



Drivers of Adoption of Sustainable Agricultural Practices (SAPs) among Farmers in Akwa-Ibom State, Nigeria

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ABSTRACT

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Despite the potential of sustainable agricultural practices (SAPs) to mitigate the problems of soil degradation, low productivity, and the adverse effects of climate change in agricultural production, these challenges persist because the adoption of SAPs remains low among farmers in Nigeria. This study therefore analysed the drivers of the adoption decisions of SAPs (crop rotation, organic manure, mulching, intercropping, and cover-cropping) among farmers in Akwa-Ibom State, Nigeria. Data were collected with the aid of structured questionnaire administered to a cross-section of 288 randomly selected crop farmers in the study area. Data obtained were analysed using descriptive statistics and the Multivariate Probit (MVP) model. Our findings show that crop farmers in the study area are smallholders, with an average of 14 years of formal schooling, 28 years of farming experience, and an average household size of about seven persons. Farmers' decisions to adopt SAPs exhibited substantial interdependence, mostly complementarity. The drivers of SAPs adoption in the study area comprised formal education, farming experience, household size, off-farm employment, land ownership, farm size, and labour availability. Among these significant drivers, formal education positively influenced the probability of adopting of all the SAPs. Thus, underscoring the crucial role of human capital development in engendering sustainable agricultural production behaviour among farmers in Nigeria.

1.0 Introduction

The ever-growing global population and the corresponding increase in food demand over the years, have necessitated the need for significant increase in agricultural productivity in order to ensure food security. This precipitated the promotion of Conventional Agricultural Practices (CAPs) that originated from the green revolution in Asia. According to Elshaer *et al.* (2023), CAPs are methods which rely mainly on irrigation, inorganic fertilizers, pesticides, herbicides, and improved crop varieties to boost agricultural yield. Although these technologies led to substantial increase in crop productivity, they also catalysed several problems that threaten the sustainability of food production in the wake of worsening climatic conditions.

Overtime, smallholder farmers in developing countries including Nigeria have adopted these unsustainable CAPs, and their indiscriminate use have undermined the sustainability of the food

production ecosystem. The continuous use of CAPs especially inorganic fertilisers, pesticides and herbicides have impoverished agricultural lands (Pham *et al.*, 2021; Oyawole *et al.*, 2019) which has in turn led to the depletion of crop yields and revenues, and poorer welfare outcomes for the vast majority of farming households. To mitigate the problems occasioned by the long-term use of CAPs, Sustainable Agricultural Practices (SAPs) and other allied climate-smart agricultural practices are increasingly being promoted by various national and international agencies with the aim of incentivising farmers to adopt them (Arslan *et al.*, 2014; Oyawole *et al.*, 2019; Pham *et al.*, 2021).

The International Centre for Tropical Agriculture (CIAT) and the World Bank (2018) defined SAPs as practices that guarantee efficiency in the usage of natural resources, at the same time mitigating the impacts of agriculture on the environment whilst supporting farmers adaptive capacity to



climate change. Foguesatto and Machado (2022) further defined SAPs as methods that simultaneously promote productivity and sustainability of food production. According to Food and Agriculture Organization [FAO] (2017) of the United Nations, SAPs are touted to be environmentally non-degrading, socially acceptable, resource conserving and economically viable. This implies that SAPs do not harm the environment. They entail utilising natural resources in ways that guarantee their long-term sustainability. Examples of SAPs include agroforestry, organic manure, crop rotation, zero tillage, minimum tillage, residue retention (Oyawole *et al.*, 2019), mulching, mixed farming, mixed cropping (Faleye & Afolami, 2020), improved seed varieties, integrated pest management, intercropping, (Oyawole & Sennuga, 2020), bio-herbicide technology (Adewuyi & Offar, 2022), amongst others.

