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Socioeconomic Factors and Climate-Smart Practices Influencing Vegetable Farming Profit in Egbeda, Oyo State, Nigeria

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ABSTRACT

This study examined the influence of socioeconomic characteristics and climate-smart agricultural practices on the profitability of vegetable farming in Egbeda Local Government Area, Oyo State, Nigeria. The research aimed to determine how farmers' demographic and economic factors, coupled with the adoption of climate-smart agricultural practices, shape their income and sustainability outcomes. Primary data were collected from 145 randomly selected vegetable farmers using a structured questionnaire, and analyzed with descriptive and inferential statistics, including multiple linear regression. Findings revealed that the majority of respondents were male (67.6%), within the productive age bracket of 31–40 years, and operating on small-scale farms of less than one hectare. Adoption of climate-smart agricultural practices such as crop rotation (73.1%), mulching (69.7%), and use of improved seeds (69.0%) was relatively high, reflecting increasing awareness of sustainable production systems. However, challenges including inadequate facilities, high input costs, and limited extension contact constrained adoption. Regression analysis showed that farm size (β = 1.581), association membership (β = 0.926), and access to climate-smart agricultural information (β = 0.737) significantly ($p < 0.05$) influenced monthly profit, while the direct effect of climate-smart agricultural adoption was positive but not statistically significant. The study concludes that socioeconomic factors, institutional participation, and information access are key determinants of profitability and adoption of climate-smart agricultural practices among smallholder vegetable farmers. Strengthening farmers' access to land, input resources, and cooperative networks, alongside integrated extension services and multi-channel information dissemination, will enhance climate-smart agriculture adoption and profitability. The findings contribute to the empirical discourse on climate-smart agribusiness and align with Sustainable Development Goals 2 (Zero Hunger) and 13 (Climate Action), supporting Nigeria's transition toward resilient and sustainable agricultural systems.

1. Introduction

Climate change poses a significant threat to agricultural productivity and rural livelihoods, especially in developing economies (Adeosun, *et al.*, 2021). Nigeria's agricultural sector, particularly vegetable

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farming, is increasingly affected by erratic weather patterns, declining soil fertility and water scarcity (Bello *et al.*, 2024). Climate-smart agriculture practices, such as soil management, water conservation and crop diversification, have emerged as vital strategies for enhancing productivity and resilience among smallholder farmers (Ifeanyi-Obi *et al.*, 2022). However, the extent of adoption and the socioeconomic factors influencing the profitability of such practices remain underexplored, especially in peri-urban contexts like Egbeda, Oyo State, where vegetable farming is a key livelihood activity.

Despite the potential of climate-smart agricultural practices to improve farm productivity and profitability (Ojoko *et al.*, 2023), their adoption among vegetable farmers in Egbeda is uneven and constrained by various factors, including socioeconomic limitations, knowledge gaps and infrastructural deficiencies. While some farmers benefit from climate-smart agriculture innovations, others struggle to access, understand, or apply these practices effectively (Jellason *et al.*, 2021). There is limited empirical evidence on how socioeconomic variables, such as age, education, farm size and information access, influence both the adoption of climate-smart agriculture and its impact on income. This knowledge gap hampers the design of targeted interventions aimed at improving agricultural profitability and sustainability.

In line with global and national efforts to address climate risks in agriculture, the adoption of climate-smart agriculture practices aligns with the United Nations Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger) and SDG 13 (Climate Action), which emphasize sustainable food production and climate resilience. At the national level, Nigeria's Climate Change Act (2021) and National Agricultural Technology and Innovation Policy (2022–2027) emphasize the need for climate-smart innovations and inclusive agricultural systems that enhance productivity while reducing environmental degradation. Therefore, examining the determinants of climate-smart agriculture adoption and profitability among smallholder vegetable farmers contributes to both global and national sustainability agendas.

The broad objective of this study was to assess the influence of socioeconomic factors and climate-smart agriculture practices on vegetable farming profit in Egbeda Local Government Area of Oyo State. The study aimed to understand how farmers' demographic and economic characteristics, alongside their engagement in sustainable agricultural practices, shaped their profitability and resilience in the face of environmental and market challenges. By focusing on the interaction between socioeconomic attributes and climate-smart strategies, the study sought to generate insights that could enhance productivity, sustainability and income generation among smallholder vegetable farmers in the region.

Specifically, the study first sought to describe the socioeconomic characteristics of vegetable farmers in the study area. This involved examining variables such as age, gender, educational level, household size, farming experience and access to resources, as these factors often influenced farmers' decision-making and adoption behavior. The second objective was to assess the level of adoption of sustainable climate-smart agricultural practices among respondents. These practices included organic manure use, drip irrigation, mulching, crop rotation, integrated pest management and other environmentally friendly innovations that improved soil fertility and reduced vulnerability to climate variability.

