
Exploring the Role of Smallholder Farmers and Technology Adoption for Agricultural Value Chain Development and Food Security in South Eastern Nigeria

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ABSTRACT

Smallholder farmers form the bedrock of Nigeria's agricultural sector, contributing substantially to crop output despite limited landholdings, capital constraints, and uneven participation along agricultural value chains. Improving smallholder productivity through technology adoption therefore remains central to rural livelihoods, agricultural modernization, and sustainable food security in South-Eastern Nigeria. This study aimed to determine the role of training and extension services in improving food utilization, examine how access to credit and finance enhances market linkages, and evaluate how perceived benefits of technology contribute to food supply stability among smallholder farmers. A descriptive survey design was adopted, covering Abia, Anambra, Ebonyi, Enugu, and Imo states. Data were collected from 388 registered farmers using structured questionnaires and key-informant interviews, and analysed using descriptive statistics, regression, ANOVA, correlation, and food security index computations. Results revealed that training and extension services significantly improved food utilization, access to credit and finance significantly strengthened market linkages, and perceived benefits of technology significantly enhanced the stability of food supply among smallholder farmers. The study concludes that technology adoption, supported by human capacity development, financial inclusion, and positive farmer perceptions, is critical to strengthening agricultural value chains and achieving sustainable food security in South-Eastern Nigeria. Based on these findings, the study recommends strengthening extension systems through practical and technology-focused training, expanding affordable and farmer-friendly credit schemes, and intensifying awareness programmes that clearly demonstrate the tangible benefits of agricultural technologies for consistent production and stable food supply outcomes for farming households and regional development goals sustainability.

Keywords: Smallholder farmers; Technology adoption; Agricultural value chain; Food security; South-Eastern Nigeria

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1. INTRODUCTION

Smallholder farmers form the bedrock of Nigeria's agricultural sector, where they contribute a large share of crop output despite limited landholdings and capital constraints (Onomu & Aliber, 2023). Farm size, education level, access to finance, and cooperative membership significantly influence how effectively farmers participate across the agricultural value chain, from production to marketing and income generation (Ogunjobi, 2024). Understanding this role is crucial because improving smallholder productivity remains central to livelihood enhancement and rural economic development. Concurrently, technology adoption is vital to agricultural modernization and food security. Yet many Nigerian smallholders show low adoption of improved seeds, mechanization, and digital tools due to weak extension services, high costs, and limited awareness (Achukwu, Sennuga, Alabuja, & Barnabas, 2023). Evidence indicates adopters achieve higher yields, efficiency, and resilience to climate variability (Amankwah, 2023). These gains enhance food availability, supply stability, and nutritional outcomes (Adewumi & Ogunniyi, 2021). This study examines interactions shaping agricultural value chains and food security.

1.1 Statement of the Problem

Despite their importance to Nigeria's agricultural economy, smallholder farmers in South-Eastern Nigeria face challenges that limit participation in value chain development. Many operate on small plots, lack credit access, have limited education, and remain outside cooperatives (Nazifi, Mgbenka, & Ezeano, 2021). These constraints reduce efficiency, hinder processing and storage, and restrict market integration, weakening income potential and value chain growth. Simultaneously, technology adoption remains low. Weak extension services, high input and digital tool costs, and low awareness are major barriers (Food Security Insights, 2025). Without training, support, and incentives, farmers hesitate to adopt improved seeds, digital applications, and mechanized practices, despite evidence of yield gains and risk reduction (Kolapo & Didunyemi, 2024). The outcome is unstable availability, affordability, and supply. Existing studies often treat these issues separately, creating a gap. This study addresses this gap by analyzing how farm characteristics and technology perceptions jointly influence efficiency, market linkages, and resilience.

1.2 Objectives of the Study

The main objective of this study was to investigate how the role of smallholder farmers and adoption of technology can be utilized for agricultural value chain development and food security in the South Eastern Nigeria. The specific objective was to:

- i) determine the role of training and extension services in improving the utilization of food through enhanced nutrition and crop management practices among smallholder farmers.
- ii) explore the role of access to credit and finance in enhancing market linkages for smallholder farmers.
- iii) evaluate how perceived benefits of technology contribute to the stability of food supply in South Eastern Nigeria

1.3 Research Questions

- (i) What is the role of training and extension services in enhancing food utilization among smallholder farmers in South-Eastern Nigeria?
- (ii) How does access to credit and finance influence market linkages for smallholder farmers in South-Eastern Nigeria?

- (iii) How do perceived benefits of technology affect the stability of food supply in South-Eastern Nigeria?

1.4 Research Hypotheses

- H₁: Training and extension services do not significantly improve food utilization among smallholder farmers in South-Eastern Nigeria.
- H₂: Access to credit and finance does not significantly affect market linkages for smallholder farmers in South-Eastern Nigeria.
- H₃: Perceived benefits of technology do not significantly contribute to the stability of food supply.