Despite the potential of SAPs to reverse the challenges occasioned by the indiscriminate use of CAPs, recent studies have reported abysmally low level of adoption of SAPs among farmers in Nigeria (Saadu *et al.*, 2024; Sennuga, 2023; Oyetunde-Usman *et al.*, 2021; Oyawole *et al.*, 2019). Thus, suggesting that the incentive to adopt SAPs is negligible. In light of the low adoption of SAPs among farmers in Nigeria and the limited information on the nature of interrelatedness of the adoption decisions of SAPs in the literature, this study therefore attempted to uncover the characteristics of farmers that significantly determine their SAPs adoption decisions. Firstly, we explored the nature of interdependence that may exist in the adoption decisions of SAPs, and secondly, we analysed the drivers of adoption decisions of SAPs among crop farmers in Nigeria.

2.0 Methodology

Study area and data: This study was carried out in Akwa-Ibom State, Nigeria. The State is located between latitudes 4⁰33 and 5⁰33 North of the equator and longitudes 7⁰35 and 8⁰25 East of the Greenwich meridian. The State spans a land mass of about 7,249 square Kilometres, with a coastline spanning 129 Kilometres. It is bounded by Rivers State in the East, Cross River State in the West, Abia State in the North and the Gulf of Guinea in the South. It has an estimated population of approximately 7.2 million people with an annual projected growth rate of 3.2% (Akwa Ibom State Government, 2025). Akwa Ibom State is located

within the humid tropical rainforest belt, characterized by dry season (November - March), Wet season (April - October), an average temperature ranging from 23⁰C - 31⁰C, and annual precipitation ranging between 2000mm to 3000mm. The State comprises six agricultural zones as delineated by the State's Agricultural Development Project (ADP) and 31 Local Government Areas (Etim and Udoh, 2020). The major economic activities of the people of Akwa Ibom State are fishing, farming, trading, artisanship and public service.

The study employed a multi-stage sampling procedure in selecting the respondents for data collection. The first stage involved random selection of the South-South geopolitical zone. The second stage involved random selection of Akwa-Ibom State from the South-South geopolitical zone. The third stage involved random selection of three LGAs from each of the six agricultural zones of the State, resulting in a total of 18 LGAs for the study. The fourth stage involved random selection of two communities from each of the 18 LGAs previously selected, resulting in 36 communities in total. The fifth stage involved random sampling of eight crop production farmers from each of the 36 communities. This resulted in a total sample size of 288 crop production farmers. However, only 263 copies of the 288 copies of questionnaire administered had complete and adequate information required for data analysis.

Data were collected on the types of SAPs adopted by the sampled farmers in the study area. Our findings from the field survey showed that the farmers in the study areas adopted five SAPs namely: crop rotation, organic manuring, intercropping, mulching, and cover cropping; which were measured as dummy variables with one representing adoption, and zero representing non-adoption. Data were also collected on several characteristics of the farmers including: age of farmer, sex of farmer, years of formal education of farmer, years of farming experience, household size, off-farm employment, land ownership, farm size, and labour availability.

Analytical technique: The adoption decision of farmers was modelled based on the utility maximization theory, which posits that the i^{th} farmer will adopt the j^{th} SAP if the net benefit of adoption Y_{ij}^* is greater than zero; where the net benefit of adoption of a particular SAP, is the difference between the benefit of adoption of the



SAP, and the benefit of non-adoption (Oyetunde-Usman, 2021). Unlike most other existing studies in Nigeria, we analyse the drivers of the adoption decisions of SAPs, while accounting for possible interdependence among the SAPs. Following Emokpae *et al.* (2022), this assumption prompted the use of the Multivariate Probit regression model (MVP) that accounts for such interconnectedness by estimation of several correlated binary outcomes simultaneously. The MVP regression models the influence of a vector of covariates on several outcome variables jointly, while accommodating potential correlations between unobserved disturbances; with one source of correlation being complementarity (positive correlation) and the other being substitutability (negative correlation) (Greene, 2003; Belderbos *et al.*, 2004). The MVP regression model is specified as:

$$Y_{ij}^* = X'_{ij}\beta_j + \varepsilon_{ij} \quad j = C, O, I, M, V \quad (1)$$

