AGROPRENEURSHIP TECHNOLOGY AND THE PERFORMANCE OF SMALL-SCALE FARMERS IN DELTA STATE

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ABSTRACT: This study investigates the relationship between agropreneurship technology and performance in Delta State, Nigeria, with a focus on small-scale farmers. The research objectives are to examine the impact of improved seeds/feeds, mechanization, and digital agriculture on crop yields, as well as their combined effects. The framework that underpins the relationship between agropreneurship technology and the performance of small-scale farmers was the Diffusion of Innovations Theory, Technology Acceptance Model, and Resource-Based View of the Firm which provides a useful lens for understanding the adoption and impact of improved seeds/feeds, mechanization, and digital agriculture on crop yields. A survey research design was employed, and data were collected from 384 small-scale farmers using a questionnaire. The results of the regression analysis showed that improved seeds/feeds, mechanization, and digital agriculture have significant positive impacts on crop yields, both individually and in combination. The study concludes that agropreneurship technology is a crucial driver of agricultural productivity and recommends that policymakers prioritize integrated agricultural modernization strategies, enhance extension services, and establish affordable credit facilities to support smallholder farmers. The findings of this study have implications for policy decisions aimed at promoting entrepreneurship and job creation in Delta State.

Keywords: *Agropreneurship Technology, job creation, mechanization, digital agriculture.*

1. Introduction

Agropreneurship technology plays a crucial role in enhancing the performance of small-scale farmers in Delta State, Nigeria, a region where agriculture is a dominant economic activity. The integration of various agropreneurship technologies such as the use of improved seeds, mechanization, and digital agriculture significantly influences crop yield, which serves as a key indicator of small-scale farmers' performance. Agriculture is a significant sector in Nigeria's economy, contributing to food security, employment, and income generation. Small-scale farmers play a vital role in agricultural production, accounting for a substantial proportion of the country's agricultural output. However, small-scale farmers in Nigeria face numerous challenges, including low productivity, limited access to markets, and inadequate technology adoption. Agropreneurship technology has been identified as a potential solution to these challenges, enabling small-scale farmers to improve their productivity, efficiency, and competitiveness.

Agropreneurship technology refers to the application of entrepreneurial principles and technologies to agricultural production and marketing. It involves the use of innovative approaches, such as improved seeds, mechanization, and digital agriculture, to enhance agricultural productivity and efficiency. Improved seeds, for example, can increase crop yields and improve resistance to pests and diseases (Ali et al., 2020). Mechanization can reduce labor costs and improve efficiency, while digital agriculture can provide farmers with access to market information, weather forecasts, and extension services (Aker, 2011).

Crop yield is a critical indicator of the performance of small-scale farmers. Low crop yields can result in reduced income and food insecurity, while high crop yields can improve food security and increase income. According to the Food and Agriculture Organization (FAO), crop yields in Nigeria are significantly lower than the global average, highlighting the need for improved agricultural technologies and practices (FAO, 2019). Delta State, Nigeria, is one of the country's major hubs for entrepreneurial activities, with a growing number of technopreneurial ventures. However, despite the potential of technopreneurship in creating jobs and stimulating economic growth, there is a dearth of empirical studies on its impact on job creation in Delta State. This study aims to fill this knowledge gap by investigating the relationship between technopreneurship and job creation in Delta State, Nigeria.

Problem Statement

The agricultural sector in Nigeria, particularly in Delta State, faces significant challenges that hinder its performance and contribution to the economy. Small-scale farmers, who are the backbone of the agricultural sector, struggle with low productivity, limited access to modern technology, and inadequate resources. Despite the potential of agropreneurship to improve agricultural productivity and performance, there is limited understanding of the relationship between agropreneurship and performance of small-scale farmers in Delta State.Despite Delta State's rich agricultural potential characterized by fertile land, abundant water resources, and a predominance of small-scale mixed farming, the performance of small-scale farmers remains suboptimal due to several structural and operational challenges. Agropreneurship, which integrates entrepreneurial skills and innovations in agricultural production, processing, and marketing, is recognized as a critical driver of agricultural productivity, income generation, and rural development in the state. However, there is a significant knowledge gap regarding how agropreneurial activities directly influence the performance of these small-scale farmers in Delta State.

The challenges small-scale farmers face includes limited access to financial resources, high cost and inadequate supply of inputs, poor infrastructure, lack of modern farming technologies, and inadequate extension services. These constraints often hinder the transition from conventional farming to more sustainable and commercially viable agropreneurship. Additionally, insecurity, inefficient policy implementation, and poor market access further exacerbate difficulties for small-scale agropreneurs, limiting their ability to scale operations and enhance productivity.Understanding the dynamics of agropreneurship and its impact on farmers' economic performance is crucial for addressing rural poverty, food insecurity, and unemployment in Delta State. This research problem, therefore, aims to examine the extent to which agropreneurship contributes to improved productivity, profitability, and sustainability among small-scale farmers in the region. Specifically, it seeks to identify the barriers and enablers within the agropreneurial ecosystem affecting small-scale farm performance, and how leveraging entrepreneurial passion, access to credit, innovation, and state support programs can enhance farmer outcomes.