2. LITERATURE REVIEW

2.1 Role of Smallholder Farmers

Smallholder farmers are not just subsistence cultivators — they are central actors in agricultural value chains. Their contributions extend from food production to market participation, post-harvest handling, and even local-level processing (Mgbenka & Mbah, 2022). These farmers often form the foundation of rural economies, using their limited land and labour resources to generate both food and income, despite facing structural and institutional challenges (Fadeyi et al., 2022). In contexts like Nigeria, smallholder farmers' engagement in cooperatives or farmer-based organizations amplifies their collective bargaining power, enabling better access to markets and extension services (Salisu, 2022). Moreover, these roles carry social significance: smallholders sustain rural communities, contribute to food stability in their regions, and can act as agents of rural development and innovation when supported by policy and development initiatives. Their dual identity (as providers of household food and contributors to market flows) makes them uniquely positioned to impact both value chain growth and food security.

2.2 Technology Adoption

Technology adoption is the process by which individuals, organizations, or societies accept, integrate, and use technologies to improve efficiency and productivity. It is shaped by economic factors influencing acceptance or rejection. Rogers' Diffusion of Innovation theory explains adoption through stages of knowledge, persuasion, decision, implementation, and confirmation, guided by attributes such as relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2023). In organizations, the Technology Acceptance Model identifies perceived usefulness and ease of use as drivers shaping attitudes and intentions (Davis, 2021). Adoption is further influenced by social influence, facilitating conditions, and organizational readiness (Venkatesh et al., 2022). Economic factors—cost, affordability, and expected returns—are critical. In developing countries, infrastructure, literacy, and socio-cultural factors affect technology engagement (Adeola & Evans, 2021).

2.3 Training and Extension Services

Extension services provide vital technical information, capacity building, and direct support to smallholder farmers, helping them adopt sustainable and more productive farming practices (Salisu, 2022). Effective extension bridges the knowledge gap between research institutions and farm-level realities, offering tailored advice for local contexts. In regions where extension reach is weak, farmers report lower uptake of recommended technologies and practices (Abdullahi, 2020).

Training, when combined with consistent follow-up, builds farmer confidence, enhances understanding of innovations, and increases the likelihood of long-term adoption. Therefore, extension and training are not just inputs – they are catalysts for sustainable technology diffusion and improved farm performance.

2.4 Access to Finance

Financial capital is a major enabler for smallholder farmers. Without access to credit, many farmers cannot afford to purchase improved inputs, mechanize operations, or adopt new technologies (Ogebe & Ogah, 2024). Empirical studies have shown that credit availability (both formal and informal) significantly affects the adoption of sustainable farming practices (Abdullahi, 2020). Moreover, mobile financial services are emerging as crucial tools to bridge the financial inclusion gap: smallholders using such services can more easily borrow, manage risks, and invest in their farms (Aliu, 2023). However, collateral requirements, high interest rates, and weak institutional frameworks remain formidable barriers, especially for the poorest smallholders.

2.5 Perceived Benefits of Technology

Perception is important in determining whether smallholder farmers adopt new technologies. When farmers believe that a technology will increase yield, reduce labour, or improve income, they are more likely to try it. For instance, smallholders' perceptions of digital agricultural tools (cost, ease of use, and local relevance) strongly influence their willingness to adopt (Maxwell & Smith, 2023). Behavioural and social factors, such as trust in the technology, risk perception, and peer influence, play substantial roles in adoption decisions (Frontiers, 2025). Thus, even where technology is technically available, the perceived benefits (or risks) ultimately shape uptake. Understanding and improving these perceptions through user-centered design, demonstration, and participatory training is critical for successful diffusion.

2.6 Agricultural Value Chain Development

Agricultural value chain development involves improving production, processing, distribution, and marketing activities to enhance efficiency, competitiveness, and incomes. It strengthens linkages among farmers, input suppliers, processors, traders, and consumers to promote value addition at each stage (Kaplinsky & Morris, 2021). Well-developed chains raise productivity through better inputs, technology adoption, and market access, enabling profitable smallholder participation (Donovan et al., 2024). Development also emphasises upgrading through quality improvement, process innovation, and functional shifts that allow actors capture greater value (Gereffi & Fernandez-Stark, 2023). Public-private partnerships support infrastructure, credit, and market information, reducing transaction costs and competitiveness constraints (Trienekens, 2022). In developing economies, targeted interventions generate employment and reduce poverty for smallholders (Stoian et al., 2023). Overall, value chain development improves coordination.

2.7 Food Security

Food security exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets dietary needs and preferences for healthy lives (FAO, 2020). It rests on four pillars: availability, access, utilization, and stability (Barrett, 2023). Achieving food security requires adequate production, efficient distribution, and household purchasing power. In developing regions, climate variability, weak infrastructure, market volatility, and socio-economic inequality remain key constraints (Pingali, 2024).

Sustainable practices, including improved seeds, efficient irrigation, and climate-smart technologies, increase availability and reduce shocks (Lipper et al., 2021). Supportive policies that enhance rural livelihoods, safety nets, and equitable market access strengthen outcomes (Timmer, 2024).

2.8 Food Utilization

Food utilization refers to the biological and nutritional use of food by the body, which depends on adequate diet quality, proper food preparation, health status, and sanitation conditions (Maxwell & Smith, 2020). It emphasizes not just the availability of food, but the ability of individuals to consume and metabolize nutrients effectively for growth, energy, and overall well-being. Adequate utilization requires access to diverse and nutrient-rich foods, safe drinking water, and good hygiene practices that prevent foodborne illnesses (Ruel, 2023). Health factors such as infections, intestinal parasites, and chronic illnesses often reduce nutrient absorption, making food utilization a critical dimension of food security (Victora, 2023). Nutrition education also plays a key role, as households must understand safe food handling, balanced diets, and appropriate feeding practices to ensure adequate utilization (Kennedy et al., 2021). Improving food utilization contributes to better health outcomes, reduced malnutrition, and enhanced productivity, particularly in vulnerable groups such as children and pregnant women.