Where Y_{ij}^* is a latent variable determined by the observed characteristics of the farmer X_{ij} ; and the error term ε_{ij} . β_j represents the vector of coefficients to be estimated; C represents crop rotation, O represents organic manure, I represents intercropping, M represents mulching, and V represents cover cropping. Y_{ij}^* was estimated based on observable binary discrete variables, Y_{ij} , which indicate whether or not a farmer adopted an SAP (Kassie *et al.* 2009). The observed binary outcome equation was specified as:

$$Y_{ij} = \begin{cases} 1 & \text{if } Y_{ij}^* > 0 \\ 0 & \text{otherwise} \end{cases} \quad j = C, O, I, M, V. \quad (2)$$

In the MVP model, the error terms jointly follow a multivariate normal (MVN) distribution, with zero conditional mean and variance normalized to unity, where $(\varepsilon_C, \varepsilon_O, \varepsilon_I, \varepsilon_T, \varepsilon_M) \sim MVN(0, \Omega)$ and the symmetric covariance matrix Ω is given by:

$$\Omega = \begin{bmatrix} 1 & \rho_{CO} & \rho_{CI} & \rho_{CV} & \rho_{CM} \\ \rho_{OC} & 1 & \rho_{OI} & \rho_{OV} & \rho_{OM} \\ \rho_{IC} & \rho_{IO} & 1 & \rho_{IV} & \rho_{IM} \\ \rho_{VC} & \rho_{VO} & \rho_{VI} & 1 & \rho_{VM} \\ \rho_{MC} & \rho_{MO} & \rho_{MI} & \rho_{MV} & 1 \end{bmatrix} \quad (3)$$

Where ρ is the pairwise correlation coefficient of the error terms to be estimated in the model (Kassie *et al.*, 2009).

The multivariate probit model is explicitly specified as:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \varepsilon_i \quad (4)$$

Where:

Y = Probability of adopting SAPs (as defined earlier);

X_1 = Age of farmer (in years);

X_2 = Sex of farmer (dummy variable: 1 if male, 0 if otherwise);

X_3 = Formal education of farmer (in years);

X_4 = Farming experience of farmer (in years);

X_5 = Household size of farmer (number of family members);

X_6 = Off-farm employment/livelihood (dummy variable: 1 if farmer has off-farm employment, 0 if otherwise);

X_7 = Ownership of land (dummy variable: 1 if farmer owns the cultivated land, 0 if otherwise);

X_8 = Farm size (in hectares);

X_9 = Labour availability (dummy variable: 1 if labour is easily available, 0 if otherwise).

3.0 Results and Discussion

Summary statistics: The socio-economic characteristics of the sampled crop farmers is presented in Table 1. The results indicate that the farmers in the study area had a mean age of 48 years, that is, on average, the farmers are middle-aged, thus suggesting a high capacity for physical labour that adopting most SAPs demand. 61.6% of the farmers were females, while 38.4% were male. On average, farmers in the study area had about 14 years of formal schooling, which suggests certain level of literacy that can enable them to comprehend the benefits of adopting SAPs and allies agricultural technologies generally. The result further shows that farmers in the study area had a mean farming experience of approximately 28 years. This suggests that the they had considerable experience in crop production and various farming techniques, as well as adequate knowledge on the prevailing conditions that impact crop production in the study area. Their average household size was about seven persons, suggesting a potential labour-force for farm activities. About 55.13% of the farmers owned their farmlands while 44.87% did not. The average farm size of the sampled farmers was approximately 0.45 hectares,

suggesting that the farmers are mostly small-scale farmers. About 53.23% of the farmers reported that they had easy access to farm labour, while 46.77% of them had difficulty in accessing labour for their farm activities.

