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Small-Scale Farmers' Uptake of Eco-Friendly Vegetable Production Practices in Enugu State, Nigeria

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Abstract

The rising demand for sustainable agriculture is driving a global shift toward eco-friendly vegetable production methods that prioritise human health and environmental protection Vegetables. However, the level of uptake of eco-friendly practices and their drivers are poorly understood, which prompts the current study. A semi-structured questionnaire was used to collect data from 300 randomly selected vegetable farmers in Enugu State. Descriptive statistics and multinomial logistic regression were used for data analysis. Results show that standard eco-friendly practices adopted by vegetable farmers included minimum/no tillage (87.0%), intercropping (64.0%), reduction of chemical inputs (64.0%), agroforestry (46%), and organic farming (33%). Most (71%) farmers were medium-level adopters of eco-friendly practices. The primary constraints to the uptake of eco-friendly practices included limited access to resources ($\bar{x}$ = 4.50), limited technical knowledge ($\bar{x}$ = 4.04) and lack of support from research and extension services ($\bar{x}$ = 4.03). Education (β = -0.159), farm size (β = -13.369), farming experience (β = - 0.145), consumer demand (β = 2.010), and access to credit (β = - 3.699) were the socioeconomic and institutional factors that influenced the level of adoption of eco-friendly vegetable production practices. To accelerate the transition to sustainable farming, the study recommends innovative solutions such as tailored farmer education programs, microfinance initiatives, government subsidies, and robust research-extension linkages.

Introduction

Globally, vegetable production plays a vital role in agriculture, offering essential nutrients for human health while significantly driving economic growth (Kaya & Bostanbudak (2021). Cultivating delicate crops such as vegetables using safe and eco-friendly methods is crucial for ensuring healthy nutrition and achieving food security (Ume et al., 2023; Kalkhajeh et al., 2021). According to the National Agricultural Products Quality Management Services (NAQS, 2023), eco-friendly production is a commitment to shun or use small quantities of synthetic pesticides, chemical fertilisers and antibiotics, bactericides, and various chemicals. Eco-friendly vegetable production is environmentally friendly, conducive to green farming practices, and can reduce chemical application by establishing a more sustainable food safety system. This was further buttressed in the study by Etuah et al. (2021), that high demand for vegetables is inevitable with increasing consumer awareness of health and environment-related benefits associated with eco-labelled foods. Consequently, The Business Research Company (2023) highlighted that the global eco-friendly vegetable-farming market had grown from $8.29 billion in 2022 to an estimated value of $8.7 billion in 2023, creating a compound annual growth rate of 4.9%. The growth will continue, and the market is expected to reach $10.55 Billion by 2027. This growth is mainly attributed to the rising demand for organic foods. Bas et al. (2024) hinted that the demand for organic food is linked to health consciousness by consumers, resulting from an awareness of its benefits- higher nutrient contents and absence of synthetic pesticides, as well as a concern regarding genetically modified organisms. By geography, the global eco-friendly vegetable farming market is classified into North America, Europe, Asia-Pacific and the Rest of the World. North

America has the largest market share due to the increased use of organic farming, higher income levels, and societal awareness. Moreover, the agencies of labelling and regulatory bodies are anticipated to foster the growth of the North American organic vegetable farming market across all regions (Infinium Global Research, 2022).

These trends represent an opportunity for Africa to improve its eco-friendly agricultural production and build global markets. In sub-Saharan Africa, eco-friendly farming occupies a mere 0.2% of all agricultural land (Willer et al., 2020). This is salient given that many traditional smallholder farmers in the region suffer from low productivity and insufficient incomes to support their farming activities (Dhillon & Moncur, 2023; Touch et al., 2024). Organic farming, for instance, is often perceived by African farmers as a foreign system dictated by rules from international organisations and geared toward meeting the demands of foreign consumers (Schader et al., 2021). Although Nigeria holds the 13th position globally regarding available land for eco-friendly farming, it is 21st in the number of eco-friendly agricultural producers within Sub-Saharan Africa (Research Institute of Organic Agriculture, 2021). As highlighted by Ewere et al. (2024), the adoption of organic farming practices in Nigeria remains disappointingly low. Approximately 60-70% of farmers in Nigeria engage in traditional rural farming, practising subsistence agriculture. These farmers naturally produce uncertified organic foods, utilising localized and natural resources due to challenges in obtaining synthetic inputs. While their current output may not be officially certified as organic, their farming practices present a favourable opportunity to transition to certified organic methods.