The third objective was to identify the major sources of information through which farmers accessed knowledge and updates about climate-smart agriculture practices. Understanding these information channels, such as extension services, farmer associations, media and peer networks, helped to identify the most effective platforms for promoting sustainable agricultural innovations. The fourth objective was to determine the perceived benefits and constraints to the adoption of climate-smart agriculture practices among vegetable farmers. This involved exploring how farmers perceived the profitability, productivity and environmental advantages of these practices, as well as the challenges they faced, including high costs, limited technical knowledge and inadequate institutional support.

Finally, the study examined the effect of socioeconomic factors and climate-smart agriculture practices on the monthly profit earned from vegetable farming. This analysis revealed the extent to which demographic and practice-related variables jointly contributed to enterprise performance and economic sustainability. The findings from this objective provided empirical evidence that could guide policy interventions, enhance farmers' adaptive capacity and promote the integration of sustainable technologies into Nigeria's agricultural sector.

The study tested the following null hypotheses:

H_{01}: There is no significant relationship between farmers' socioeconomic characteristics and the adoption of climate-smart agriculture practices.

H_{02}: Socioeconomic factors and climate-smart agriculture practices do not significantly influence monthly vegetable farming profit in Egbeda, Oyo State.

The findings of this study are crucial for informing agricultural policy and extension strategies aimed at enhancing climate resilience and economic returns for smallholder vegetable farmers. By identifying the key drivers and barriers to climate-smart agriculture adoption, this research provides evidence-based insights for targeted interventions by governmental and non-governmental stakeholders. Additionally, the study contributes to the broader discourse on sustainable agriculture by highlighting the role of socioeconomic factors in shaping the outcomes of climate-smart innovations, thus supporting the achievement of food security and environmental sustainability goals in Nigeria.

2. Literature Review

Climate-smart agriculture has emerged as a transformative approach to achieving sustainable agricultural growth in the face of climate variability and resource scarcity. The concept integrates three interrelated objectives i.e. by enhancing productivity, strengthening resilience (adaptation) and reducing greenhouse gas emissions (mitigation), to ensure long-term agricultural sustainability (Kabato et al., 2025; Borsetta et al., 2025). According to Begna & Wakweya, (2025), climate-smart agriculture enables farmers to adopt innovative practices that not only mitigate the effects of climate change but also improve soil health, water-use efficiency and overall farm profitability.

In Nigeria, vegetable production constitutes an important component of the agricultural economy due to its contribution to household nutrition, income diversification and rural employment (Mukaila et al., 2022; Olajide & Ogundele, 2022). However, this subsector is increasingly threatened by erratic rainfall, pest infestations and limited access to adaptive technologies. These challenges necessitate the integration of climate-smart agriculture practices, such as mulching, crop rotation, organic manure use and improved irrigation management, among vegetable farmers to enhance productivity and income sustainability (Olarewaju et al., 2025).

This study was anchored in the Sustainable Livelihoods Framework (SLF), which emphasized the interactions between human, social, natural, physical and financial capitals in determining livelihood outcomes (DFID, 2000; Karki, 2021). Within this framework, farmers' socioeconomic characteristics, such as age, education, experience, farm size and access to extension services, constitute human and social capitals that influence the adoption of climate-smart agriculture practices. These practices, in turn, enhance resource efficiency, resilience and profitability in vegetable farming systems. The framework assumes that increased adoption of climate-smart agriculture technologies improves productivity and income, thereby contributing to sustainable livelihoods and environmental stability.

Climate-smart agriculture adoption serves as the mediating variable linking farmers' characteristics and profitability outcomes. The model posits that farmers with higher education, access to credit and training are more likely to adopt climate-smart agriculture practices, leading to improved farm performance and income sustainability. Conversely, limited access to resources or extension support constrains adoption, reducing potential gains in profitability (Jellason et al., 2021; Sardar et al., 2021).

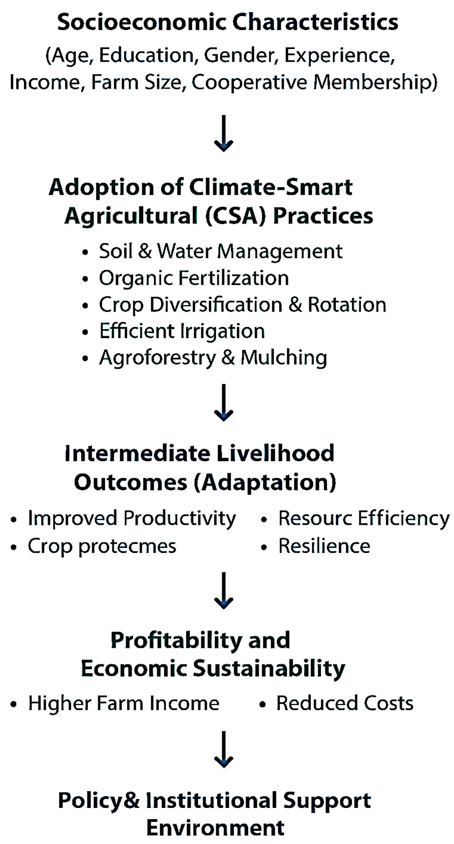

Figure 1. Conceptual Framework showing the interaction between Socioeconomic Characteristics, Climate-Smart Agricultural Adoption and Profitability Outcomes within the Sustainable Livelihoods Framework

Source: Adapted from the Sustainable Livelihoods Framework (DFID, 2000) and modified by the author to illustrate the interaction among socioeconomic characteristics, climate-smart agricultural adoption and profitability outcomes.