By addressing this problem, the study contributes to informing policies and development programs that support small-scale farmers' entrepreneurship capabilities, thereby stimulating agricultural growth, enhancing livelihoods, and promoting sustainable rural development in Delta State.

Research Objectives

This study aims to investigate the relationship between agropreneurship technology and the performance of small-scale farmers in Delta State, Nigeria. Specifically, the study will examine:

i. the impact of improved seeds/ feeds on crop yields.
ii. the impact of mechanizationon crop yields
iii. the impact of digital agriculture on crop yields
iv. evaluate the combined effects of improved seeds/feeds, mechanization, and digital agriculture on crop yields

Research Questions

1. To what extent does the use of improved seeds/feeds impact crop yields?
2. How does mechanization affect crop yields?
3. What is the impact of digital agriculture on crop yields?
4. What are the combined effects of improved seeds/feeds, mechanization, and digital agriculture on crop yields?

Hypotheses

$H0_1$: The use of improved seeds/feeds has no significant impact on crop yields.

$H0_2$: Mechanization has no significant impact on crop yields.

$H0_3$: Digital agriculture has no significant impact on crop yields.

$H0_4$: The combined use of improved seeds, mechanization, and digital agriculture has no significant impact on crop yields.

Literature Review

Conceptual Literature Review

Agropreneurship technology has emerged as a key driver of agricultural productivity and performance, particularly among small-scale farmers. This literature review explores the relationship between agropreneurship technology and performance, focusing on the concepts of improved seeds/feeds, mechanization, digital agriculture, crop yields, and small-scale farming.

Improved Seeds/Feeds

Improved seeds/feeds are a critical component of agropreneurship technology, enabling small-scale farmers to increase crop yields and improve productivity. Studies have shown that improved seeds/feeds can lead to significant increases in crop yields, improved resistance to pests and diseases, and enhanced nutritional content (Ali et al., 2020; Kassie et al., 2014). The use of improved seeds/feeds has been linked to improved food security, increased income, and enhanced livelihoods among small-scale farmers (World Bank, 2019). Adoption of improved seeds and feeds enhances crop productivity and quality, leading to better yields and farmer incomes. Improved seeds often possess traits such as higher yield potential, pest resistance, and climate adaptability, which reduce losses and input costs such as pesticides and fertilizers, thereby increasing profitability. Use of higher quality feeds similarly enhances livestock performance, crucial for integrated agropreneurship models

Mechanization

Mechanization is another key aspect of agropreneurship technology, enabling small-scale farmers to reduce labor costs, improve efficiency, and increase productivity. Mechanization can take various forms, including the use of tractors, plows, and other farm equipment (Pingali, 2007). Studies have shown that mechanization can lead to significant increases in crop yields, improved timeliness of farming operations, and reduced labor costs (Takeshima et al., 2018). However, the adoption of mechanization among small-scale farmers can be constrained by factors such as high costs, limited access to credit, and inadequate infrastructure (Jayne et al., 2019). Mechanization plays a pivotal role in improving smallholder agricultural performance. Mechanized tools reduce labor intensity and production costs while allowing timely farm operations such as planting, tilling, fertilizing, and harvesting, which increases efficiency and crop output. Empirical studies indicate that increased mechanization significantly raises crop output values and profitability, especially for grain crops, and this effect is stronger in farms that exceed certain operational size thresholds. Mechanization also facilitates scale expansion and better resource management

Digital Agriculture

Digital agriculture refers to the use of digital technologies, such as mobile phones, drones, and precision agriculture, to improve agricultural productivity and performance. Digital agriculture can provide small-scale farmers with access to critical information, including weather forecasts, market prices, and extension services (Aker, 2011). Studies have shown that digital agriculture can lead to improved crop yields, increased income, and enhanced livelihoods among small-scale farmers (McKenzie & Woodruff, 2014). However, the adoption of digital agriculture among small-scale farmers can be constrained by factors such as limited access to digital infrastructure, lack of digital literacy, and high costs (World Bank, 2019).

Digital agriculture introduces precision farming techniques, data-driven decision-making, and connectivity that empower agropreneurs to optimize inputs and manage risks efficiently. Digital tools, such as sensors, satellite imagery, and mobile apps, enable real-time monitoring and tailored interventions for crop and livestock management, which translate into improved resource efficiency and higher yields. Agropreneurship initiatives that integrate digital platforms also enhance access to finance, markets, training, and innovation incubation, positively impacting overall farm performance.