Table 1: Socio-economic characteristics of farmers in the study area

Description	%	Mean	Standard Deviation
Age		48.152	10.985
Sex			
Female	61.60		
Male	38.40		
Years of formal education		14.388	5.031
Years of farming experience		27.897	14.472
Household size		7.228	3.434
Land ownership			
Rented	44.87		
Owned	55.13		
Farm Size		0.446	0.549
Labour availability			
Not easily available	46.77		
Easily available	53.23		

Source: Field survey, 2025

Summary statistics of SAPs adoption decisions in the study area: The proportion of farmers that adopted the identified SAPs in the study area is shown in Figure 1. The result shows that intercropping is the most adopted SAP, with 74.14% of the farmers being adopters. Atiyong *et al.* (2020), Babalola and Olayemi (2013), Faleye and Afolami (2020), and Iheke and Agodike (2016) reported similar findings in their studies. This suggests that intercropping is popular among farmers that adopt SAPs. Organic manure and

cover cropping had similar adoption levels of 66.92% and 66.54% respectively. The result for organic manure is relatively lower than what was reported by Dahal *et al.* (2023), it is however similar to the findings of Atiyong *et al.* (2020). For organic manure, our findings refute that of Aminu *et al.* (2018). Approximately two-thirds of the farmers in our study adopted cover cropping. This corroborates the findings of Iheke and Agodike (2016). However, Babalola and Olayemi (2013), Aminu *et al.* (2018) and Dahal *et al.* (2023) reported low proportion of adopters.

Furthermore, about 56.27% of the farmers in our study adopted crop rotation. This is consistent with the reports of Faleye and Afolami (2020), Iheke and Agodike (2016) and Babalola and Olayemi (2013). It however refutes the findings of Atiyong *et al.* (2020) who reported that a very high percentage of farmers adopted crop rotation. Lastly, the result in Figure 1 shows that mulching is the least adopted SAP, with 52.47% adopters. This finding is contrary to the report of Aminu *et al.* (2018) who reported mulching to be the most adopted SAP in their study area. Faleye and Afolami (2020) also reported very high proportion of farmers adopting mulching. It further contradicts the findings of Babalola and Olayemi (2013) and Dahal *et al.* (2023) who reported very low percentage of adopters of mulching in their study area. Overall, the adoption of SAPs in the study area can be considered to be modest given that the least SAP adopted had about 50% adopters.