The framework (Figure 1) illustrates how farmers' socioeconomic characteristics influence access to livelihood assets, which in turn determine the level of climate-smart agriculture adoption. Adoption of climate-smart agriculture practices enhances intermediate livelihood outcomes such as productivity, resource efficiency and resilience, leading to improved profitability and sustainable income. These relationships are moderated by the institutional and policy environment, including access to extension services, infrastructure and credit facilities.

A growing body of literature has examined the drivers and economic implications of climate-smart agriculture adoption among smallholder farmers across Sub-Saharan Africa. Studies by Foguesatto & Machado (2022) and Swart et al., (2023) revealed that farmers' socioeconomic attributes significantly influence the uptake of sustainable agricultural practices. Educated farmers tend to exhibit greater awareness and technical ability to implement climate-smart agriculture innovations, while those with cooperative affiliations benefit from shared resources, information exchange and collective bargaining power.

Jellason et al. (2021) and Ifeanyi-Obi et al. (2022) identified knowledge gaps, resource constraints and weak institutional support as major barriers to climate-smart agriculture adoption in Nigeria. Furthermore, empirical evidence from Hussein, (2024) and Zheng, et al., (2024) demonstrated that climate-smart agriculture adoption enhances farm productivity, soil conservation and resilience to climate shocks. However, most of these studies have not explicitly linked adoption levels with measurable profitability indicators, particularly within the vegetable subsector.

Recent research by Tanti et al., (2024) and Gudina & Alemu, (2024) revealed that the adoption of climate-smart practices leads to improved total factor productivity and income diversification among smallholder farmers. Nonetheless, the magnitude of these outcomes is influenced by local contextual factors such as extension contact, market access and farm size. Similarly, studies by Olumba & Alimba, (2022) and Balayar & Mazur, (2022) emphasized gender disparities and socio-cultural limitations that affect the extent of participation in sustainable farming practices.

Despite extensive research on climate-smart agriculture adoption in Nigeria, empirical gaps persist regarding the interaction between socioeconomic factors and profitability outcomes among vegetable farmers in peri-urban settings. Existing studies have predominantly focused on staple crops such as maize, rice and cassava (Oparaojiaku, et al., 2025; Oyekale et al., 2022), with limited attention to high-value, short-cycle crops like vegetables that are vital to urban food systems and income generation.

Moreover, prior research often isolates climate-smart agriculture adoption as a technical variable, neglecting the socioeconomic and institutional contexts that shape its economic impacts. There is, therefore, a need for location-specific evidence that connects farmers' demographic characteristics, adoption intensity and farm profitability within the framework of climate-smart practices.

Thus, this study seeks to bridge these empirical and contextual gaps by analyzing the combined influence of socioeconomic characteristics and climate-smart agriculture adoption on vegetable farming profitability in Egbeda, Oyo State. Grounded in the Sustainable Livelihoods Framework, the study integrates theoretical and empirical perspectives to capture the multifaceted interactions among human, social, financial and natural capital in shaping adaptation and income outcomes.

By doing so, the study contributes to the growing discourse on climate-smart agribusiness and provides evidence-based recommendations for policymakers, agricultural extension agencies and development partners. The findings are expected to inform the design of inclusive, profitability-driven climate-smart agriculture interventions tailored to the needs of smallholder vegetable farmers in Nigeria, advancing both SDG 2 (Zero Hunger) and SDG 13 (Climate Action) in alignment with Nigeria's Climate Change Act (2021).

3. Methods

The study was conducted in Egbeda Local Government Area (LGA) of Oyo State, located in the southwestern region of Nigeria. Egbeda lies within latitude 7°25′N and longitude 4°05′E, situated on the outskirts of Ibadan, the state capital. The area is characterized by a tropical wet and dry climate, with distinct rainy and dry seasons. Annual rainfall averages between 1,200–1,500 mm, supporting intensive crop cultivation, particularly vegetables such as tomatoes, okra, pepper and leafy greens. Socioeconomically, Egbeda is semi-urban, with a mix of commercial and subsistence farming. Agriculture forms a major livelihood source for the population, with smallholder farmers playing a dominant role in vegetable production.

The study adopted a descriptive survey design, which enabled the collection of quantitative data from a cross-section of vegetable farmers. This design was appropriate for examining patterns in socioeconomic characteristics, adoption levels of climate-smart agriculture practices and their relationship with farm income (profit).