2.9 Market Linkages

Market linkages refer to the connections between farmers and markets that enable the efficient flow of agricultural goods, information, and services across the value chain. Strong market linkages help farmers access buyers, negotiate better prices, and reduce transaction costs (Barrett, 2021). These linkages include relationships with wholesalers, processors, retailers, aggregators, and export markets, supported by institutions such as cooperatives and contract farming arrangements (Poulton et al., 2022). Effective market linkages improve farmers' ability to commercialize production, participate in value-added activities, and respond to market signals regarding quality standards and consumer preference (Markelova et al., 2022). Infrastructure (roads, storage facilities, and communication networks) also plays a vital role in connecting farmers to markets and reducing post-harvest losses. In developing regions, strengthening market linkages is essential for integrating smallholder farmers into competitive markets, stimulating rural income growth, and reducing poverty.

2.10 Stability of Food Supply

Stability of food supply refers to the consistency of food availability and access over time, without significant disruptions caused by economic, environmental, or political shocks. It ensures that households are not vulnerable to seasonal variability, market price fluctuations, or climate-induced production declines (Timmer, 2022). Food supply stability depends on factors such as effective storage systems, diversified production, robust market networks, and strategic grain reserves (Gilbert & Morgan, 2024). Climate variability (droughts, floods, and extreme temperatures) poses a major threat to food stability, making climate-resilient agriculture crucial (Morton, 2023). Additionally, economic shocks such as inflation, input price volatility, and global commodity crises can destabilize food systems and compromise household food access (Headey & Fan, 2022). Social protection mechanisms (including insurance, safety nets, and emergency food assistance) help buffer households against these shocks and support long-term food system resilience.

2.11 Theoretical Review

This study is anchored on Agricultural Innovation Systems (AIS) Theory, which explains agricultural development as an outcome of interactions among farmers, extension services, financial institutions, markets, and technology providers. AIS recognize smallholder farmers as active innovators whose access to training, credit, and supportive institutions shapes technology adoption, market participation, and food security outcomes (Klerkx, Begemann, & Scott, 2021). The theory aligns closely with the study objectives by linking extension services to improved food utilization, financial access to stronger market linkages, and farmers' perception of technology benefits to food supply stability. AIS are best suited because it integrates behavioural, institutional, and value-chain perspectives needed to explain food security dynamics in South-Eastern Nigeria.

2.12 Empirical Review

Training and Extension Services and Food Utilization

Empirical work links extension/training to improved food-use and nutrition outcomes among smallholders. Adeyemi (2023) assessed nutrition capacity within extension systems using qualitative interviews and surveys, concluding that integrating nutrition into extension increases household knowledge and use of diverse foods but requires capacity building and institutional coordination. A study on integrating nutrition into agricultural extension (Spring Journals study) used household surveys and impact analysis to show that households receiving nutrition-oriented extension exhibited higher Food Consumption Scores and better child feeding practices, concluding that nutrition-sensitive extension enhances food utilization (Arising studies, 2021). Suvedi (2023) reviewed extension training needs and found that strengthened extension competencies (including nutrition counseling) improve farmers' adoption of improved crop and post-harvest practices, thereby contributing to diet quality.

2.13 Access to Credit and Finance and Market Linkages

Research in Nigeria and West Africa underscores the centrality of finance and market linkages for smallholders. Shima (2023) assessed how credit and financial services affect marketing of farm produce via surveys and policy analysis, reporting that credit scarcity impedes timely harvesting and aggregation, weakening producers' bargaining position and market access. Recent reviews (Uche, 2024) highlight public programs (like NIRSAL) as partial mitigators but note implementation gaps and risk perceptions by lenders. Overall, empirical evidence indicates that access to affordable credit combined with strengthened market linkages (aggregation, information, transport) is crucial for enabling smallholders to adopt productivity-enhancing technologies and integrate into value chains.

2.14 Perceived Benefits of Technology and Stability of Food Supply

Studies investigating the perceived benefits of agricultural technology adoption show positive associations with household food security and supply stability. Anser (2021) analyzed ICT adoption and governance effects across developing countries and found that ICT adoption positively and significantly increases measured food security indicators; their econometric panel study concluded that a 1% rise in ICT adoption could raise food security by double digits, but noted governance as an important moderator. Akpabio (2025) reviewed e-agriculture in developing countries and reported qualitative and quantitative evidence that digital tools (price info, weather advisory) improve farmer decision making and can stabilise supply when adoption is widespread and supported by extension infrastructure.

However, these studies highlight that perceived benefits translate to supply stability only when adoption is sustained and accompanied by credit, storage and market access; otherwise, benefits remain farm-level and limited in system-wide impact.