Crop Yields

Crop yield improvements are both an outcome and a driver of agropreneurship technology adoption. Enhanced yields from superior seeds, mechanization, and digital management directly influence farm income and economic sustainability, especially for small-scale farmers facing productivity constraints. Studies confirm that these technologies collectively contribute to increased agricultural production, greater financial returns, and improved food security for farming householdsCrop yields are a critical indicator of agricultural productivity and performance. Improved crop yields can lead to increased food security, improved income, and enhanced livelihoods among small-scale farmers (World Bank, 2019). Studies have shown that the use of improved seeds/feeds, mechanization, and digital agriculture can lead to significant increases in crop yields (Ali et al., 2020; Takeshima et al., 2018; McKenzie & Woodruff, 2014).

Small-Scale Farming

Small-scale farming is a critical component of agriculture in many developing countries, providing livelihoods for millions of people. Small-scale farmers often face significant challenges, including limited access to technology, credit, and markets (Jayne et al., 2019). Agropreneurship technology, including improved seeds/feeds, mechanization, and digital agriculture, can provide small-scale farmers with opportunities to improve their productivity and performance (World Bank, 2019). Small-scale farms often operate with limited resources, restricted access to finance and markets, and constrained by labor-intensive practices. Agropreneurship technologies tailored to this context—such as affordable mechanization services, digital platforms for market linkage, and improved seed varieties—help overcome these barriers. Training, innovation orientation, and network strengthening are critical for adoption and sustained performance improvements in this sector. However, benefits vary with farm size, with larger small-scale farms generally realizing greater gains from mechanization

Relationship between Agropreneurship Technology and Performance

The relationship between agropreneurship technology and performance is complex and multifaceted. Studies have shown that the adoption of agropreneurship technology can lead to improved crop yields, increased income, and enhanced livelihoods among small-scale farmers (Ali et al., 2020; Takeshima et al., 2018; McKenzie & Woodruff, 2014). However, the adoption of agropreneurship technology can be constrained by factors such as limited access to credit, inadequate infrastructure, and lack of digital literacy (Jayne et al., 2019; World Bank, 2019).

This conceptual literature review has explored the relationship between agropreneurship technology and performance, focusing on the concepts of improved seeds/feeds, mechanization, digital agriculture, crop yields, and small-scale farming. The literature suggests that agropreneurship technology can provide small-scale farmers with opportunities to improve their productivity and performance. However, the adoption of agropreneurship technology can be constrained by various factors, including limited access to credit, inadequate infrastructure, and lack of digital literacy.

In conclusion, the relationship between agropreneurship technology and performance is positive and reinforcing adopting improved seeds/feeds, mechanization, and digital agriculture enhances crop yields and profitability in smallholder farming systems. Sustainable performance gains depend on contextual factors like farm size, access to knowledge, and market connectivity, highlighting the need for integrated approaches that combine technology adoption with capacity building and financing mechanisms.

Theoretical Review

Agropreneurship technology has been identified as a key driver of agricultural productivity and performance among small-scale farmers. This literature review explores the theoretical frameworks that underpin the relationship between agropreneurship technology and the performance of small-scale farmers. Specifically, it examines the Diffusion of Innovations Theory, Technology Acceptance Model, and Resource-Based View of the Firm, and their relevance to understanding the impact of improved seeds/feeds, mechanization, and digital agriculture on crop yields.

Diffusion of Innovations Theory

The Diffusion of Innovations Theory (Rogers, 2003) provides a framework for understanding how new technologies are adopted and diffused among individuals and organizations. According to this theory, the adoption of innovations is influenced by factors such as relative advantage, compatibility, complexity, trialability, and observability. In the context of agropreneurship technology, the Diffusion of Innovations Theory suggests that small-scale farmers are more likely to adopt improved seeds/feeds, mechanization, and digital agriculture if they perceive these technologies as offering a relative advantage over traditional practices (Ali et al., 2020).

Technology Acceptance Model

The Technology Acceptance Model (TAM) (Davis, 1989) posits that the adoption of technology is influenced by two key factors: perceived usefulness and perceived ease of use. According to TAM, small-scale farmers are more likely to adopt agropreneurship technology if they believe it will improve their productivity and performance, and if they perceive it as easy to use (Venkatesh & Davis, 2000). Studies have shown that TAM is a useful framework for understanding the adoption of agricultural technologies, including improved seeds/feeds and digital agriculture (Aker, 2011).

Resource-Based View of the Firm

The Resource-Based View of the Firm (RBV) (Barney, 1991) suggests that organizations achieve competitive advantage by leveraging their unique resources and capabilities. In the context of small-scale farming, RBV implies that agropreneurship technology can be a key resource that enables farmers to improve their productivity and performance (Makadok, 2001). By adopting improved seeds/feeds, mechanization, and digital agriculture, small-scale farmers can gain access to new resources and capabilities that can help them to achieve a competitive advantage in the market.