Eco-friendly crops contain twice the nutrient value of conventionally grown crops. However, despite its importance, producing environmentally safe and whole vegetables is encumbered with complex challenges deeply rooted in socio-economic and institutional conditions. In Nigeria, consumer acceptability and the willingness to pay for eco-friendly agricultural products, which subsequently drive demand for environmentally safe vegetables, are low. (Okonkwo-Emegha et al., 2020). One reason for this reluctance is the cost of eco-labelled goods, which can be substantially higher than conventional alternatives, creating a barrier for low-income consumers (Onyia et al., 2023). This, in addition to price volatility caused by the lack of a mechanism to control agricultural products, especially perishable items like vegetables, constitutes a significant constraint (Mukaila, 2021).

The growing environmental and food safety concerns have necessitated the clamour for promoting sound eco-friendly production practices, especially within urban areas such as Enugu Metropolis, Nigeria. Though vegetables are inherently at a high risk of experiencing the adverse effects associated with synthetic chemical application in agriculture, the level of uptake of eco-friendly practices and the possible drivers are poorly understood and not well documented. Consequently, there is a conspicuous gap in research explicitly addressing the eco-friendly production of vegetables in the Enugu Metropolis. For instance, Ume et al. (2023) explored the factors influencing the adoption of organic agriculture in Southeast Nigeria; however, the study was limited to organic agricultural practices while ignoring other eco-friendly production practices; in addition, the study did not focus on vegetables which has the highest degrees of contaminants and human health risks (Kalkhajeh et al., 2021). Similarly, Anugwa et al. (2020) studied the adoption of organic practices among crop farmers, while Nwonu et al. (2022) explored sustainable yellow pepper production practices. This study seeks to bridge the existing research gap by investigating the uptake of eco-friendly vegetable production practices among small-scale farmers, identifying key drivers, and addressing prevalent challenges. These insights are crucial for mitigating environmental degradation while promoting food safety and societal well-being.

Methodology

The study was conducted in Enugu Metropolis, Enugu State, Nigeria, which spans three local government areas (Enugu East, North, and South) within the savanna belt. It is situated between 5°56'N - 7°36'N latitude and 6°53'E - 7°55'E longitude (ENADEP, 2006). The area experiences high rainfall (1600-2000mm annually) and temperatures ranging from 24.3°C (August) to 29.0°C (February) (Climate-data.org, CDO, 2021), making it suitable for diverse vegetable cultivation. A multistage sampling technique was employed in the selection of the respondents. A purposive selection was employed in selecting ten peri and urban towns in the three LGAs in Enugu Metropolis due to the high concentration of eco-friendly vegetable farmers in these areas in the first stage. This was followed by randomly selecting two communities in each of the ten selected towns. Finally, 15 vegetable farmers were randomly selected from each of the 20 communities selected; thus, 300 respondents were used for the study. Primary data was collected with the aid of a semi-structured questionnaire and was analysed using descriptive statistics and a multinomial regression model.

Model Specifications

The multinomial regression model was used to examine the factors influencing the adoption of eco-friendly production among vegetable farmers. The explicit form of the equation was specified as:

$Pr(Yi=j) = e\beta_j\ X_{ij},\ \ j= 1,2,3$……………………………………………………………(1)

$Pj = Pr\ (Yi=j) = e\beta_i x_{ij},\ j= 1,2,3$……………………………………………………………(2)

$1+\sum e^{\beta m \times\ ijm=0}$……………………………………………………………………………(3)

Where: $Pr\ (Y_i=j_i)$ is the probability of adopting any level of eco-friendly production set aside. J is the number of levels of eco-friendly production options in the adoption set. The X_i is a vector of the predictor variables. β_j is a vector of the estimated parameters. The probability response was stated as follows:

P = Response Probability (J=1,2,3) ……………………………………………………..(4)

Y= Level of adoption of eco-friendly practices category =1,2, 3………………………(5)

1 = Low level of adoption (if the respondent adopts ≤ 5 eco-friendly production practices)

2 = Medium level of adoption (if the respondent adopts 6-10 eco-friendly production practices)

3 = High level of adoption (if the respondent adopts ≥ 11 eco-friendly production practices).