2.15 Gaps in the Literature

Existing studies often examine smallholder farmers' constraints or technology adoption separately, rarely linking both to value chain development and food security outcomes. Evidence on how training, extension, credit access, and farmers' benefit perceptions jointly influence market linkages and food supply stability across South-Eastern Nigeria remains limited. Few studies integrate household food security indices with value chain analysis at sub regional level.

3. METHODOLOGY

The study adopts a descriptive survey design to examine smallholder farmers' contributions and technology adoption effects on agricultural value chain development and food security in South-Eastern Nigeria. The area covers Abia, Anambra, Ebonyi, Enugu and Imo states, dominated by cassava, yam, rice and vegetable farming. The population comprises 12,480 registered farmers from ADP records. Using Yamane's (1967) formula $n = N/(1+N(e^2))$, with $N=12,480$ and $e=0.05$, a sample of 388 was selected. Multistage sampling involved purposive state selection, random LGAs, and systematic sampling of farmers. Data were gathered via structured questionnaires and key-informant interviews. Analysis employed descriptive statistics, regression, ANOVA, correlation, food security index computation, using SPSS software for data analysis.

3.1 Data Presentation and Analysis

Descriptive Statistics of Responses on Cultural Factors

Table 1: Descriptive Statistics of Smallholder Farmers and Technology Adoption Factors

S/N	Descriptive	Mean	Std. Deviation
Training and Extension Services: Please Rate your business based on the following items:			
1	Frequency of extension visits	4.01	1.093
2	Access to agricultural training programmes	4.45	1.331
3	Relevance of training content	4.46	1.309
4	Method of extension delivery	4.57	1.201
5	Farmer satisfaction with extension services	4.48	1.331
Access to Finance: Please Rate your business based on the following items:			
1	Access to informal financing sources	4.68	1.249
2	Availability of formal credit	4.73	1.196
3	Amount of credit obtained	4.51	1.386
4	Timeliness of fund disbursement	4.48	1.253
5	Affordability of interest rates	4.36	1.403

Perceived Benefits of Technology: Please Rate your business based on the following items:

1	Perceived yield improvement	4.76	1.221
2	Perceived cost reduction	4.48	1.453
3	Perceived labour efficiency	4.69	1.260
4	Perceived risk reduction	4.55	1.302
5	Perceived income enhancement	4.57	1.462

From Table 1, respondents agreed with most of the items measuring training and extension services as an aspect of smallholder farmers and technology adoption factors (frequency of extension visits, access to agricultural training programmes, relevance of training content, method of extension delivery, and farmer satisfaction with extension services).

Amongst the items used to measure training and extension services, the respondents gave more attention to method of extension delivery as an important smallholder farmers and technology adoption factor. This suggests that how extension services are delivered critically influences smallholder farmers' technology adoption decisions.

Also, respondents agreed with most of the items measuring access to finance as an aspect of technology adoption factors (access to informal financing sources, availability of formal credit, amount of credit obtained, timeliness of fund disbursement, and affordability of interest rates). Amongst the items used to measure access to finance, the respondents gave more attention to availability of formal credit as an important technology adoption factor. This suggests that formal credit availability seriously influence farmers' technology adoption decisions.

Again, respondents agreed with most of the items measuring perceived benefits of technology as an aspect of smallholder farmers and technology adoption factors (perceived yield improvement, perceived cost reduction, perceived labour efficiency, perceived risk reduction, and perceived income enhancement). Amongst these items, the respondents gave more attention to perceived yield improvement as an important technology adoption factor. This suggests that yield improvement immensely motivates farmers' adoption of new technologies.

Table 2: Descriptive Statistics of Agricultural Value Chain Development and Food Security

S/N	Descriptive	Mean	Std. Deviation
Food Utilization: Please Rate your centre based on the following items			
1	Dietary diversity	4.18	1.019
2	Food preparation practices	4.75	1.307
3	Nutritional knowledge	4.92	1.127
4	Safe food handling practices	4.88	1.154
5	Household food consumption patterns	4.78	1.250

Market Linkages: Please Rate your centre based on the following items

1	Access to output markets	4.71	1.113
2	Number of regular buyers	4.56	1.297
3	Access to market price information	4.67	1.229
4	Participation in farmer groups/cooperatives	4.61	1.265
5	Reliability of market channels	4.93	1.149

Stability of Food Supply: Please rate your centre based on the following items

1	Consistency of food production across seasons	4.83	1.255
2	Storage capacity and practices	4.70	1.235
3	Ability to cope with supply shocks	4.81	1.194
4	Price stability of food commodities	4.58	1.265
5	Diversification of food sources	4.65	1.146

From Table 2, respondents agreed with most of the items measuring food utilization as an aspect of agricultural value chain development and food security (dietary diversity, food preparation practices, nutritional knowledge, safe food handling practices, and household food consumption patterns). Amongst the items used to measure food utilization, the respondents gave more attention to nutritional knowledge as an important factor that smallholder farmers consider in value chain and food security. This suggests that nutritional knowledge immensely influences food utilization and security outcomes among farmers.

Again, respondents agreed with most of the items measuring market linkages as an aspect of agricultural value chain development and food security (access to output markets, number of regular buyers, access to market price information, participation in farmer groups/cooperatives, and reliability of market channels). Amongst the items, the respondents gave more attention to reliability of market channels as an important factor that farmers consider for value chain development and food security. This suggests that reliable market channels critically influence value chain and food security.