The target population comprised all registered and active vegetable farmers across selected farming communities in Egbeda LGA. A multistage sampling technique was employed. In the first stage, five major vegetable-producing communities (Awaye/Osegere, Kumapayi/Olodo, Erunmu, Alakia/Olode and Egbeda town) were purposively selected based on the intensity of vegetable cultivation and accessibility. In the second stage, a simple random sampling method was used to select 145 respondents from the lists of registered farmers obtained from local farmer associations and extension offices. This sample size was deemed adequate to ensure representativeness while allowing for robust statistical analysis.

Primary data were collected using a structured questionnaire, which consisted of both closed- and open-ended questions. The instrument covered variables such as demographic profiles, climate-smart agriculture adoption levels, perceived benefits and constraints, sources of information and farm income. The questionnaire was pre-tested for reliability and face validity among 15 vegetable farmers in Lagelu LGA, a neighboring area with similar agricultural conditions. Based on feedback, necessary adjustments were made to ensure clarity, cultural appropriateness and content relevance.

Data collection was carried out through face-to-face interviews conducted by trained enumerators who were fluent in English and Yoruba, ensuring effective communication with all respondents. The exercise lasted for four weeks, between May and June 2024, to capture accurate information within the main planting season. Supplementary data were also obtained through key informant interviews with extension officers and farmer group leaders, which provided contextual insights into climate-smart agriculture awareness and adoption challenges.

Data analysis involved both descriptive and inferential statistical methods. Descriptive statistics such as frequencies, percentages, means and standard deviations were used to summarize respondents' socioeconomic characteristics, climate-smart agriculture adoption rates and perceived constraints. Inferential analysis was performed using multiple linear regression to determine the effect of socioeconomic factors and climate-smart agriculture adoption on monthly vegetable farming profit. The statistical analysis was conducted using SPSS version 25, with a significance level set at $p < 0.05$. The general regression model was specified as follows:

$$Y=\beta_0+\beta_1X_1+\beta_2X_2+\ldots+\beta_nX_n+\varepsilon$$

Where:

Y = Monthly profit from vegetable farming (₦),

$X_1 \ldots X_n$ = Vector of explanatory variables representing socioeconomic factors (e.g., age, education, household size, farm size, experience, access to credit and climate-smart agriculture adoption index),

β_0 = Constant term,

$\beta_1 \ldots \beta_n$ = Regression coefficients and

ε = Error term.

Ethical considerations were duly observed throughout the study. Participation was voluntary and all respondents were provided with clear explanations of the study's purpose, confidentiality measures and their right to withdraw at any stage. Informed consent was obtained verbally before administering the questionnaires and respondents' identities were kept anonymous to protect their privacy. Data collected were used solely for academic purposes and securely stored to ensure confidentiality.

4. Results

As shown in Table 1, the majority of vegetable farmers in Egbeda were male (67.6%), indicating a gender imbalance consistent with prior observations of male dominance in smallholder farming in southwestern Nigeria (Nnadi *et al*., 2023). Most respondents (45.5%) were within the 31–40 years age range, suggesting an active, economically productive population (Maisule *et al*., 2023). Over half (52.4%) were married, while 36.6% had no formal education, a factor that may influence the adoption of modern agricultural practices (Oyetunde-Usman *et al*., 2021). Farming households with six or fewer members constituted the majority (55.9%). Notably, 56.6% of respondents earned ≤₦75,000 monthly from vegetable farming, indicating relatively low income levels. Most farmers (59.3%) had less than 10 years of farming experience and 71.7% operated on small landholdings (≤1 hectare), emphasizing the prevalence of small-scale farming. About 66.2% belonged to associations, which may facilitate access to resources and information.

Table 1. Socio-economic Characteristics of Respondents

Socio-economic Characteristics		Frequency	Percentage
Sex	Male	98	67.6
	Female	47	32.4
Age	<=30 Years	34	23.4
	31-40 Years	66	45.5
	41-50 Years	34	23.4
	>50 Years	11	7.6

Socio-economic Characteristics		Frequency	Percentage
Marital Status	Not Married	69	47.6
	Married	76	52.4
Education level	No Formal Education	53	36.6
	Primary Education	41	28.3
	Secondary Education	27	18.6
	Tertiary Education	24	16.6
Household (Persons)	<=6	81	55.9
	>6	64	44.1
Monthly Vegetable Farming Profit (Naira)	<=75,000	82	56.6
	>75,000	63	43.4
Years of farming experience (Years)	<=10	86	59.3
	>10	59	40.7
Size of farmland (Ha)	<=1	104	71.7
	>1	41	28.3
Membership of association	No	49	33.8
	Yes	96	66.2

Source: Field Survey, 2025.

As detailed in Table 2, adoption levels of climate-smart agriculture practices were generally high across several categories. Practices such as crop rotation (73.1%), mulching (69.7%) and use of improved seeds (69.0%) recorded the highest adoption rates. Soil and water management techniques like terracing (57.2%) and water conservation (64.6%) also had moderate uptake. These findings suggest growing awareness and willingness among farmers to integrate sustainability measures into their production systems. Similar adoption trends were noted by Jellason *et al.*, (2021) and Ifeanyi-Obi *et al.*, (2022), who observed that smallholder farmers are increasingly embracing climate-smart agriculture practices to enhance resilience and productivity.

