,200,000) reflects disparities in production scale and productivity among farmers. The average years of formal education (3.2 years) indicate a relatively low educational level, which may affect the comprehension and adoption of improved agricultural innovations.

Half of the respondents were male (50%), suggesting gender balance in sweet potato seed production. A large proportion were natives of their communities (95%) and married (75%), indicating social stability and strong local ties that may enhance participation in community-based agricultural activities. Notably, all respondents (100%) reported no access to credit, highlighting a major financial constraint that could limit investment in improved technologies. However, a high proportion (81.7%) belonged to farming organizations, which may facilitate information sharing and collective action. Despite this, 95% had no access to extension contact, pointing to weak institutional support services. Interestingly, all respondents (100%) were aware of Climate-Smart Agriculture (CSA) and organic practices, suggesting that awareness alone does not necessarily translate into adoption without adequate institutional, financial, and technical support.

Level of awareness and adoption of Organic and Climate-Smart Agriculture (CSA) adaptation and mitigation strategies among seed producers in Ebonyi States

Table 2 presents the level of awareness and adoption of Climate-Smart Agriculture (CSA) adaptation and mitigation strategies among sweet potato seed producers in Ebonyi States. The study in Table 1 reveals a significant disconnect between awareness and adoption for several Climate-Smart Agriculture (CSA) practices among sweet potato seed producers. While awareness is near-universal for most strategies, adoption is only uniformly high for varietal improvements (e.g., early maturing varieties, quality vines), likely due to their direct and visible impact on yield (FAO, 2013). In contrast, practices such as crop rotation, mulching, and particularly capital-intensive water management techniques like borehole irrigation face substantial adoption barriers. The high discontinuation rates for practices like mulching and riverine farming suggest that labor constraints, seasonal risks, and lack of technical guidance often override initial willingness to adopt (Kpadonoo *et al.*, 2022). Furthermore, the relatively low awareness of agroforestry

highlights a critical gap in extension messaging, underscoring the need for tailored dissemination strategies that address practice-specific adoption hurdles.

Adoption patterns for Integrated Pest Management (IPM) and nursery technologies further illustrate the influence of cost and complexity. While labor-intensive but simple practices like weeding and vine discarding achieved universal adoption, biologically complex methods such as utilizing natural enemies saw negligible uptake due to limited technical knowledge. Similarly, despite moderate awareness of advanced nursery technologies like screen houses and the Triple S system, adoption remained strikingly low. This suggests that the high initial capital costs and technical complexity of these innovations pose prohibitive barriers for smallholder seed producers, contrasting sharply with the widespread adoption of low-cost, low-technology options like sunken beds (Ogero *et al.*, 2019).

Pairwise Correlation between OCSA Practices

The pairwise correlation results (Table 3) indicate that adoption of Climate-Smart Agriculture (CSA) practices exhibits both complementarity and trade-offs among farmers. Improved Varieties (IV) show significant negative relationships with Integrated Pest and Disease Management Practices (IPDMP) and Smart Nursery Type Practices (SNTP), suggesting possible substitution effects or resource constraints limiting simultaneous adoption. In contrast, IPDMP and Soil Health Management Practices (SHMP) display a strong positive and significant correlation, indicating that these practices are complementary and are often adopted together. Water Management Practices (WMP) show no significant association with other practices, implying that their adoption may be largely independent and influenced by external factors such as climate conditions or infrastructure. The findings suggest that farmers selectively adopt OCSA practices based on perceived benefits, compatibility, and available resources, consistent with studies by Food and Agriculture Organization (2010) which highlight the roles of complementarity, substitution, and constraints in agricultural technology adoption.

Factors influencing the adoption of OCSA strategies among seed producers in Ebonyi State

The multinomial logit regression results in Table 4 show that the model has strong explanatory power, with a Pseudo R² of 0.6978, indicating

that approximately 69.8% of the variation in the adoption of CSA strategies among seed producers in Ebonyi State is explained by the included socio-economic variables. However, only statistically significant variables are discussed.