Also, respondents agreed with most of the items measuring stability of food supply as an aspect of value chain development and food security (consistency of food production across seasons, storage capacity and practices, ability to cope with supply shocks, price stability of food commodities, and diversification of food sources). Amongst the items used to measure stability of food supply, the respondents gave more attention to consistency of food production across seasons as an important factor that farmers consider for value chain development and food security. This suggests that seasonal production underpins value chain development and food security.

3.2 Hypotheses Testing

Hypothesis One: Training and extension services do not significantly improve food utilization among smallholder farmers in South-Eastern Nigeria.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.777 ^a	0.754	0.754	0.24407

- Predictors: (Constant), Training and extension services
Source: Researcher's Field Result (2025)

This table illustrates the extent that the model accounts for variation in the dependent variable, food utilization. In this model summary, the R square value is 0.777, indicating that 77.7% of the variance in food utilization can be explained to differences in training and extension services.

ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	406.077	1	406.077	6816.521	0.000
	Residual	19.540	328	0.060		
	Total	425.617	329			

- Dependent Variable: Food Utilization
- Predictors: (Constant), Training and extension services
Source: Researcher's Field Result (2025)

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.678	0.053		12.824	0.000
	Training and extension services	0.702	0.011	0.777	82.562	0.000

- Dependent Variable: Food Utilization
Source: Researcher's Field Result (2025)

This table highlights the variables in the model significantly contribute to predicting the dependent variable, food utilization. The coefficients table shows the expected change in the dependent variable for each one-unit change in the independent variable. In this case, the unstandardized beta coefficient for training and extension services is $\beta = 0.702$, indicating that an increase in training and extension services among registered smallholder farmers is associated with a 0.702 increase in food utilization. This suggests that training and extension services strongly influence food utilization. Additionally, the relationship between training and extension services and food utilization is statistically significant, as indicated by the (t-value= 82.562, P-value= 0.000).

These results meet the criteria of statistical significance P-value below the 0.05 significance level and T-value above the threshold of 1.96. This confirms a positive and significant impact of training and extension services on food utilization.

Decision:

Based on the analysis above, the result shows that the t-value = 82.562 is more than 1.96 and its significant level, $p = 0.00$ is less than 0.05. This implies that the null, which states that training and extension services do not significantly improve food utilization among smallholder farmers in South-Eastern Nigeria, is rejected. Therefore, alternative hypothesis which states that training and extension services do significantly improve food utilization among smallholder farmers is accepted.

Hypothesis Two: Access to credit and finance does not significantly affect market linkages for smallholder farmers in South-Eastern Nigeria.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.791 ^a	0.782	0.782	0.16172

a. Predictors: (Constant), Access to credit and finance

Source: Researcher's Field Result (2025)

This table illustrates how the model accounts for variation in the dependent variable, market linkages. Here, the R-squared value is 0.791, indicating that 79.1% of the variance in market linkages can be explained by differences in access to credit and finance.

ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	466.365	1	466.365	17831.426	0.000 ^b
	Residual	8.579	328	0.026		
	Total	474.944	329			

- Dependent Variable: Market Linkages
- Predictors: (Constant), Access to credit and finance

Source: Researcher's Field Result (2025)

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.313	0.034		9.235	0.000
	Values	0.739	0.007	0.791	93.534	0.000

Ditto

This table highlights that the variables in the model significantly contribute to predicting the dependent variable, market linkages. The coefficients table shows the expected change in the dependent variable for each one-unit change in the independent variable. Here, the unstandardized beta coefficient for market linkages is $\beta = 0.739$, indicating that an increase in access to credit and finance among smallholder farmers is associated with a 0.739 increase in market linkages. This suggests that access to credit and finance play a critical role in affecting the market linkages of value chain development and food security. Additionally, the relationship between access to credit and finance and market linkages is statistically significant, as indicated by the (t-value= 93.534, P-value= 0.000). These results meet the criteria of statistical significance p-value below the 0.05 significance level and a t-value above the threshold of 1.96. This confirms a positive and significant impact of access to credit and finance on market linkages.

Decision:

Based on the analysis above, the result shows that the t-value = 93.534 is more than 1.96 and its significant level, P= 0.00 is less than 0.05. This implies that the null, which states that access to credit and finance does not significantly affect market linkages for smallholder farmers in South-Eastern Nigeria, is rejected. Therefore, alternative hypothesis which states that access to credit and finance does significantly affect market linkages for smallholder farmers in South-Eastern Nigeria, is accepted.

Hypothesis Three: Perceived benefits of technology do not significantly contribute to the stability of food supply.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.792 ^a	0.784	0.784	0.15674

a. Predictors: (Constant), Perceived benefits of technology

Source: Researcher's Field Result (2025)

This table illustrates how the model accounts for variation in the dependent variable, stability of food supply. In this model summary, the R square value is 0.792, indicating that 79.2% of the variance in stability of the food supply can be explained to differences in perceived benefits of technology.

ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	500.328	1	500.328	20366.214	0.000 ^b
	Residual	8.058	328	0.025		
	Total	508.386	329			

- Dependent Variable: Stability of the food supply
- Predictors: (Constant), Perceived benefits of technology

Source: Researcher's Field Result (2025)

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.331	0.032		10.346	0.000
	perceived benefits of technology	0.733	0.007	0.792	92.710	0.000

- Dependent Variable: Stability of food supply

Source: Researcher's Field Result (2025)

This table highlights the variables in the model that significantly contribute to predicting the dependent variable, stability of food supply. The coefficients table shows the expected change in the dependent variable for each one-unit change in the independent variable. In this case, the unstandardized beta coefficient for perceived benefits of technology is $\beta = 0.733$, indicating that an increase in perceived benefits of technology among smallholder farmers is associated with a 0.733 increase in stability of food supply. This suggests that perceived benefits of technology is critical in affecting the stability of food supply. Additionally, the relationship between perceived benefits of technology and stability of food supply is statistically significant, as indicated by the (t-value= 92.710, P-value= 0.000). These results meet the criteria of statistical significance p-value below the 0.05 significance level and a t-value above the threshold of 1.96. This confirms a positive and significant impact of perceived benefits of technology on stability of food supply

Decision:

Based on the analysis above, the result shows that the t-value = 142.710 is more than 1.96 and its significance level, P= 0.00 is less than 0.05. This implies that the null, which states that perceived benefits of technology do not significantly contribute to the stability of food supply in South-Eastern Nigeria, is rejected. Therefore, alternative hypothesis which states that perceived benefits of technology do significantly contribute to the stability of food supply in South-Eastern Nigeria, is accepted.

4. DISCUSSION OF RESULTS

This study explored farmers' role in technology adoption for agricultural value chain development and food security in South Eastern Nigeria. Three hypotheses were tested using regression analysis, and all were found to be statistically significant, indicating strong relationships between smallholder farmers and technology adoption and components of agricultural value chain development and food security.

Ho1: Training and extension services do not significantly have an effect on food utilization

The first hypothesis, which tested whether training and extension services significantly affects food utilization, was supported by the data. The results revealed that training and extension services had a strong positive effect on food utilization ($\beta = 0.702$, $p < 0.000$), with an R^2 value of 0.754, meaning 75.4% of the variance in food utilization is explained by training and extension services.

These findings align with the assertions of a scholar who emphasised that training and extension services is a fundamental element of technology adoption that strengthened extension competencies, improve farmers' adoption of improved crop and post-harvest practices (Suvedi, 2023).

Ho2: Access to credit and finance do not significantly have an effect on market linkages

The second hypothesis examined whether access to credit and finance significantly affect market linkages. The result was also statistically significant ($\beta = 0.739$, $p < 0.000$), with $R^2 = 0.782$, showing that 78.2% of the variation in market linkages is attributed to access to credit and finance. This finding is consistent with the work of a scholar who posited that credit scarcity impedes timely harvesting and aggregation, weakening producers' bargaining position and market access (Shima, 2023).

Ho3: Perceived benefits of technology do not significantly affect stability of food supply

The third hypothesis focused on the impact of perceived benefits of technology on stability of food supply, and again, the relationship was significant ($\beta = 0.733$, $p < 0.000$), with $R^2 = 0.784$. This suggests that perceived benefits of technology account for 78.4% of the variation in stability of food supply. This finding supports the works of scholars who argued that perceived benefits of technology plays a vital role in shaping consumption patterns, service expectations, and brand loyalty (Akpabio, 2025).

5. SUMMARY OF FINDINGS

The study found that training and extension services significantly enhance food utilization among smallholder farmers. Regression results showed strong positive influence, confirming that capacity-building initiatives strengthen technology adoption, improve crop and post-harvest practices, and support effective food use, consistent with technology adoption literature (Suvedi, 2023). The findings revealed that access to credit and finance significantly strengthens market linkages for smallholder farmers. Results showed a strong positive relationship, indicating that adequate financing improves harvesting, aggregation, bargaining power, and market access, thereby enhancing farmers' integration into value chains sustainably regionally (Shima, 2023). The study established that perceived benefits of technology significantly improve food supply stability. Findings showed a strong positive effect, suggesting that favourable perceptions encourage consistent production decisions, influence consumption patterns, and reinforce supply reliability, thereby supporting food security outcomes through perceived technological value (Akpabio, 2025).

6. CONCLUSION

This study concludes that technology adoption by smallholder farmers is critical to agricultural value chain development and food security in South-Eastern Nigeria. Training and extension services emerged as essential drivers of improved food utilization, as capacity-building enhances farmers' skills, promotes effective crop and post-harvest practices, and supports better household food use outcomes. Access to credit and finance was also decisive, as adequate financing strengthens market linkages by improving harvesting efficiency, aggregation capacity, bargaining power, and access to profitable markets.

Furthermore, farmers' perceived benefits of technology significantly contributed to food supply stability, as positive perceptions encourage consistent production decisions, reliable supply patterns, and sustainable food availability. Overall, the findings demonstrate that human capacity development, financial inclusion, and positive technology perceptions operate jointly to strengthen agricultural value chains. The study therefore concludes that policies promoting extension services, affordable agricultural credit, and awareness of technological benefits are vital for achieving long-term food security.