Table 2. Adoption of Sustainable Climate-Smart Agricultural Practices

Category	Adopted Sustainable Climate-Smart Agricultural Practices	No (%)	Yes (%)
Soil Management Practices	Soil conservation	30.3	69.7
	Use of improved fertilizer	37.2	62.8
	Minimum tillage	39.3	60.7
	Zero tillage	40.0	60.0
	Mulching	30.3	69.7
	Terracing	42.8	57.2
	Contour plowing	33.8	66.2
Water Management Practices	Water conservation	35.4	64.6
Cropping System Practices	Crop rotation	26.9	73.1

Category	Adopted Sustainable Climate-Smart Agricultural Practices	No (%)	Yes (%)
	Crop diversification	36.6	63.4
	Intercropping	31.7	68.3
	Shifting cultivation	41.4	58.6
Agroforestry & Plant-Based	Planting of trees	37.9	62.1
	Planting of leguminous plants	33.8	66.2
Input-Based Practices	Use of improved seed	31.0	69.0

Source: Field Survey, 2025.

Table 3 highlights a diverse range of information sources. Commercial sources, especially agro-stores (Mean = 2.87, SD = 1.11) and mass media such as billboards (Mean = 2.81, SD = 1.07) and posters (Mean = 2.79, SD = 1.10), were the most utilized. Interpersonal communication through neighborhood farmers (Mean = 2.75) and institutional channels like extension services (Mean = 2.65) also played important roles. These findings reinforce the multi-channel nature of agricultural knowledge dissemination, as documented by Ameh, *et al*., (2025), particularly in peri-urban contexts like Egbeda.

Table 3. Sources of Information on Sustainable Climate-Smart Agricultural Practices

Category	Sources of Information on Sustainable Climate-Smart Agricultural Practices	Mean	Std. Dev.
Interpersonal Sources	Friends/Neighbors	2.49	1.13
	Associations	2.57	1.17
	Neighborhood farmers	2.75	1.13
Institutional Sources	Extension services	2.65	1.03
	Seminars/Workshops	2.60	1.11
Mass Media Sources	Television	2.74	1.05
	Radio	2.77	1.03
	Newspapers	2.73	1.12
	Magazines	2.57	1.11
	Pamphlets & Handbills	2.57	1.01
	Posters	2.79	1.10
	Billboard	2.81	1.07
Digital Sources	Internet	2.55	1.01
	Social media	2.54	1.13
	Email	2.66	1.02
Commercial Sources	Agro stores	2.87	1.11
Mobile Communication	Mobile phones	2.73	1.05

Source: Field Survey, 2025

As presented in Table 4, respondents perceived substantial benefits across environmental, economic, agronomic and climate resilience dimensions. A significant proportion (69.7%) believed climate-smart agriculture reduced the use of agrochemicals and minimized soil erosion (69.0%). Economic gains were recognized, with 67.6% stating that climate-smart agriculture encourages the use of locally accessible resources. Additionally, 62.1% affirmed its role in promoting sustainable agriculture and enhancing adaptive capacity. These perceptions align with findings by Mohammed *et al*., (2024), which emphasized climate-smart agriculture's multifaceted contributions to productivity and environmental sustainability.

Table 4. Perceived Benefits of Sustainable Climate-Smart Agricultural Practices

Thematic Benefits	Perceived Benefits of Sustainable Climate-Smart Agricultural Practices	No (%)	Yes (%)
Environmental Benefits	Reduce the use of agro chemicals on the soil	30.3	69.7
	Reduce the cost of soil fertilization	35.9	64.1
	Reduce environmental pollutions through wastes	29.0	71.0
	Reducing the use of artificial chemicals on farmland	29.0	71.0
	Helps to conserve/reduce soil and water loss	39.3	60.7
	Encompass the reduction in environmentally hazardous inputs	35.2	64.8
	Reduction in cases of land degradation	36.6	63.4
	Minimize soil erosion	31.0	69.0
	Improve water retention ability of the soil	34.5	65.5
	Protect crops from harsh weather conditions like temperatures	31.0	69.0
Economic Benefits	Increase the economic value of farmers	37.9	62.1
	Increase standard of living of farmers	36.6	63.4
	Encourage utilizing locally accessible resources	32.4	67.6
	Contribute to enhancing food security	42.8	57.2
Agronomic & Crop Productivity Benefits	Increase fertility of soil	31.9	69.0
	It helps to control pests and diseases infestation	44.8	55.2
	Enhance crop growth	45.5	54.5
	Compress weed growth	33.1	66.9
Climate Resilience & Sustainability Benefits	It helps to ensure sustainable agriculture	37.9	62.1
	Enhanced smallholder farmers' ability to adapt to climate change's impacts	37.9	62.1

Source: Field Survey, 2025

Table 5 outlines several barriers. Resource and infrastructure constraints were among the most pronounced, with "inadequacy of facilities" (Mean = 2.44) and "inadequate contact with extension agents" (Mean = 2.42) scoring highly. Economic constraints such as the "cost of some techniques" (Mean = 2.36) also hindered adoption. These findings are consistent with Obasi *et al*., (2024), who identified inadequate funding and institutional support as key obstacles to climate-smart agriculture uptake in rural Nigeria.