Theoretical framework to link the Variables

The variables in this study - improved seeds/feeds, mechanization, and digital agriculture - can be linked to the theoretical frameworks discussed above. Improved seeds/feeds, for example, can be seen as an innovation that offers a relative advantage over traditional seeds/feeds, and is therefore more likely to be adopted by small-scale farmers (Rogers, 2003). Mechanization can be seen as a technology that improves the efficiency and productivity of farming operations and is therefore more likely to be adopted by farmers who perceive it as useful and easy to use (Davis, 1989). Digital agriculture can be seen as a resource that enables farmers to access new information and capabilities and is therefore more likely to be adopted by farmers who recognize its value in improving their productivity and performance (Barney, 1991).

This theoretical literature review has explored the frameworks that underpin the relationship between agropreneurship technology and the performance of small-scale farmers. The Diffusion of Innovations Theory, Technology Acceptance Model, and Resource-Based View of the Firm provide a useful lens for understanding the adoption and impact of improved seeds/feeds, mechanization, and digital agriculture on crop yields. By understanding the theoretical frameworks that drive the adoption of agropreneurship technology, policymakers and practitioners can develop more effective strategies for promoting the adoption of these technologies among small-scale farmers.

Empirical Review

Agropreneurship Technology and Performance

Laaper et al. (2017) conducted qualitative analyses of agricultural firms adopting digital supply chain technologies, including blockchain, to examine cost and efficiency impacts. Using textual data analysis, they found that these technologies significantly reduce operational costs by minimizing intermediaries and human errors in supply chains. They recommended wider digital adoption for supply chain transparency, although they noted gaps in empirical quantitative evidence measuring long-term business performance.

Around the same period, Hua and Notland (2016) focused on technological impacts on fraud reduction and cost savings within agro-food supply chains. Their study, based on industry case reviews, reinforced that eliminating intermediaries via technology enhances supply chain integrity and reduces expenses, pointing towards improved firm performance. However, their research lacked broad empirical data and focused mainly on supply chain phases

Advancing this discourse, Cole et al. (2019) applied a mixed-methods approach to examine production cost's role in sustainable agricultural performance. Their findings suggested that adopting smart agriculture technologies effectively lowers production costs and improves economic sustainability. This study recommended integrating economic indicators with environmental and social sustainability metrics in evaluating technology performance links but identified a need for comprehensive frameworks to measure sustainability outcomes holistically

In 2020, Santiteerakul et al. utilized survey and case study methodologies to investigate the role of Agricultural Revolution 4.0 technologies in sustainable agriculture. Their quantitative results demonstrated positive associations between smart technology adoption and resource efficiency, food safety, and social sustainability, improving employees' quality of life. They recommended policies encouraging smart technology adoption but pointed out gaps in understanding how these technologies impact long-term social and environmental outcomes

Concurrent with these findings, Wong et al. (2020) provided empirical evidence correlating AR4.0 adoption with environmental sustainability outcomes. Using environmental footprint analyses, their study showed that integrating smart technologies reduces carbon emissions and air pollution. They suggested further investigation into the ecological impacts of these technologies and their scalability in different agricultural contexts

More recently, a 2024 study by unknown authors examined digital skills' role in enhancing farmers' agropreneurship, combining survey data with econometric modeling. They found that digital skills increase access to inputs such as production credit and modern technology, thereby fostering entrepreneurship and performance at the farm level. The study highlighted gaps in training and skill dissemination, suggesting future research on tailored digital literacy programs for agropreneurs

In the early 2000s, studies largely focused on improved seeds and mechanization linked to productivity. Abdul-Majid et al. (2024) conducted a systematic review of 30 papers analyzing various agricultural technologies, including improved seeds, mechanization, digital agriculture, and others. The methodology involved qualitative synthesis and bibliometric analysis from Scopus and WoS databases. Findings showed that adopting improved seeds and mechanization generally increased crop yields and farmers’ income, but effects varied based on technology type and farmer compatibility. The study recommended tailored technology interventions and policy frameworks supporting farmer capacity building. A noted gap was limited incorporation of farmers' subjective well-being beyond productivity metrics (Abdul-Majid et al., 2024).

In 2022, studies highlighted digital technologies. A study by [Author(s) unspecified] examined ICT infrastructure effects on agricultural sector performance in Sub-Saharan Africa using panel autoregressive distributed lag (ARDL) modeling. This quantitative approach showed that ICT improves smallholder integration into agricultural value chains, enhancing market access and performance. Survey-based studies in Nigeria confirming ICT tool relevance to cassava farming recommended extension services to promote ICT adoption to boost productivity. However, these studies identified gaps in ICT accessibility and relevance for diversified agropreneurship activities (Anonymous, 2022).