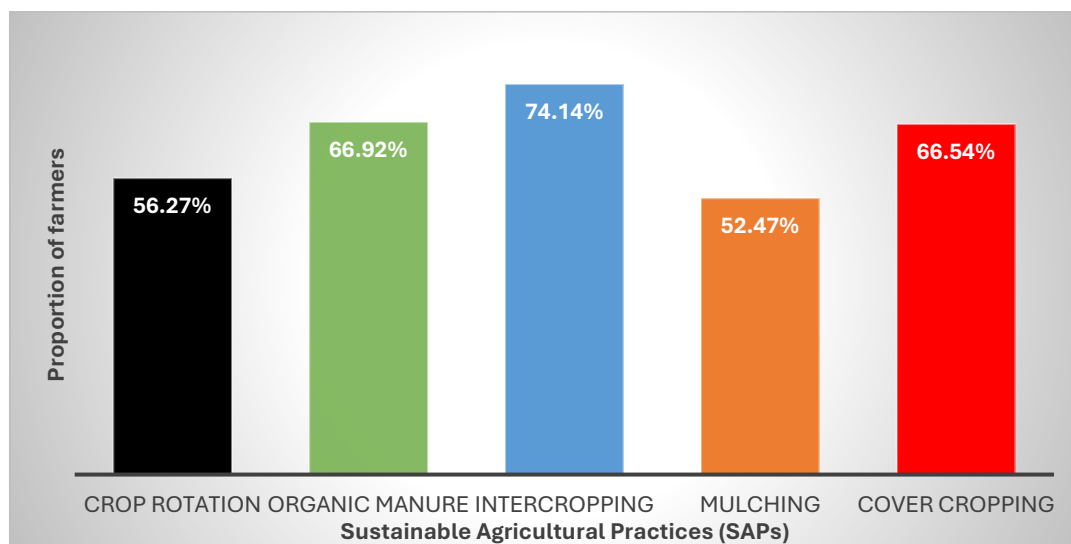


Figure 1: Proportion of farmers that adopted various SAPs in the study area



Drivers of SAPs adoption decisions: The result of the multivariate probit analysis is presented in Table 2. The result of the likelihood ratio test is statistically significant, hence the implicit null hypothesis of zero covariance of the error terms across the adoption equations is rejected. This supports the use of MVP model in analysing the drivers of SAPs adoption decisions, highlighting the existence of interdependence in the adoption decisions of the SAPs considered in this study. The result further revealed significant correlations in the adoption decisions of the five SAP adoption while accounting for the influence of the control variables, thus further justifying the use of the MVP model. As an example, crop rotation had positive significant correlations with organic manure, intercropping, mulching, and cover cropping, suggesting that a complementary relationship exists between these SAPs. Complementarities were also observed between organic manure and intercropping, mulching, and cover cropping. These complementarities indicate that the farmers' decision to adopt a particular SAP, positively influenced the probability of adopting the other SAP in the pair. For instance, from the result, a farmer who adopts crop rotation will probably also adopt either organic manure, intercropping, mulching, or cover cropping, and vice versa. Mulching and crop rotation had the highest complementarity, whereas, cover cropping and crop rotation, and also, mulching and organic manure had the least complementarity.

The results in Table 2 further show that formal schooling positively influenced the adoption decisions for all five SAPs. Every additional year of formal schooling increased the probability of adoption of SAPs. This finding may be attributed to advanced knowledge that more years of schooling affords farmers. Education exposes them to the concept of sustainability, facilitating their understanding of this concept, and disposition to towards it. Thus, increasing their probability of adopting SAPs. With regards to farming experience, the result showed a positive influence on the probability of adopting organic manure, and a negative influence on the probability of adopting mulching, that is, more experienced farmers were more probable to adopt organic manure but less probable to adopt mulching. The negative effect of farming experience on mulching may be explained by the fact that conventionally, most farmers practice complete removal of crop residues from their

farmland before the next planting cycle commences, and with every additional year of farming experience in which this practice is carried out, the farmers consider it a norm and are less likely to adopt mulching, which involves leaving the crop residues on the farmland.

Farmers with larger households were less probable to adopt mulching. This finding is contrary to the result of Atiyong *et al.* (2020) who found household size to positively influence the adoption of mulching. This aversion may be attributed to the notion that as the size of farming households increase they may want to prioritise short-term productivity by applying inorganic fertilisers in order to meet increasing households' needs, over long-term sustainability which can be brought about by the adoption of mulching. The effects of applying inorganic fertilisers are faster to manifest than that of mulching that takes a longer time.

For off-farm employment, findings showed a positive influence on the probability of adopting of organic manure, intercropping, and cover cropping. Farmers who had other sources of income were more likely to adopt these practices. This may be because additional sources of income for farmers can lessen the pressure on farmers to gratify immediate needs by adopting technologies that are not sustainable in the long-run. If farmers are able to meet their pressing needs from off-farm income sources, they may not be pressured to adopt technologies that promises quick returns but are ecologically unsustainable. However, farmers with off-farm income were less probable to adopt mulching probably because off-farm income increases farmers' purchasing power for alternatives to mulching, such as inorganic fertilisers and herbicides for rapid yield gain and weed control, respectively.

Findings further showed that the probability of adopting crop rotation, organic manure, mulching, and cover cropping, was greater for farmers that owned the land they cultivated. This finding is in line with that of Teklewold *et al.* (2019), and Kassie *et al.* (2015), who found that farmers who owned the land they cultivated were more likely to adopt crop rotation and organic manure. This finding may be due to tenure security that is often times associate with land ownership. Cultivation of rented land suggests short-term agreements and given the fact that the benefits of these SAPs accrue over time, farmers



that rent lands are less likely to adopt these practices (Teklewold *et al.*, 2019).