A five-point Likert-type scale was used to identify the significant constraints to adopting eco-friendly vegetables. It was specified as follows: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree with the corresponding values of 5, 4, 3, 2, and 1, respectively. The mean score ($\bar{x}$) of the respondents based on the 5-point scale was given as:

$\bar{x} = \sum \frac{X}{n} = \frac{5+4+3+2+1}{4} = \frac{15}{5} = 3.0$ ……………………………………………………(6)

A 3.0 cut-off point using the interval scale 0.05 was adopted; the upper limit cut-off point was 3.0 + 0.05 = 3.05, while the lower limit cut-off point was 3.0 - 0.05 = 2.95. Therefore, any item with a mean score of less than 2.95 ($\bar{x}$ < 2.95) was considered a weak constraint and thus not significant, while mean values above 3.05 ($\bar{x}$ >3.05) was regarded as an extreme constraint to the eco-friendly production of vegetables.

Results and Discussion

Eco-friendly Practices Adopted by Framers

Table 1 highlights the diverse eco-friendly production practices vegetable farmers adopt. The Table shows that 33.0% of the farmers practised organic farming; this implies that these farmers relied on organic farming practices such as using organic manure, compost manure, wood ash and organic fertiliser to enhance the vegetable production output. Further analysis of the organic farming practices, as shown in Figure 1, indicates that animal manure, including poultry droppings, cow dung, and pig manure, constitute 59.0% of the organic inputs used, followed by wood ash (16.8%), compost (13.7%), and organic fertilizer (10.5%). The result is consistent with Palemo et al. (2024) and Okonta et al. (2023), who observed that organic manure is the most commonly used organic input in crop production due to its perceived efficiency, cheapness and availability.

Table 1: Eco-friendly production practices adopted by the respondents

Eco-friendly production practice	Percentage (300)
Organic farming	33.0
Agroforestry	46.0
No-tillage/minimum tillage farming	87.0
Planting of early maturing varieties	67.0
Reduced chemical input	64.0
Integrated soil fertility management	62.0
Crop rotation	17.0
Use of improved seed varieties	83.0
Mulching	33.0
Integrated pest management (IPM)	37.0
Intercropping	64.0
Water conservation	94.0
Cover cropping	7.0
Recycling of organic materials	11.0

Source: Field Survey, 2024

Other eco-friendly practices adopted by vegetable farmers included agroforestry (46.0%) and no-tillage/minimum tillage (87.0%). These two eco-friendly practices contribute to sustainable agriculture by enhancing ecological processes, maintaining ecosystem services, and improving soil fertility. The result aligns with Sileshi et al. (2020), Tsufac et al. (2021), Octavia et al. (2023), Musafiri et al. (2022) and Githongo et al. (2021), who, in their separate studies, affirmed that agroforestry and minimum tillage reduces the need for chemical fertilizer as it not only improves soil fertility but also reverses land degradation and restores carbon and nutrient stocks.