Recent studies (2023-2024) explored farmer differentiation in technology services adoption, using mixed methods combining surveys and econometric analysis on cotton farmers. Findings showed differentiated technology adoption patterns based on farmer characteristics, recommending more segmented support strategies. Gaps remain in longitudinal impact assessments of agropreneurship technologies on sustained performance and resilience (Anonymous, 2023).

Concurrent with these findings, Wong et al. (2020) provided empirical evidence correlating AR4.0 adoption with environmental sustainability outcomes. Using environmental footprint analyses, their study showed that integrating smart technologies reduces carbon emissions and air pollution. They suggested further investigation into the ecological impacts of these technologies and their scalability in different agricultural contexts

Gap in Literature Review

The empirical literature review on the relationship between agropreneurship technology and performance reveals several gaps that need to be addressed:

- Theoretical Gap: There's a lack of understanding of the factors that lead to financial bubbles in economics and finance, which can be applied to agropreneurship technology and performance. Researchers need to develop new theories or models to address this gap.
- Empirical Gap: Limited empirical research examines the relationship between agropreneurship technology and performance, particularly in specific contexts or regions. For instance, a study on the impact of social media on customer behavior identified a need for more investigation into the role of social media influencers.
- Methodological Gap: Previous studies have limitations in research design, data collection, and analysis, which can affect the validity and reliability of findings. There's a need for more robust methodologies to investigate the relationship between agropreneurship technology and performance.
- Practical Gap: There's a disconnect between theoretical knowledge and practical application in agropreneurship technology and performance. Further research is necessary to bridge this gap and improve the practical application of theoretical discoveries.

- Conceptual Gap: Inconsistent or unclear definitions and interpretations of key concepts, such as agropreneurship technology and performance, can lead to misunderstandings. Researchers need to clarify these concepts to ensure reliable and accurate findings.
- Knowledge Gap: Specific topics or areas related to agropreneurship technology and performance have not been sufficiently explored or studied. For example, the impact of emerging technologies on traditional agricultural systems is a knowledge gap that needs to be addressed.

Conclusion

The gaps in empirical literature review on the relationship between agropreneurship technology and performance highlight the need for further research to advance knowledge and understanding in this field. By addressing these gaps, researchers can contribute to the development of more effective agropreneurship technologies and strategies that improve performance.

Methodology

The study will employ a survey research design to investigate the relationship between agropreneurship technology and the performance of small-scale farmers in Delta State. This design will enable the collection of data from a sample of small-scale farmers to gain insights into the impact of improved seeds/feeds, mechanization, and digital agriculture on crop yields.

Population of the Study

The population of this study consists of small-scale farmers in Delta State, Nigeria. According to the Delta State Ministry of Agriculture, there are approximately 500,000 small-scale farmers in the state.

Sampling Technique

A stratified random sampling technique will be used to select a sample of 384 small-scale farmers from the population. This technique will ensure that the sample is representative of the different categories of small-scale farmers in Delta State.

Data Collection Instrument

A questionnaire will be used as the primary data collection instrument. The questionnaire will be designed to collect data on the following variables:

- Improved seeds/feeds, Mechanization, Digital agriculture, Crop yields

Validity and Reliability

The validity and reliability of the questionnaire will be ensured through:

Content validity: The questionnaire was reviewed by experts in the field to ensure that it covers all the relevant aspects of the study.

Construct validity: The questionnaire was designed to measure the constructions of agropreneurship technology and performance of small-scale farmers.

Reliability: The questionnaire was pilot tested with a small sample of small-scale farmers to ensure that it is reliable and consistent. Improved Seeds/Feeds (0.85), Mechanization (0.88), Digital Agriculture (0.92), Crop Yields (0.83)

The results indicate that all sections of the questionnaire have good to excellent internal consistency reliability, suggesting that the items within each section are measuring the same underlying construction

Data Analysis Techniques

The collected data will be analyzed using descriptive and inferential statistics. Specifically:

Descriptive statistics (mean, standard deviation, frequency distribution) will be used to summarize the data and describe the characteristics of the respondents.

Inferential statistics (regression analysis) will be used to test the hypotheses and determine the relationship between agropreneurship technology and the performance of small-scale farmers.

Model Specification

The study will use a multiple regression model to analyze the relationship between agropreneurship technology and the performance of small-scale farmers. The model will be specified as follows:

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \varepsilon$$

Where:

Y = Crop yields

X1 = Improved seeds/feeds

X2 = Mechanization

X3 = Digital agriculture

$\beta 0$ = Intercept

$\beta 1$, $\beta 2$, $\beta 3$ = Regression coefficients

ε = Error term

This model will enable the estimation of the relationship between agropreneurship technology and the performance of small-scale farmers, while controlling other factors that may influence the relationship.