With regards to farm size, the results showed that cultivating larger farms increased the probability of adopting intercropping and mulching. Larger farmlands may provide sceptical farmers with available land to experiment with the adoption of these practices and experience their benefits first-hand, which in turn facilitates their adoption. On the contrary, sceptical farmers with smaller farm sizes are less probable to adopt these practices, as they lack the available land to experiment with and experience the benefits of SAPs first-hand. Larger farm size also makes intercropping more appealing to farmers as they maximize the use of the available land, while optimising the spacing requirements for the various crops they cultivate.

Farmers with easy access to labour were more probable to adopt crop rotation and mulching. SAPs in general are considered labour intensive, hence labour availability is key. When labour is easily available to farmers, they are more inclined to adopt labour-intensive practices like mulching.

Conclusion

There was interdependence in the adoption decisions of the five SAPs among farmers in the study area and complementarities dominated most of the SAPs adoption decisions. The greatest complementarity existed between mulching and crop rotation. The significant drivers of SAPs adoption in the study area included formal education, farming experience, household size, off-farm employment, land ownership, farm size, and labour availability. Remarkably, formal education significantly influenced the adoption of all the SAPs in the study area. This, underscores the crucial role of human capital development in engendering sustainable agricultural production behaviour among farmers in Nigeria.

Based on the findings from this study, the following recommendations are proposed to improve the adoption of SAPs among farmers in the Nigeria. Future interventions designed to promote the adoption of SAPs should prioritise promoting SAPs that exhibit complementarities. By so doing, farmers will be able to optimise the environmental, agronomic and economic benefits of SAPs. Policies that encourage farmers to acquire large farmlands should be promoted while regulations against land fragmentation should be put in place in order to ensure that large farmlands are available to farmers, which in turn encourage

the adoption of SAPs such as intercropping and mulching. For farmers who cannot afford to own farmlands, policies that make renting or leasing of lands for farming purposes profitable should be enacted in order to provide some form of security, thus encouraging farmers to incorporate long-term sustainability into their farming activities and goals. Credit facilities should be easily accessible to farmers in order to lessen the pressure on their farming activities. Such pressure can spur them to opt for conventional agricultural technologies that yield quick returns but are unsustainable in the long-run.

References

- Adewuyi, K. A. and Offar, G. (2022). Analysis of the Determinants of Adoption of Bio-Herbicide Technology for Sustainable Food Production in the North-Eastern Region of Nigeria. *African Journal of Agricultural Research*, 18(6), 464–469. <https://doi.org/10.5897/ajar2021.15801>
- Akwa Ibom State Government (2025). Our Culture, Our Pride: Quick Facts about Akwa Ibom. <https://www.akwaibomstate.gov.ng>
- Aminu, F. O., Rosulu, H. O., Balogun, E. O. S. and Babawale, O. H. (2018). Analysis of Adoption of Sustainable Land Management Practices for Yam Production in Osun State, Nigeria. *Journal of Agricultural Science and Practice*, 3(6), 154–160. <https://doi.org/10.31248/jasp2018.115>
- Arslan, A., McCarthy, N., Lipper, L., Asfaw, S. and Cattaneo, A. (2014). Adoption and Intensity of Adoption of Conservation Farming Practices in Zambia. *Agriculture Ecosystems & Environment*, 187, 72–86. <https://doi.org/10.1016/j.agee.2013.08.017>
- Atiyong, B. R., Oriola, E. O. and Sankey, A. N. (2020). Determinants of the Adoption of Farm Management Practices for Sustainable Crop Production Among Farmers in Southern Part of Kaduna state, Nigeria. *Analele Universității din Oradea, Seria Geografie*, 30(1), 97–106. <https://doi.org/10.30892/auog.301111-836>