7. RECOMMENDATIONS

This study carried out in-depth research on smallholder farmers' technology adoption and food security through agricultural value chain development. From the findings of the research, the following recommendations were put forward:

- **Strengthening training and extension systems:** Government agencies, agricultural development programmes, and NGOs should intensify investment in regular, well-structured training and extension services for smallholder farmers. Extension delivery should be practical, technology-focused, and tailored to local farming realities, with emphasis on improved crop management, post-harvest handling, and food utilization practices. Strengthening extension personnel capacity and integrating digital extension platforms will further enhance farmers' technology adoption and efficient food use.
- **Expanding access to agricultural credit and finance:** Policymakers and financial institutions should design affordable, flexible, and farmer-friendly credit schemes targeted at smallholder farmers. Reducing collateral requirements, promoting cooperative-based lending, and linking credit access to market participation can improve farmers' harvesting capacity, aggregation, bargaining power, and market access, thereby strengthening market linkages within agricultural value chains.
- **Enhancing awareness of technological benefits:** Stakeholders should promote awareness campaigns, demonstrations, and success stories that clearly communicate the tangible benefits of agricultural technologies. By improving farmers' perceptions of technology value, adoption decisions will be more consistent, production planning more stable, and food supply reliability strengthened, ultimately supporting long-term food security outcomes.

8. CONTRIBUTION TO KNOWLEDGE

This study demonstrates how smallholder farmers' participation influences agricultural value chain development in South-Eastern Nigeria. By linking farm size, education, cooperative membership, and resource access to production efficiency and market integration, it highlights their strategic importance beyond cultivation. The findings provide evidence for policymakers and development partners to design interventions that enhance farmers' capacity to contribute effectively to value addition, improve income generation, and strengthen rural economies, bridging gaps in understanding smallholders' multifaceted roles in value chain performance. The research advances understanding of how technology adoption (improved seeds, mechanization, and digital tools) affects smallholder productivity, efficiency, and resilience. By examining farmers' perceptions, adoption barriers, and utilization patterns, it integrates socio-economic and behavioural factors shaping uptake with value chain participation.

This evidence supports the design of effective extension services, training programs, and support mechanisms that encourage sustainable technological engagement. The study fills a critical gap in linking technology adoption with practical improvements in smallholder agricultural operations and market participation.

This study links smallholder farm characteristics and technology adoption directly to food security outcomes, including availability, stability, and household access. Combining value chain analysis with household food security indicators, it shows how training, credit access, and technology use jointly influence production, market participation, and nutritional outcomes. The findings provide policymakers, NGOs, and development stakeholders with actionable insights to enhance agricultural productivity, strengthen rural value chains, and promote resilient, inclusive food systems, addressing the literature gap on integrated approaches to smallholder productivity and food security.

9. SUGGESTED AREAS FOR FURTHER RESEARCH

The suggestions for further studies are as follows:

- Assess the impact of climate-smart technologies on smallholder value chain development.
- Investigate gender-specific barriers and opportunities in technology adoption among farmers.
- Explore the role of digital platforms in enhancing market access for smallholders.
- Evaluate the long-term effects of integrated training, credit, and technology interventions on household food security.

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REFERENCES

- Abdullahi, U. (2020). Financial and technical constraints in the adoption of sustainable land management practices by smallholder farmers in Nigeria. *International Journal of Research and Innovation in Social Science*.
- Achukwu, G. A., Sennuga, S. O., Alabuja, F. O., & Barnabas, T. M. (2023). Factors affecting the rate of adoption of agricultural technology among small-scale rice farmers in Gwagwalada Area Council, FCT, Nigeria. *Journal of Agricultural Science and Practice*, 8(2).
<https://doi.org/10.31248/JASP2023.407>
- Adeola, O., & Evans, O. (2021). Digital transformation and economic development in Africa. *Technology in Society*, 64, 101–114.
- Adewumi, I. A., & Ogunniyi, L. (2021). Small-scale farming, agricultural productivity and poverty reduction in Nigeria: The enabling role of agricultural technology adoption *Journal of Agriculture and Ecology Research International*, 19(1), 1–15.
<https://doi.org/10.9734/jaeri/2019/v19i130074>