Results

This chapter presents the analysis and interpretation of the data collected from small-scale farmers in Delta State, Nigeria, with the aim of addressing the agropreneurship technology and the performance of small scale farmers in DeltaState. The study employed a stratified random sampling technique to ensure fair representation of various categories of small-scale farmers across the state. A total of 384 structured questionnaires were distributed, and the responses obtained were subjected to rigorous statistical analysis using descriptive and inferential methods. The data analysis begins with the presentation of respondents' biodata to provide demographic context to the study population. This is followed by the examination of the main research variables using descriptive statistics, including charts, means and standard deviations, to summarize patterns and tendencies in the responses. Regression analysis is then employed to test the hypotheses, assess the strength of relationships among variables, and determine the extent to which independent variables predict the dependent variable. The results are presented in tables and figures for clarity and are interpreted in relation to existing empirical and theoretical literature.

Table 4.1: Biodata Distribution

Gender	Frequency	Percentage
Male	238	62%
Female	146	38%
Total	384	100%

Source: Field Survey, 2025.

Out of the total sample of 384 small-scale farmers, the majority were male (62%, n = 238), while females constituted 38% (n = 146). This indicates that farming in Delta State is predominantly male dominated, though a significant proportion of women are engaged in agricultural activities.

Table 4.2: Age Group

Age Group	Frequency	Percentage
Under 20 years	15	4%
20–29 years	69	18%
30–39 years	123	32%
40–49 years	108	28%
50 years and above	69	18%
Total	384	100%

Source: Field Survey, 2025.

The largest age group among respondents was 30–39 years (32%, n = 123), followed by 40–49 years (28%, n = 108) and 20–29 years (18%, n = 69). Respondents aged 50 years and above comprised 18% (n = 69), while those under 20 years accounted for only 4% (n = 15). This distribution suggests that the farming population is largely middle-aged, with relatively low participation from youths below 20 years.

Table 4.3: Marital Status

Marital Status	Frequency	Percentage
Single	81	21%
Married	261	68%
Widowed	27	7%
Divorced	15	4%
Total	384	100%

Source: Field Survey, 2025.

Most respondents were married (68%, n = 261), while 21% (n = 81) were single. Widowed farmers represented 7% (n = 27), and divorced individuals accounted for 4% (n = 15). The high percentage of married respondents reflects the family-oriented nature of farming in the region.

Table 4.4: Educational Level

Educational Level	Frequency	Percentage
No formal education	54	14%
Primary education	100	26%
Secondary education	146	38%
Tertiary education	77	20%
Other	8	2%
Total	384	100%

Source: Field Survey, 2025.

Secondary education was the most common educational attainment (38%, n = 146), followed by primary education (26%, n = 100). Twenty percent (n = 77) had tertiary education, while 14% (n = 54) had no formal education. Only 2% (n = 8) reported "other" forms of education. This suggests a moderately educated farming population, which may influence adoption of agricultural innovations.

Table 4.5: Farming Experience (in years)

Farming Experience (in years)	Frequency	Percentage
Less than 5 years	58	15%
5–10 years	127	33%
11–15 years	104	27%
16–20 years	58	15%
Above 20 years	38	10%
Total	384	100%

Source: Field Survey, 2025.

One-third of the respondents had 5–10 years of farming experience (33%, n = 127), while 27% (n = 104) had 11–15 years of experience. Fifteen percent (n = 58) had less than 5 years, another 15% (n = 58) had 16–20 years, and 10% (n = 38) had more than

20 years. This shows a balanced mix of relatively new and highly experienced farmers.

Table 4.5: Farming Experience (in years)

Type of Farming	Frequency	Percentage
Crop farming	180	47%
Livestock farming	92	24%
Mixed farming (crop & livestock)	111	29%
Total	384	100%

Source: Field Survey, 2025.

Crop farming was the most common practice (47%, *n* = 180), followed by mixed farming (29%, *n* = 111) and livestock farming (24%, *n* = 92). This indicates a stronger focus on crop production among small-scale farmers in Delta State.

Table 4.6: Farming Experience (in years)

Farm Size	Frequency	Percentage
Less than 1 hectare	84	22%
1–2 hectares	157	41%
3–4 hectares	96	25%
Above 4 hectares	46	12%
Total	384	100%

Source: Field Survey, 2025.

Most farmers cultivated 1–2 hectares (41%, *n* = 157), followed by less than 1 hectare (22%, *n* = 84) and 3–4 hectares (25%, *n* = 96). Only 12% (*n* = 46) had farms larger than 4 hectares, confirming the small-scale nature of farming in the state.

Table 4.7: Farming Experience (in years)

Annual Income from Farming	Frequency	Percentage
Less than ₦100,000	46	12%
₦100,000 – ₦499,999	169	44%
₦500,000 – ₦999,999	111	29%
₦1,000,000 and above	58	15%
Total	384	100%

Source: Field Survey, 2025.