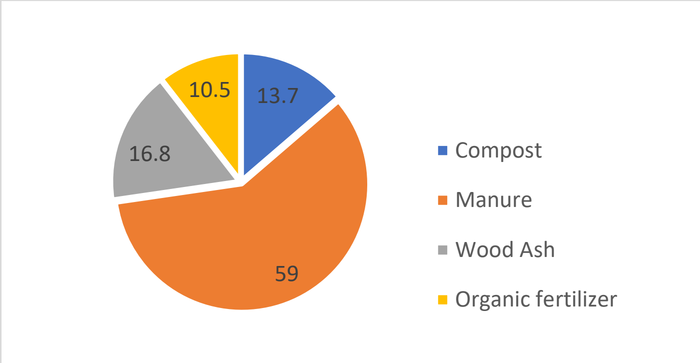

Figure 1: Types of organic inputs used

Planting early maturing varieties and using improved varieties were also among the eco-friendly vegetable production practices adopted. The result shows that 67.0% and 83.0% of the respondents used early maturing and improved varieties, respectively. This implies that a relatively earlier harvest due to the shorter life cycle or growing season of early-maturing vegetable varieties reduces the need to use chemicals such as fungicides and pesticides (Ukwuaba & Ileka, 2024). Improved varieties are also used to make vegetable disease and pest-tolerant; this diminishes the need for pesticides or similar chemicals. Thus, increased adoption of these practices strengthens food safety and improves the production levels and the health of farming households and consumers. This is consistent with the findings of Apeh et al. (2024), Aryal et al. (2020), and Nyang'au et al. (2021), who posited that relying on early maturing and improved varieties are some of the adaptation mechanisms to mitigate climate change impacts and ensure sustainable agricultural production.

The study further reveals that 64.0% of vegetable farmers applied fewer chemical inputs to produce their vegetables. Studies by Pahalvi et al. (2021) and Wu et al. (2020) reported that excess use of chemicals such as fertilisers in agriculture hardens the soil, pollutes air, water, and soil, and lessens essential nutrients of soil and minerals, leading to hazards to the environment. The result suggests that the farmers are probably knowledgeable about the negative impact of excess chemical usage in vegetable farming and thus use biofertilizers/organic manures or natural methods to control pests and diseases to complement the few chemicals used in vegetable farming. Reduced usage of chemicals such as fertilisers, pesticides and fungicides in vegetable production reduces the risk of chemical residues on produce, promoting consumer health. The result is in agreement with Wang et al. (2020) that reduced chemical use promotes healthy, safe and sustainable vegetable production in China. The study indicates that 37.0% of the respondents used diverse

Integrated Pest Management (IPM) practices to control pests and diseases on the farm instead of relying solely on regular pesticides, insecticides and fungicides. IPM advocates for less usage of chemical pesticides, thereby mitigating environmental pollution and human health risks in vegetable consumption. Further analysis highlighted that the various IPM used included reduced use of chemical pesticides (27.2%), use of natural predators (12.9%), microbial insecticides (6%), handpicking (23%), use of traps and barriers (25.3%), and others (5.6 %) such as pruning and crop rotation. This suggests that vegetable farmers drastically reduced the amount of chemicals used in farming and contributed significantly to a healthier environment and ecosystems through various IPM strategies. This result aligns with Souto et al. (2021), Singh et al. (2020) and Lengai et al. (2020), which highlighted that IPM improves the efficiency of crop production sustainably while preserving consumer health.

Table 1 further reveals that 62.0% of the farmers used integrated soil fertility management in addressing soil fertility issues; this ensures sustainability and the soil structures and ecosystems were not compromised. This corroborates the studies of Hörner and Wollni (2021) and Srivastava (2021), where integrated soil fertility management was a frequently applied eco-friendly production method. Other central eco-friendly practices identified and used among vegetable farmers include intercropping (64.0%), water conservation (94.0%) and Integrated pest management strategies (37.0%), which are of different forms, as shown in Figure 2. These practices improve soil structure, fertility and ecosystem while ensuring safe and healthy vegetable production due to reduced chemical usage on the farm (Ukwuaba & Ileka, 2024).