- Adeyemi, O. (2023). Nutrition capacity assessment of agricultural extension services. [Journal/Report].
- Arising studies (Integrating nutrition into agricultural extension). (2021). Spring Journals. (Integrating nutrition and extension report).
- Akpabio, E. S. (2025). E-agriculture and food security in developing countries. [Article].
- Aliu, I. O. (2023). A literature review on the usage of mobile financial services for smallholder farming. *Transactions on Quantitative Finance and Beyond*.
- Amankwah, A. (2023). Climate variability, agricultural technologies adoption, and productivity in rural Nigeria: A plot-level analysis. *Agriculture & Food Security*, 12(7).
<https://doi.org/10.1186/s40066-023-00411-x>
- Barrett, C. B. (2021). Smallholder market participation. *Food Policy*, 33(4), 299–317.
- Barrett, C. B. (2023). Measuring food insecurity. *Science*, 327(5967), 825–828.
- Markelova, H., Meinzen-Dick, R., Hellin, J., & Dohrn, S. (2022). Collective action for smallholder market access. *Food Policy*, 34(1), 1–7.
- Davis, F. D. (2021). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340.
- Donovan, J., Franzel, S., Cunha, M., Gyau, A., & Mithöfer, D. (2024). Guides for value chain development. World Agroforestry Centre.
- Fadeyi, O. A., Ariyawardana, A., & Aziz, A. A. (2022). Factors influencing technology adoption among smallholder farmers: A systematic review in Africa. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, (JARTS). <https://doi.org/10.17170/kobra-202201195569>
- FAO. (2020). The state of food security and nutrition in the world 2020. Food and Agriculture Organization.
- Lipper, L., Thornton, P., Campbell, B. M., Baedeker, T. (2021). Climate-smart agriculture. *Nature Climate Change*, 4(12), 1068–1072.
- Food Security Insights. (2025). Agricultural Technology Adoption in Nigeria: Challenges and Opportunities. *Food Security Insights*.
- Gereffi, G., & Fernandez-Stark, K. (2023). Global value chain analysis: A primer. Duke University Center on Globalization, Governance & Competitiveness.
- Gilbert, C. L., & Morgan, C. W. (2024). Food price volatility. *Philosophical Transactions of the Royal Society B*, 365(1554), 3023–3034.
- Headey, D., & Fan, S. (2022). Reflections on the global food crisis. IFPRI Research Monograph.
- Morton, J. F. (2023). Climate change and food security. *Proceedings of the National Academy of Sciences*, 104(50), 19680–19685.
- Kaplinsky, R., & Morris, M. (2021). A handbook for value chain research. IDRC. *Frontiers in Sustainable Food Systems*. (2025). Digital agriculture technology adoption in low and middle-income countries – a review.
- Kennedy, G., Nantel, G., & Shetty, P. (2021). The role of food and nutrition system approaches. *FAO Nutrition Paper*.
- Klerkx, L., Begemann, S., & Scott, P. (2021). Digital agriculture and food systems transformation: Identifying the role of innovation systems. *Agricultural Systems*, 193, 103211.
<https://doi.org/10.1016/j.agsy.2021.103211>
- Kolapo, A., & Didunyemi, A. J. (2024). Effects of exposure on adoption of agricultural smartphone apps among smallholder farmers in Southwest Nigeria: Implications on farm level efficiency. *Agriculture & Food Security*, 13(31). <https://doi.org/10.1186/s40066-024-00485-1>

- Maxwell, S., & Smith, M. (2023). Household food security. *Development Policy Review*, 10(1), 49–63.
- Ruel, M. T. (2023). Urbanization and nutrition. *Food and Nutrition Bulletin*, 24(2), 231–232.
- Victora, C. G. (2023). Maternal and child undernutrition. *The Lancet*, 371(9608), 340–357.
- Mgbenka, R. N., & Mbah, E. N. (2022). A review of smallholder farming in Nigeria: Need for transformation. *International Journal of Agricultural Extension and Rural Development Studies*, 3(2), 43–54.
- Nazifi, M., Mgbenka, R. N., & Ezeano, C. (2021). Food insecurity among smallholder maize farmers in Nigeria: role of extension services, credit and market access. *Journal of Agriculture and Environment*, 17(1), 1–13.
- Ogebe, F. O., & Ogah, M. O. (2024). Smallholders' access to agricultural credit in North-Central Nigeria. *International Journal of Research and Innovation in Applied Science*, 5(III).
- Ogunjobi, V. O. (2024). Determinants of Adoption of USAID Markets II Project's Agricultural Technology by Smallholder Farmers in Southwest, Nigeria. *Greener Journal of Agricultural Sciences*, 14(1), 23–32.
- Onomu, A. R., & Aliber, M. (2023). Nigeria's agriculture and technology use: Current structure and challenges. *Path of Science*.
- Pingali, P. (2024). Agricultural policy and nutrition outcomes. *Food Policy*, 62, 139–149.
- Poulton, C., Dorward, A., & Kydd, J. (2022). The future of small farms. *World Development*, 38(10), 1413–1428.
- Rogers, E. M. (2023). *Diffusion of innovations* (5th ed.). Free Press.
- Salisu, K. (2022). Smallholder farmer's relationship with extension workers and services: Implications for adoption of sustainable practices. *FUDMA Journal of Agriculture and Agricultural Technology*, 8(1), 232–243.
- Shima, K. S. (2023). Access to credit and financial services on marketing of farm produce: Evidence from Nigeria. *Journal of Agriculture and Sustainable Development*.
- Stoian, D., Donovan, J., Fisk, J., & Muldoon, M. (2023). Value chain development for rural poverty reduction. *Journal of Agribusiness in Developing and Emerging Economies*, 9(1), 1–20.
- Suvedi, M. (2023). Strengthening agricultural extension training in Nigeria: Overall report. Michigan State University / CSUS report.
- Timmer, C. P. (2022). The macro dimensions of food security. *Food Policy*, 25(3), 283–295*.
- Timmer, C. P. (2024). Food security, structural transformation, and economic growth. *Asia & the Pacific Policy Studies*, 4(1), 4–19.
- Trienekens, J. H. (2022). Agricultural value chains in developing countries. *International Food and Agribusiness Management Review*, 14(2), 51–82.
- Uche, I. V. (2024). Prospects and challenges of agricultural financing in Nigeria. GSC Online Press.
- Anser, M. K. (2021). Impact of ICT adoption and governance interaction on food security: Evidence from developing countries. *Sustainability*, 13(10), 5570. <https://doi.org/10.3390/su13105570>
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2022). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3), 425–478.