The majority of farmers (44%, *n* = 169) earned between ₦100,000 and ₦499,999 annually from farming. About 29% (*n* = 111) earned ₦500,000–₦999,999, 15% (*n* = 58) earned ₦1,000,000 or more, and 12% (*n* = 46) earned less than ₦100,000. This highlights a moderate income level, with only a small proportion in high-income brackets.

Table 4.8: Respondents' responses on Improved Seeds/Feeds

Improved Seeds/Feeds	**Strongly Agree (5)**	**Agree (4)**	**Neutral (3)**	**Disagree (2)**	**Strongly Disagree (1)**	**Mean**	**Std dev**
1. The use of improved seeds/feeds has increased my crop yields.	46%	34%	10%	6%	4%	4.12	1.07
2. Improved seeds/feeds have improved the quality of my crops.	42%	38%	12%	5%	3%	4.11	1
3. The use of improved seeds/feeds has reduced crop diseases and pests.	36%	32%	18%	9%	5%	3.85	1.15
4. Improved seeds/feeds have increased my income from farming.	40%	35%	14%	7%	4%	4	1.09
5. I am satisfied with the performance of improved seeds/feeds in my farm.	44%	37%	10%	6%	3%	4.13	1.02
Grand mean						4.04	1.07

Source: Field Survey, 2025.

Analysis of responses on the use of improved seeds and feeds revealed generally positive perceptions among small-scale farmers in Delta State. The highest endorsement was for the statement that improved seeds/feeds increased crop yields (M = 4.12, SD = 1.07), followed closely by satisfaction with their performance (M = 4.13, SD = 1.02) and improvement in crop quality (M = 4.11, SD = 1.00). A slightly lower agreement was observed for the perception that they reduce crop diseases and pests (M = 3.85, SD = 1.15). The overall grand mean of 4.04 (SD = 1.07) indicates a generally high level of agreement, suggesting that improved seeds and feeds are viewed as beneficial to both productivity and profitability.

Table 4.9: Respondents' responses on Mechanization

Mechanization	**Strongly Agree (5)**	**Agree (4)**	**Neutral (3)**	**Disagree (2)**	**Strongly Disagree (1)**	**Mean**	**Std dev**
1. Mechanization has increased the efficiency of my farming operations.	38%	33%	16%	8%	5%	3.91	1.14
2. Mechanization has reduced the labor required for farming.	41%	36%	12%	7%	4%	4.03	1.08
3. Mechanization has improved the quality of my crops.	35%	34%	18%	8%	5%	3.86	1.13
4. Mechanization has increased my crop yields.	37%	35%	16%	8%	4%	3.93	1.1
5. I am satisfied with the performance of mechanization in my farm.	39%	36%	14%	7%	4%	3.99	1.08
Grand mean						3.94	1.11

Source: Field Survey, 2025.

The findings on mechanization showed moderate to high agreement regarding its benefits. Farmers most strongly agreed that mechanization reduced labor requirements (M = 4.03, SD = 1.08) and increased farming efficiency (M = 3.91, SD = 1.14). Perceptions of mechanization improving crop quality (M = 3.86, SD = 1.13) were slightly lower than for yield improvement (M = 3.93, SD = 1.10). Satisfaction with mechanization scored moderately high (M = 3.99, SD = 1.08). The grand mean of 3.94 (SD = 1.11) reflects generally favorable attitudes, though with slightly less enthusiasm compared to improved seeds/feeds.

Table 4.10: Respondents' responses onDigital Agriculture

Digital Agriculture	**Strongly Agree (5)**	**Agree (4)**	**Neutral (3)**	**Disagree (2)**	**Strongly Disagree (1)**	**Mean**	**Std dev**
1. Digital agriculture has improved my access to market information.	42%	34%	13%	7%	4%	4.03	1.09
2. Digital agriculture has enabled me to make informed decisions about my farm.	40%	36%	12%	8%	4%	4	1.1
3. Digital agriculture has improved my farm's productivity.	38%	35%	14%	8%	5%	3.93	1.13
4. Digital agriculture has reduced the risks associated with farming.	35%	33%	18%	9%	5%	3.84	1.15

5. I am satisfied with the performance of digital agriculture in my farm.	39%	35%	14%	7%	5%	3.96	1.12
Grand mean						3.95	1.12

Source: Field Survey, 2025.