Table 5. Constraints to Adoption of Sustainable Climate-Smart Agricultural Practices

Thematic Constraints	Perceived Constraints to Adoption of Sustainable Climate-Smart Agricultural Practices	Mean	Std. Dev.
Educational & Informational Constraints	Inability to read and write (illiteracy)	2.39	0.77
	Limited information on practices	2.27	0.81
	Poor transfer	2.35	0.78

Thematic Constraints	Perceived Constraints to Adoption of Sustainable Climate-Smart Agricultural Practices	Mean	Std. Dev.
Resource & Infrastructure Constraints	Unavailability of materials	2.40	0.74
	Inadequacy of facilities	2.44	0.73
	Inadequate contact to extension agent	2.42	0.77
Economic Constraints	Cost of practicing some techniques	2.36	0.74
	Financial problem	2.34	0.75
Societal & Behavioral Constraints	Farmers preference	2.43	0.75
	Societal beliefs	2.21	0.80
	Failure from experience of some practices	2.28	0.77

Source: Field Survey, 2025

Table 6 presents the regression analysis results showing the effects of various socioeconomic factors and climate-smart agriculture variables on monthly vegetable farming profit in Egbeda, Oyo State. The model yielded an R-value of 0.392 and an R^2 of 0.155, indicating that approximately 15.5% of the variation in farming profit was explained by the independent variables included in the model. The F-statistic (F = 3.123) confirms the model's statistical significance at the 5% level.

Among the predictors, three variables significantly influenced monthly profit. First, size of farmland exhibited a strong positive and statistically significant relationship with income ($\beta = 1.581$, $p = 0.005$), suggesting that access to more land correlates with increased output and earnings (Daudu *et al.*, 2022). This aligns with expectations, as larger landholdings typically allow for more diversified and intensive vegetable production.

Second, membership in farmer associations had a significant positive effect ($\beta = 0.926$, $p = 0.046$). This implies that social capital, access to group resources, shared knowledge and cooperative marketing, enhances income generation among vegetable farmers (Adéchian *et al.*, 2022). Similarly, access to information on climate-smart agriculture practices also showed a positive and significant effect on profit ($\beta = 0.737$, $p = 0.042$), reinforcing the role of awareness and timely knowledge in supporting profitable and resilient farming practices (Arowosegbe *et al.*, 2024).

Conversely, variables such as age ($\beta = 0.201$, $p = 0.489$), household size ($\beta = 0.279$, $p = 0.535$), years of farming experience ($\beta = 0.013$, $p = 0.671$) and adoption of climate-smart agriculture practices ($\beta = 1.225$, $p = 0.366$) were not statistically significant, although their coefficients suggest a generally positive trend. Notably, the climate-smart agriculture adoption variable, while not significant, showed a positive beta value, indicating potential benefits to income that may become more evident with long-term adoption or improved implementation quality (Odunaiya *et al.*, 2021).

These findings are partially consistent with Mukaila *et al.*, (2021), who also identified land size and association membership as critical income determinants in smallholder farming. However, unlike Mukaila *et al.*'s study where climate-smart agriculture adoption directly influenced profit, the current results suggest a weaker direct income effect from climate-smart agriculture practices. This divergence may stem from contextual differences in crop type, scale of operation, or farmer education levels.

Overall, the analysis call attention to the importance of resource access (land), institutional support (associations) and effective information flow in enhancing profitability. While climate-smart agriculture practices are recognized and practiced among respondents, their income-enhancing potential may be limited by adoption intensity, input availability, or technical barriers, warranting targeted support for improved uptake and effectiveness.

Table 6. Effect of Socioeconomic Factors and Climate-Smart Agricultural Practices on Monthly Vegetable Farming Profit

Variables	β	t	Sig.
(Constant)	-1.052	-0.504	0.615
Age	0.201	0.694	0.489
Household	0.279	0.621	0.535
Years of farming experience	0.013	0.425	0.671
Size of farmland	1.581	2.869	0.005
Membership of association	0.926	2.018	0.046
Sources of Information on Sustainable Climate-Smart Agricultural Practices	0.737	1.754	0.042
Constraints to Adoption of Sustainable Climate-Smart Agricultural Practices	0.168	0.319	0.751
Adoption of Sustainable Climate-Smart Agricultural Practices	1.225	0.907	0.366
R value	0.392		
R Square	0.155		
Adjusted R Square	0.106		
F value	3.123		

Dependent Variable: Monthly Vegetable Farming Profit (per 10,000 Naira)

Source: Field Survey, 2025

5. Discussion

The findings of this study highlight the critical role of socioeconomic characteristics and climate-smart agriculture practices in shaping the profitability and sustainability of smallholder vegetable farming in Egbeda, Oyo State. The results reveal a predominantly male farming population, a pattern that aligns with the persistent gender imbalance reported in southwestern Nigeria, where men often dominate land-based production due to cultural norms and differential access to productive resources (Saka & Adebiyi, 2021; Olowoyo et al., 2023). This gender skew suggests that women, despite their contributions to marketing and processing activities, remain underrepresented in core farming operations, a gap that may limit the sector's inclusive development potential.