- Babalola, D. A., & Olayemi, J. K. (2013). Determinants of Farmers' Preference for Sustainable Land Management Practices for Maize and Cassava Production in Ogun State, Nigeria. <https://doi.org/10.22004/ag.econ.160578>
- Belderbos, R., Carree, M., Diederer, B., Lokshin, B. and Veugelers, R. (2004). Heterogeneity in R&D Cooperation Strategies. *International journal of Industrial Organization*, 22(8-9), 1237-1263. <https://doi.org/10.1016/j.ijindorg.2004.08.001>
- CIAT; World Bank. (2018). Climate-Smart Agriculture in Malawi. CSA Country Profiles for Africa Series. International Center for Tropical Agriculture (CIAT), Washington, D.C.
- Dahal, S., Dangi, B., Dangi, R. K., Bista, P., Bhandari, A., Adhikari, P. and Bhattarai, M. (2023). Determinants of Adoption of Multiple Sustainable Agriculture Practices Among Mandarin Producing Farmers in Salyan District of Karnali Province, Nepal. *European Journal of Sustainable Development Research*, 7(4). <https://doi.org/10.29333/ejosdr/13440>
- Etim, N. A. and Udoh, E. J. (2020). Adoption of Organic Waterleaf Farming for Sustainable Food Production in Akwa Ibom State, Nigeria. *International Journal of Development and Sustainability*, 9(1), 1-13.
- Elshaer, I. A., Azazz, A. M., Hassan, S. S. and Fayyad, S. (2023). Farm-to-Fork and Sustainable Agriculture Practices: Perceived Economic Benefit as a Moderator and Environmental Sustainability as a Mediator. *Sustainability*, 15(14), 11462. <https://doi.org/10.3390/su151411462>
- Emokpae, O.P., Umeokeke, I.N. and Okoruwa, V. O. (2022). Estimating the Interlink between Agricultural Production Decisions: A Case of Maize Farming Households in Nigeria. *Nigerian Journal of Agricultural Economics*, 12(1): 11-20. <https://doi.org/10.22004/ag.econ.348736>
- Faleye, O. S., & Afolami, C. A. (2020). Determinants of Choice of Climate Smart Agricultural Practices Adoption among Yam-Based Farming Households in Ogun State, Nigeria. *Journal of Agricultural Science and Practice*, 5, 131–141. <https://doi.org/10.31248/jasp2020.202>
- Foguesatto, C. R. and Machado, J. A. D. (2022). Adoption of Sustainable Agricultural Practices in Brazil: Understanding the Influence of Socioeconomic and Psychological Factors. *Journal of Agribusiness in Developing and Emerging Economies*, 12(2), 204-222. <https://doi.org/10.1108/jadec-11-2020-0256>
- Food and Agriculture Organization of the United Nations. (2017). Sustainable Food and Agriculture. <http://www.fao.org/sustainability/en/>
- Food Security Information Network and Global Network Against Food Crises. (2024). Global Report on Food Crises 2024. Rome. <https://www.fsinplatform.org/grfc2024>
- Greene, W. H. (2003). *Econometric Analysis*, 2nd Edition, New York, Macmillan.
- Iheke, O. R. and Agodike, W. C. (2016). Analysis of Factors Influencing the Adoption of Climate Change Mitigating Measures by Smallholder Farmers in Imo State, Nigeria. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, 16(1), 213-220.
- Kassie, M., Teklewold, H., Jaleta, M., Marennya, P., & Erenstein, O. (2015). Understanding the Adoption of a Portfolio of Sustainable Intensification Practices in Eastern and Southern Africa. *Land Use Policy*, 42, 400–411. <https://doi.org/10.1016/j.landusepol.2014.08.016>
- Kassie, M., Zikhali, P., Manjur, K. and Edwards, S. (2009). Adoption of Sustainable Agriculture Practices: Evidence from a Semi-Arid Region of Ethiopia. *Natural Resources Forum*, 33, 189–198. <https://doi.org/10.1111/j.1477-8947.2009.01224.x>

Oyawole, F. P., Dipeolu, A. O., Shittu, A. M., Obayelu, A. E. and Fabunmi, T. O. (2019). What Drives the Adoption of Climate Smart Agricultural Practices? Evidence from Maize Farmers in Northern Nigeria. *Nigerian Journal of Agricultural Economics*, 9(1), 14-28. <https://doi.org/10.22004/ag.econ.304677>