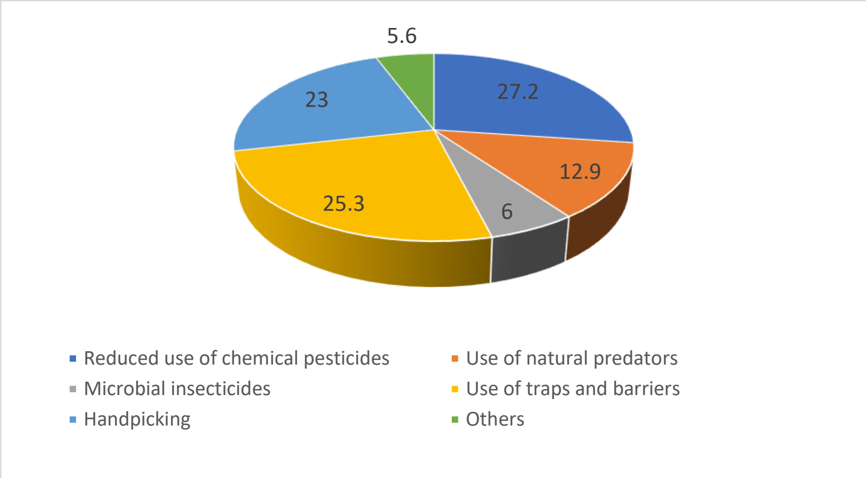

Figure 2: Integrated pest management strategies used

Level of Adoption of Eco-friendly Practices

The results of the level of adoption of eco-friendly practices are presented in Figure 3. Three adoption categories were identified: low, medium and high. Farmers who adopted less than five eco-friendly were regarded as low adopters; those who adopted between six and ten were classified as medium adopters, while 11 and above were classified as high adopters. The result indicates that the majority of vegetable farmers (71.0%) were medium adopters. This suggests a potential for future growth in the level of adoption of eco-friendly practices. The findings suggest that farmers are aware of the benefits of eco-friendly practices, but various socioeconomic factors may constrain them from adopting these methods more widely. Thus, additional support in the form of training, provision of organic inputs or incentives can spur them to higher adoption.

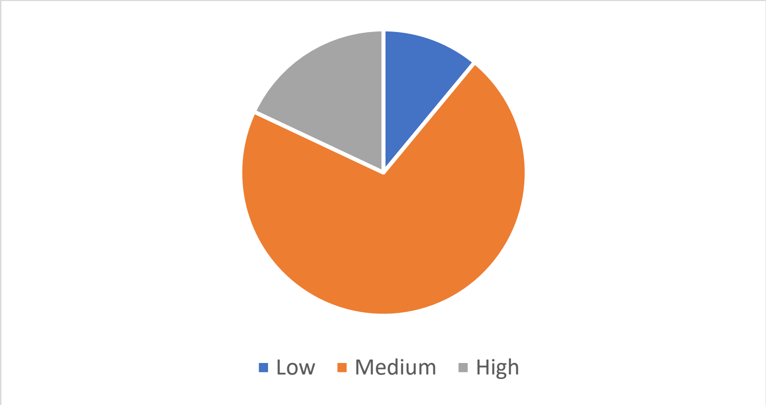

Figure 3: Level of adoption of eco-friendly practices

The result is corroborated by Das et al. (2020), Luczka and Kalinowski (2020), and Ukwuaba and Ileka (2024), who reported a medium-level adoption by most farmers. These authors linked economic barriers to the lack of a high adoption rate of eco-friendly practices.

Barriers to Adoption of Eco-Friendly Practices

The result in Table 2 indicates the significant constraints to adopting eco-friendly practices among vegetable farmers. The Table shows that eco-friendly vegetable farmers consider limited access to credit ($\bar{x}$ = 4.64), limited access to resources ($\bar{x}$ = 4.50), and the land tenure system ($\bar{x}$ = 4.45) as the most pressing barriers. This suggests that the primary challenges faced by vegetable farmers in adopting eco-friendly production practices revolve around the physical access to resources crucial for farming, which include access to credit, organic inputs like manure and compost, improved seed varieties, and land and other production inputs. This finding is consistent with the study by Effiong et al. (2021) and Jochen et al. (2020), which identified limited access to land, finances, and resources as significant constraints for eco-friendly vegetable farmers. Similarly, Dhillon and Moncur (2023) highlighted limited access to resources, such as high labour costs and the unavailability of organic inputs, as significant constraints to eco-friendly vegetable farming.

Table 2: Constraint to eco-friendly production of vegetables

Constraints	Mean	Std. Dev.
Limited access to credit	4.64	0.718
Limited access to resources	4.50	0.959
Land ownership system	4.45	1.009
Limited technical knowledge	4.04	0.875
Poor support from research and extension services	4.03	0.870
Limited access to market information	3.93	0.879
Poor pest and disease management	3.82	1.184
Severe weather events	3.34	1.343
High cost of production	3.19	1.522
Low consumer awareness	2.97	1.306
Low consumer demand	2.96	1.385
Water scarcity	2.87	1.542
Poor weed management	2.77	1.355
Poor soil fertility	2.70	1.418
Gender inequality	0.04	0.243