The concentration of farmers within the 31–40 years age bracket indicates a relatively young, active and economically productive population, consistent with findings by Fola et al., (2021) and Okafor & Adeyemi, (2025), who observed that youth engagement is increasingly vital for agricultural transformation in peri-urban Nigeria. Younger farmers are often more open to innovation and technology adoption, including climate-smart agriculture practices, although their adoption decisions are still influenced by access to resources, credit and training opportunities. The low educational attainment observed among respondents, with over one-third having no formal education, reinforces the need for extension communication strategies that are culturally and linguistically adapted to reach farmers with limited literacy (Yuldashova, 2024).

The predominance of small-scale operations, as evidenced by the high proportion of farmers cultivating one hectare or less, reflects a typical feature of Nigeria's vegetable subsector, which is constrained by land fragmentation, insecure tenure and limited access to inputs (Liverpool-Tasie et al., 2025). Despite these constraints, most respondents demonstrated awareness and partial adoption of climate-smart agriculture practices. High adoption levels of crop rotation, mulching, improved seeds and soil conservation indicate that farmers recognize the importance of practices that enhance soil fertility and reduce vulnerability to climatic shocks. These findings align with the reports of Adesida et al., (2021); Ahuchaogu et al., 2022 and Akinnagbe & John, (2023), who documented similar patterns of climate-smart agriculture uptake among smallholder farmers in southern Nigeria. The results suggest a gradual diffusion of sustainability-oriented innovations, although the intensity and consistency of adoption may vary across practices due to technical or financial constraints.

Information access emerged as a key enabler of climate-smart agriculture adoption and profitability. Farmers relied heavily on diverse information channels, particularly agro-input stores, mass media and interpersonal networks, to acquire knowledge on sustainable practices. This multi-channel pattern corroborates Lara-Llanderal et al., (2025), who emphasized that information dissemination in peri-urban agrarian settings often occurs through hybrid communication networks rather than formal extension alone. The significant role of commercial outlets, such as agro-stores, implies that market-based actors are increasingly functioning as informal knowledge brokers, thereby complementing conventional extension systems. Strengthening such hybrid networks can accelerate innovation diffusion and improve farmers' adaptive capacities.

Perceptions of climate-smart agriculture benefits were overwhelmingly positive, reflecting a high level of appreciation for its environmental, economic and agronomic impacts. Respondents associated climate-smart agriculture adoption with reduced agrochemical use, improved soil structure, enhanced productivity and better adaptation to climate variability. These perceptions are consistent with Alhassan & Haruna, (2024), who found that smallholder farmers in Nigeria perceived climate-smart agriculture as a multifaceted strategy that simultaneously enhances soil health, yields and resilience. The observed appreciation of climate-smart agriculture's economic and ecological benefits reinforces the argument that farmers are not merely profit-driven but also environmentally conscious when the long-term benefits of sustainable practices are evident (Wang & Matsumoto, 2025).

However, adoption remains constrained by several interrelated barriers. Resource and infrastructure deficiencies, particularly inadequate facilities, poor extension contacts and limited materials were among the most prominent. These findings echo Jellason et al., (2021) and Olarewaju et al., (2025), who identified infrastructural deficits and weak institutional linkages as major impediments to climate-smart agriculture scaling in rural Nigeria. Economic constraints such as the high cost of inputs and techniques also deterred adoption, accentuating the need for financial inclusion mechanisms and government-supported incentives that can reduce the initial cost burden of sustainable transitions. Behavioral and societal barriers, including skepticism and entrenched traditional beliefs, further highlight the importance of participatory extension models that build trust and demonstrate practical results to farmers.

The regression analysis provides deeper insights into the determinants of profitability among vegetable farmers. Land size emerged as a significant positive predictor, indicating that access to larger holdings enhances production scale, resource utilization efficiency and income generation. This finding supports the observations of Debie & Ayele, (2023) and Amede et al., (2023), who found landholding size to be one of the strongest determinants of farm profitability and livelihood resilience in smallholder systems. Membership in farmer associations also significantly influenced income, confirming the value of collective action and social capital in improving market access, sharing information and reducing transaction costs (Kehinde et al., 2021 and Ankrah Twumasi et al., 2021). Similarly, access to climate-smart agriculture information significantly affected profit, suggesting that knowledge diffusion remains a crucial pathway for translating sustainable practices into measurable economic outcomes (Sardar et al., 2021).