Among the gender and social inclusion factors, gender significantly influenced the adoption of Water Management Practices (WMP), Integrated Pest and Disease Management Practices (IPDMP), and Smart Nursery Type Practices (SNTP). Gender had a positive and significant effect on WMP ($p < 0.05$) and SNTP ($p < 0.05$), but a negative and significant effect on IPDMP ($p < 0.01$). This implies that gender differences play an important role in determining adoption decisions, possibly reflecting disparities in access to resources, labor, and decision-making power. Age was negatively and significantly related to the adoption of Improved Varieties (IV) ($p < 0.01$) and SNTP ($p < 0.05$), but positively and significantly related to IPDMP ($p < 0.01$). This suggests that younger farmers are more likely to adopt improved varieties and nursery practices, while older farmers tend to adopt pest and disease management practices. Being a native of the community positively influenced the adoption of WMP ($p < 0.05$) and SNTP ($p < 0.05$), indicating that community attachment and possibly stronger land tenure security encourage investment in these practices. Marital status had a positive and significant effect on WMP ($p < 0.01$) and SNTP ($p < 0.05$), suggesting that married farmers may have better access to household labor or financial stability, which supports adoption. Household size positively and significantly influenced IV and WMP adoption ($p < 0.05$), implying that larger households may provide the labor required for implementing these practices.

Regarding access to information and knowledge factors, years of farming experience had a negative and significant effect on the adoption of IV, WMP, and IPDMP ($p < 0.05$). This indicates that more experienced farmers may be less inclined to adopt newer climate-smart practices, possibly due to reliance on traditional methods. Educational level was positive and significant only for SNTP ($p < 0.05$), suggesting that higher education enhances the ability to adopt technically demanding nursery practices. Extension contact had a positive and significant influence on IV ($p < 0.01$) and IPDMP ($p < 0.01$), underscoring the critical role of extension

services in promoting awareness and uptake of climate-smart technologies. Among the cost and financial factors, farm monthly income positively and significantly influenced the adoption of WMP ($p < 0.01$), indicating that higher-income farmers are more capable of investing in capital-intensive water management technologies.

Conclusion of Recommendations

Improving OCSA adoption among sweet potato seed producers requires an integrated approach that combines institutional reform, financial inclusion, technical capacity building, infrastructure investment, and inclusive policy design. Addressing these interconnected constraints will enhance resilience, boost seed productivity, and contribute to sustainable agricultural development in Ebonyi State and beyond.

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Table 1: Average Characteristics of the Sweet potato Seed producers

| Variables | Mean | Standard dev. | Min | Max |
|---------------------------|--------------|---------------|------------|--------------|
| Age | 48.000 | 10.5332 | 30.000 | 67.000 |
| Farming experiences | 10.0500 | 3.8330 | 1.000 | 17.000 |
| Household size | 5.4500 | 1.9781 | 1.000 | 8.000 |
| Monthly farm income | 479,100.0000 | 269,876.4123 | 150,000.00 | 1,200,000.00 |
| Years of education | 3.2 | 0.5142 | 3.000 | 5.000 |
| Dummy | | | | |
| Gender (Male) | 30(50.00) | | | |
| Native of community (Yes) | 57(95.00) | | | |
| Married | 45(75) | | | |

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|--------------------------------------|-----------|
| Access to credit (No) | 60(100) |
| Member of farming organization (Yes) | 49(81.70) |
| No access to extension contact | 57(95.00) |
| Aware of CSA practices (Yes) | 60(100) |

| | | | | |
|--|----------|----------|----------|-----------|
| Marital status | (-0.62) | (1.99)* | -2.0653 | (1.95)* |
| | -1.3485 | 15.0307 | (-0.78) | 0.2921 |
| | (-0.71) | (3.01)** | 3.6753 | (2.20)* |
| Household size | 0.1200 | 0.0447 | (1.28) | 1.9882 |
| | (1.97)* | (2.05)* | 0.0180 | (0.085) |
| Access to Information and knowledge factors | | | | |
| Years of experiences | -0.0854 | -0.4381 | | 0.0851 |
| | (-2.55)* | (-2.08)* | -0.4618 | (0.40) |
| Educational level | -0.2202 | 18.0417 | (-1.97)* | 1.9975 |
| | (-0.13) | (-0.01) | 0.9192 | (1.96)* |
| Extension contact | 0.5025 | 18.0418 | (0.37) | 6.0001 (- |
| | (3.16)** | (0.00) | 15.9941 | 0.94) |
| | | | (2.78)** | |
| Cost and financial factor | | | | |
| Farm monthly income | 1.02e-06 | 3.024-06 | | -2.97e-06 |
| | (0.38) | (3.84)** | 7.29e-07 | (-0.65) |
| Constant | 4.2576 | * 6.7420 | (0.19) - | 7.9998 |
| | (0.40) | (0.90) | 23.9695 | (0.49) |
| Number of observation | 60 | | (-0.00) | |
| LR chi2 (60) | 65.10 | | | |
| Prob > chi 2 | 0.6547 | | | |
| Pseudo R2 | 0.6978 | | | |
| Log likelihood | -65.0778 | | | |