Source: Field Survey,2024

Following closely are significant drawbacks, such as a lack of technical knowledge ($\bar{x}$ = 4.04) and poor support from research and extension services ($\bar{x}$ = 4.03). This indicates that the farmers lacked the technical know-how or infrastructure for environmental-friendly production and post-harvest phases. The result suggests that such research-based information and support services are essential in facilitating the adoption of innovations such as eco-friendly vegetable adoption. It cannot be overemphasised that farmers need training and educational programs to improve their knowledge about eco-friendly techniques. This is corroborated by the report by Nwonu et al. (2022), which highlighted the lack of training and support from the extension and research institutes as significant barriers to eco-friendly adoption practices. Similarly, Singh and Thakur (2022) identified limited institutional support as another challenge in promoting eco-friendly vegetable farming. Despite these constraints, many farmers fall into the medium adoption category, highlighting the potential for future improvements.

Factors Influencing the Level of Adoption of Eco-friendly Production Practices

The result of the multinomial logistic regression analysis showing the socioeconomic and institutional factors influencing the adoption of eco-friendly production is presented in Table 3. The log pseudo-likelihood ratio test illustrates that incorporating predictor variables significantly improved the model's predictive capability, with a chi-square value of 54.137($p < 0.01$), indicating a good fit for the regression model. This is supported by the pseudo-R squared value of 0.528, which indicates statistical significance at a 1% alpha level (Prob>Chi2; $p<0.01$). This implies that the predictor variables play a meaningful role in explaining the variability in the outcome variable.

Among the explanatory variables tested, five were significant across the attributes of adoption levels. Education, farming experience, and farm size determined vegetable farmers' low adoption of eco-friendly practices compared to medium-level adopters. Regarding factors influencing farmers' high level of eco-friendly adoption, farming experience, consumer demand, and access to credit were the factors influencing farmers' high-level adoption of eco-friendly practices against being medium-level adopters. Education shows a negative and significant relationship with the low adoption of eco-friendly production practices at a 10% probability level. This suggests that as the duration of formal education decreases, the likelihood of farmers belonging to the low adoption level category against those belonging to the medium level category increases. This aligns with a priori expectations as individuals with higher educational attainment are more equipped with knowledge and skills relevant to understanding and adopting new practices or technologies (Akanbi et al., 2024). Thus, farmers with low formal education had low adoption of eco-friendly production practices. Farm experience was also negative but significantly influenced the low adoption of eco-friendly practices in vegetable farms at a 10% probability level. This implies that as farming experiences decrease, the likelihood of the farmer being a low adopter of eco-friendly farming practices against being a medium-level adopter increases. It could also be that inexperienced farmers lack the expertise necessary

Table 3: Factors influencing the level of adoption of eco-friendly production practices

	Low level		High level	
Variables	**coefficient**	**St. Error**	**coefficient**	**St. Error**
Age	-0.051	0.815	0.196	0.681
Education	-0.159*	0.087	0.115	0.087
Gender	-0.305	1.364	1.525	1.360
Marital status	-0.120	1.144	-0.109	1.110
Income	0.523	0.430	0.319	1.103
Household size	0.135	0.240	0.263	0.424
Farming experience	-0.178*	0.100	-0.145**	0.069
Farm size	-13.369**	6.625	-2.189	1.864
Land tenure system	-0.487	1.342	-18.001	0.000
Consumer awareness	-1.358	1.039	-2.667	1.105
Consumer demand	1.565	0.970	2.010**	0.962
Access to credit	-0.845	2.122	-3.699**	1.879
Access to extension	16.538	1.000	-0.256	1.705
Livestock ownership	1.872	1.405	-1.186	0.963
Log Likelihood ratio = 54.137				
Pseudo R^2 = 0.528				
Prob>Chi^2 = 0.000 (30)				

Reference category = medium level of adoption. Note: **P≤ 0.05, *P≤0.1.
Source: Field Survey, 2024

to adopt eco-friendly vegetable production, which requires specific skills. Consequently, low experience prohibits adoption rates (Ume et al., 2023).