Although the direct effect of climate-smart agriculture adoption on profit was positive but not statistically significant, this outcome may be attributed to several contextual factors. First, climate-smart agriculture benefits are often realized over time rather than immediately, particularly for soil-related practices such as mulching and organic fertilization (Tóth et al., 2025). Second, the quality and consistency of adoption vary; partial or improper implementation can reduce observable financial returns in the short term (Tsuma, 2025). Third, the relatively low average farm income and small production scale may mask the full profitability potential of climate-smart agriculture innovations. These nuances suggest that climate-smart agriculture adoption, while essential for long-term resilience, may require supportive measures, such as training, credit access and input subsidies, to yield immediate financial rewards.

Theoretically, the results reinforce the sustainable livelihoods framework, which posits that access to assets, natural (land), social (associations), human (knowledge) and financial (income), determines adaptive capacity and livelihood outcomes (Sargani et al., 2023). In practical terms, this study illustrates how social networks and information flow serve as mediating factors linking resource endowment and profitability. From a policy perspective, the findings emphasize the need for integrated extension systems that leverage both public and private communication channels, alongside enabling policies that enhance land access, farmer organization and digital information dissemination.

As a whole, this study contributes empirical evidence that emphasizes the intertwined roles of socioeconomic attributes, institutional participation and information access in determining both the adoption and profitability outcomes of climate-smart agricultural practices. Strengthening these linkages through targeted policy interventions, such as farmer cooperatives, input support schemes and climate adaptation training, can significantly enhance the economic viability and sustainability of smallholder vegetable farming in peri-urban Nigeria.

6. Conclusions

This study examined the influence of socioeconomic characteristics and climate-smart agriculture practices on the profitability of vegetable farming in Egbeda Local Government Area, Oyo State, Nigeria. The findings revealed that while the majority of farmers were male, relatively young and operating on small landholdings, there was a growing adoption of climate-smart agriculture practices such as crop rotation, mulching and the use of improved seeds. This reflects increasing awareness of sustainable production systems among smallholder farmers, aligning with broader trends in Sub-Saharan Africa.

Regression analysis showed that land size, association membership and access to climate-smart agriculture-related information significantly influenced monthly farm profit. These factors give emphasis to the critical role of resource access, institutional participation and knowledge flow in improving farm-level outcomes. While climate-smart agriculture adoption showed a positive, though statistically non-significant, relationship with profit, this suggests that the financial benefits of climate-smart agriculture may take time to materialize or depend on complementary factors such as adequate inputs, technical support and consistent market access.

Theoretically, the study contributes to the empirical discourse on climate-smart agriculture adoption by highlighting how socioeconomic and institutional variables interact to shape profitability outcomes within semi-urban agricultural systems. Practically, it reinforces the need for inclusive, knowledge-driven and resource-supported interventions that can bridge the gap between sustainability and economic viability for smallholder farmers.

Nevertheless, the study had some limitations. First, it relied on cross-sectional data, which limits causal inference about the long-term effects of climate-smart agriculture practices on profitability. Second, self-reported income data may be subject to recall bias. Future research should employ panel data or experimental designs to capture dynamic adoption patterns, profitability trajectories and environmental impacts. Additionally, future studies could explore gendered differences in climate-smart agriculture adoption and assess how digital technologies or cooperative networks mediate information and market access.

Based on the study findings, the following recommendations are proposed to strengthen climate-smart vegetable production and improve farmer welfare:

1. Enhance Access to Land and Inputs: Government and development agencies should design policies that facilitate smallholders' access to productive land, improved seeds and climate-smart agriculture-compatible inputs through credit schemes and land tenure reforms.
2. Strengthen Farmer Associations and Cooperatives: Given the positive impact of association membership on profitability, capacity-building programs should focus on strengthening local farmer groups for collective input procurement, information sharing and market linkages.
3. Expand climate-smart agriculture Extension and Training Services: Agricultural extension systems should integrate climate-smart agriculture modules into regular outreach programs, emphasizing practical demonstrations and peer learning to improve adoption quality and consistency.
4. Promote Multi-Channel Information Dissemination: Since multiple communication platforms, such as agro-stores, radio and neighborhood networks, were effective in this study, policymakers should support blended communication strategies that combine interpersonal, mass media and digital approaches.

5. Incentivize Sustainable Practices: Subsidies, tax rebates, or certification programs could encourage wider adoption of environmentally friendly practices, aligning with Nigeria's Climate Change Act (2021) and Sustainable Development Goals (SDG 2: Zero Hunger; SDG 13: Climate Action).
6. Encourage Participatory Policy Development: Policymakers should involve farmers and local institutions in designing climate-smart agriculture policies to ensure contextual relevance and sustainability of implementation outcomes.

In all, integrating climate-smart agriculture practices into smallholder vegetable farming in Egbeda and similar agroecological zones holds substantial potential for enhancing productivity, resilience and profitability. However, these gains can only be fully realized when institutional support, access to resources and effective knowledge dissemination systems are strengthened in alignment with national and global sustainability frameworks.

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