Source: Field survey, 2025
Figures in parenthesis are the percentage

Table 2: Level of awareness and adoption of Climate-Smart Agriculture (CSA) adaptation and mitigation strategies among seed producers in Abia and Ebonyi States

| Practices | Awareness | Adopted | Adopted and stop | Never used |
|--|-----------|----------|------------------|------------|
| A. Use of improved varietal | | | | |
| Drought tolerant varieties | 53(88.3) | 40(75.5) | 0(0) 2(3.3) | 13(24.5) |
| Early maturing varieties | 60(100) | 58(96.7) | - | 0(0) |
| Use of quality vines | 60(100) | 60(100) | - | - |
| B. Water management/irrigation | | | | |
| Bore hole source | 60(100) | 0 | 0 8(13.3) | 60(100) |
| Harvest water | 60(100) | 23(38.3) | - | 37(61.7) |
| River source | 60(100) | 49(81.7) | - | 3(5) |
| C. Soil health management | | | | |
| Use of manure/compost | 60(100) | 60(100) | 15(25) | - |
| Crop rotation | 60(100) | 23(38.3) | 18(30) | - |
| Mulching | 60(100) | 21(35) | - | 22(36.7) |
| Agroforestry | 52 | - | - | 21(35) |
| D. Integrated pest & disease management | | | | |
| Discard of infected vines | 60(100) | 60(100) | - | - |
| Use of natural pesticides | 57(95) | 55(96.5) | - | 2(3.5) |
| Use of natural enemies of pests | 26(43.3) | 60(100) | - | 26(100) |
| Regular weeding/field visit | 60(100) | - | 2(5.4) | - |
| A. Smart Nursery types practices | | | | |
| Use of net tunnel/screen-houses | 37(61.7) | 7(18.9) | 14(23.3) | - |
| Triple S technology | 31(51.6) | 9(29.0) | - | 28(75.7) |
| Use of well drained sunken bed | 49(81.7) | 39(79.6) | - | 11(35.5) |
| River-line seed production | 60(100) | 49(81.7) | - | 10(20.4) |
| | | | | 3(5) |

Source: Field survey, 2025
Figures in parenthesis are the percentage

Table 3: Pairwise Correlation Matrix of Climate-Smart Agriculture (CSA) Practice Adoption

| Adoption Practices | IV | WMP | IPDMP | SHMP | SNTP |
|--------------------|----------------------|---------------------|--------------------|--------------------|------|
| IV | 1.00 | | | | |
| WMP | -0.0784 (0.5518) | 1.00 | | | |
| IPDMP | -0.2604* (0.0445) | -0.1244 (0.3437) | 1.00 | | |
| SHMP | -0.1193 (0.3639) | -0.0710 (0.5896) | 0.7009* (0.000) | 1.00 | |
| SNTP | -0.2722* (0.0354) | 0.0320 (0.8083) | 0.0340 (0.7964) | 0.1299 (0.3227) | 1.00 |

Source: Field survey, 2025
Source: Field survey, 2025

IV= use of Improved Varieties practices,
WMP= Water management practices, IPDMP= Integrated pest/Diseases Management practices, SNTP = Smart Nursery Type Practices, Soil Health Management Practices SHMP

Table 4: Multinomial Logit Regression of factors influencing the adoption of CSA strategies among seed producers in Ebonyi State

| Variety | IV(1) | WMP(2) | IPDMP(4) | SNTP(5) |
|---|---------------------|-------------------|-----------------------|---------------------|
| Gender and social Inclusion factor | | | | |
| Gender | -0.0903 (-1.08) | 4.1726 (2.45)* | -0.6879 (-) | 2.0021 (1.90)* |
| Age | -0.016 (-3.23)** | 0.1801 (1.50) | 3.41** (0.0359) | 0.0142 (- 2.14)* |
| Native of the community | -1.0258 (-0.62) | 0.7208 (1.99)* | (2.37)** (-2.0653) | 0.0484 (1.95)* |



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MAY, 2026



ISSN 2315-8567



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