The results reveal a negative and statistically significant coefficient for farm size to low adoption levels at the 5% probability level. A negative coefficient suggests that as farm size decreases, the likelihood of the farmer belonging to the low adoption category against a medium-level adoption increases. This means that farmers with smaller plots of land are more likely to adopt a few numbers of eco-friendly farming practices. Thus, farmers with larger plots of land are more likely to adopt a more significant number of eco-friendly farming practices. This trend can be attributed to economies of scale, where the per-unit cost of production decreases as farm size increases. This finding is consistent with Pineiro et al. (2020), who suggest that larger farms have more land available for crop or livestock production, which supports the implementation of agroecological principles. The coefficient of farm experience was negative and significant at the 5% probability level about high adoption levels of eco-friendly agricultural practices. This indicates that as farming experience increases, the likelihood of the farmer being a high adopter of eco-friendly farming practices against being a medium adopter decreases. This observation may be due to experienced farmers being more entrenched in conventional practices and less receptive to new or alternative approaches, including eco-friendly farming practices. Adesida et al. (2021) support this observation, noting that farmers with more excellent farming experience were less likely to adopt innovations such as animal manure utilization than those with less experience. Similarly, Prodhan et al. (2023) found that increasing farming experience correlates with more excellent resistance to change and a lower likelihood of adopting innovations. However, these findings contradict those of Ume et al. (2023), who have posited a positive relationship between farming experience and adoption rates.

The consumers' demand shows a positive and significant relationship with high adoption levels at the 5% probability level. This implies that increased consumer demand for eco-friendly vegetables increased the likelihood of vegetable farmers being high adopters of eco-friendly production practices against medium-level adopters. This suggests that consumer demand can significantly influence changes in agricultural practices. This is because production is tailored towards consumers' needs. When there is a high demand for eco-friendly vegetables, farmers may adjust their practices accordingly to meet market preferences, potentially leading to higher prices or expanding market share. Access to credit had a negative and significant relationship with high adoption levels at the 5% probability level. This result suggests that a decrease in farmers' access to credit increases a farmer's probability of being high adopters of eco-friendly practices against being medium adopters. This result deviates from a priori expectations, suggesting that access to credit alone may not be adequate to drive the adoption of eco-friendly practices. Farmers might require additional assistance, such as access to extension services, technical guidance, training programs, or demonstration plots, to fully understand eco-friendly practices' implementation strategies and benefits. In cases where extension services or agricultural advisors fail to effectively advocate for eco-friendly practices or offer guidance on accessing credit for sustainable investments, farmers may not prioritize adopting these practices. This finding contrasts with Olayemi et al. (2020) and Usman (2021), who identified access to credit as a significant factor influencing the adoption of good agricultural practices. It is also a common practice among some smallholders in Nigeria to divert the credit to other non-productive purposes, such as payment of children's school fees and ceremonies. These could be the reasons for the negative effect of credit access on the high adoption level of eco-friendly practices.

Conclusions and Recommendations

Vegetable farmers in Enugu are transitioning towards eco-friendly methods, with most farmers categorized as medium-level adopters. This highlights a positive shift toward sustainable agricultural practices, though there is considerable room for improvement. Consumer demand emerged as a critical driver, positively influencing the level of adoption and signalling an opportunity to leverage market forces to encourage eco-friendly farming. However, the study identified several socioeconomic and institutional factors that negatively influence adoption rates, including education levels, farm size, farming experience, and limited credit access. These barriers underscore the need for targeted interventions to address both systemic and resource-based challenges. Limited access to credit and resources, coupled with insufficient technical knowledge, were highlighted as the most significant constraints hindering widespread adoption. These issues reveal the necessity of equipping farmers with the tools, skills, and financial support needed to transition fully to eco-friendly practices. To ensure a more robust adoption of eco-friendly farming practices, this study emphasises the importance of creating widespread awareness about the benefits of eco-friendly farming for both farmers and consumers. Comprehensive training programs and capacity-building initiatives should be developed to enhance farmers' knowledge and skills, enabling them to adopt and implement eco-friendly techniques effectively. Strengthening extension services is also essential to ensure that farmers receive consistent technical support and up-to-date information on sustainable agricultural innovations. Moreover, the provision of monitored credit facilities and targeted subsidies can play a transformative role in reducing financial barriers and incentivising farmers to transition to eco-friendly practices.

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