Oyetunde-Usman, Z., Olagunju, K. O. and Ogunpaimo, O. R. (2021). Determinants of Adoption of Multiple Sustainable Agricultural Practices among Smallholder Farmers in Nigeria. *International Soil and Water Conservation Research*, 9(2), 241-248. <https://doi.org/10.1016/j.iswcr.2020.10.007>

Oyewole, S. O. and Sennuga, S. O. (2020). Factors Influencing Sustainable Agricultural Practices among Smallholder Farmers in Ogun State of Nigeria. *Asian Journal of Advances in Agricultural Research*, 14(1), 17-24. <https://doi.org/10.9734/ajaar/2020/v14i130120>

Pham, H. G., Chuah, S. H., & Feeny, S. (2021). Factors Affecting the Adoption of Sustainable Agricultural Practices:

Findings from Panel Data for Vietnam. *Ecological Economics*, 184, 107000. <https://doi.org/10.1016/j.ecolecon.2021.107000>

Saadu, B., Ibrahim, H. Y., Nazifi, B. and Mudashiru, A. (2024). Adoption of Climate-Smart Agricultural Practices and its Impact on Smallholder Farming Households in some Rural Areas of North-Western Nigeria. *Agricultura Tropica et Subtropica*, 57(1), 23-34. <https://doi.org/10.2478/ats-2024-0003>

Sennuga, S. O. (2023). Exploring the Determinants of Sustainable Agricultural Practices Among Smallholder Farmers in Ogun State, Nigeria. *American Journal of Biomedical Science & Pharmaceutical Innovation*, 3(05), 19-23. <https://doi.org/10.37547/ajbspi>

Teklewold, H., Mekonnen, A. and Kohlin, G. (2019). Climate Change Adaptation: A Study of Multiple Climate-Smart Practices in the Nile Basin of Ethiopia. *Climate and Development*, 11(2), 180-192. <https://doi.org/10.1080/17565529.2018.1442801>

Table 2: Estimate of Multivariate Probit Model

Variables	Crop rotation		Organic manure		Intercropping		Mulching		Cover cropping	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Sex	0.365	0.201	-0.162	0.223	-0.317	0.229	0.036	0.193	-0.328	0.204
Age	-0.023	0.014	-0.001	0.015	-0.021	0.015	0.013	0.014	-0.019	0.013
Years of formal education	0.087***	0.023	0.089***	0.026	0.072***	0.026	0.098***	0.023	0.048**	0.023
Years of farming experience	-0.001	0.010	0.028**	0.012	0.009	0.011	-0.031***	0.010	0.017	0.010
Household size	0.030	0.036	-0.077	0.040	-0.028	0.038	-0.123***	0.035	-0.021	0.034
Off-farm employment	0.057	0.303	1.302***	0.321	1.404***	0.303	-0.700**	0.313	1.493***	0.285
Land ownership	1.132***	0.231	1.226***	0.254	0.488	0.260	0.988***	0.241	0.519**	0.231
Farm size	0.322	0.205	0.411	0.231	0.624**	0.274	0.649***	0.212	0.091	0.189
Labour availability	1.020***	0.206	0.417	0.227	0.293	0.234	0.819***	0.211	0.365	0.208
Constant	-1.639***	0.617	-2.782***	0.640	-0.865	0.643	-1.019	0.607	-1.083	0.576
Diagnostics										
Crop rotation	1									
Organic manure	0.386***	0.123	1							
Intercropping	0.380***	0.127	0.466***	0.145	1					
Mulching	0.686***	0.089	0.357***	0.141	0.203	0.142	1			
Cover cropping	0.355***	0.117	0.605***	0.102	0.255	0.142	0.196	0.122	1	
LR test of rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 0: chi square (10) = 82.9455, Prob > chi square = 0.0000										
Wald chi square (45) = 316.07; Log likelihood = -473.30033; Prob > chi square = 0.0000										