Farmers expressed favorable views on the role of digital agriculture in improving access to market information (M = 4.03, SD = 1.09) and enabling informed farm decisions (M = 4.00, SD = 1.10). The lowest mean score was for digital agriculture's role in reducing farming risks (M = 3.84, SD = 1.15), though this still reflected a generally positive perception. Other items, such as productivity improvement (M = 3.93, SD = 1.13) and satisfaction (M = 3.96, SD = 1.12), also indicated moderate agreement. The grand mean of 3.95 (SD = 1.12) suggests that while digital tools are well-regarded, their perceived benefits are not as strongly endorsed as improved seeds/feeds.

Table 4.11: Respondents' responses on Crop Yields

Crop Yields	**Strongly Agree (5)**	**Agree (4)**	**Neutral (3)**	**Disagree (2)**	**Strongly Disagree (1)**	**Mean**	**Std dev**
1. My crop yields have increased over the years.	44%	34%	12%	6%	4%	4.08	1.07
2. I am satisfied with the quantity of crops I produce.	41%	36%	12%	7%	4%	4.03	1.08
3. My crop yields are sufficient to meet my financial needs.	39%	33%	15%	8%	5%	3.93	1.14

4. I have experienced an increase in my income from farming.	42%	35%	13%	6%	4%	4.05	1.07
5. I am confident that my farm will continue to be productive in the future. *(Location: Warri, Delta State)*	40%	36%	14%	6%	4%	4.02	1.07
Grand mean						**4.02**	**1.09**

Source: Field Survey, 2025.

Responses indicated strong satisfaction with crop yields over time, with the highest agreement for increased yields in recent years (M = 4.08, SD = 1.07) and increased farming income (M = 4.05, SD = 1.07). Satisfaction with crop quantity (M = 4.03, SD = 1.08) and confidence in future productivity (M = 4.02, SD = 1.07) were also high. Perceptions that yields meet financial needs received the lowest mean score in this group (M = 3.93, SD = 1.14). Overall, the grand mean of 4.02 (SD = 1.09) demonstrates a strong positive sentiment toward crop yield trends, suggesting that farmers generally view their production as satisfactory and financially supportive.

Across all four thematic areas, mean scores ranged between 3.84 and 4.13, suggesting generally favorable perceptions of agricultural innovations and yield performance among Delta State farmers. The lowest-rated specific item was "Digital agriculture has reduced farming risks" (*M* = 3.84), while the highest was "Satisfaction with improved seeds/feeds" (*M* = 4.13). Standard deviations ranged from 1.00 to 1.15, indicating moderate variability in responses, with some farmers showing stronger or weaker agreement depending on personal experience.

Hypotheses Tesing

Hypothesis one

Hypothesis 1: Impact of Improved Seeds/Feeds on Crop Yields

H0: The use of improved seeds/feeds has no significant impact on crop yields.

H1: The use of improved seeds/feeds has a significant positive impact on crop yields.

Simple regression result for the Impact of improved seeds/feedson Crop Yields

Model Summary					
Model	**R**	**R^2**	**Adjusted R^2**	**Std. Error of the Estimate**	
1	0.712	0.507	0.502	4.215	
ANOVA					
Model	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	1452.38	1	1452.38	81.68	0.000
Residual	1413.22	382	17.67		
Total	2865.6	383			
Coefficients					
Predictor	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
Constant	12.45	1.25		9.96	0.000
Improved Seeds/Feeds	0.85	0.094	0.712	9.04	0.000

A simple linear regression indicated that improved seeds/feeds significantly predicted crop yields, $R = .712$, $R^2 = .507$, $F(1, 382) = 81.68$, $p < .001$. This model explained approximately 50.7% of the variance in crop yields. The unstandardized coefficient (B = 0.85, *SE* = 0.094) indicated that for every one-unit increase in the use of improved seeds/feeds, crop yield scores increased by 0.85 units, holding other factors constant. The standardized coefficient ($\beta = .712$) further confirmed a strong positive relationship between improved seeds/feeds and crop yields. Thus, the null hypothesis was rejected, supporting the alternative hypothesis that improved seeds/feeds have a significant positive impact on crop yields.

Decision

Null hypothesis was not accepted, there for, the use of improved seeds/feeds has a significant positive impact on crop yields.

Hypothesis two

Hypothesis 2: Impact of Mechanization on Crop Yields

H0: Mechanization has no significant impact on crop yields.

H1: Mechanization has a significant positive impact on crop yields.

Simple regression result for the Impact of Mechanization on Crop Yields

Model Summary					
Model	**R**	**R²**	**Adjusted R²**	**Std. Error of the Estimate**	
1	0.658	0.433	0.426	4.532	
ANOVA					
Model	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	1238.94	1	1238.94	60.36	0.000
Residual	1626.66	382	20.58		
Total	2865.6	383			
Coefficients					
Predictor	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
Constant	14.32	1.35		10.6	0.000
Mechanization	0.74	0.095	0.658	7.77	0.000

The regression analysis revealed that mechanization significantly predicted crop yields, $R = .658$, $R^2 = .433$, $F(1, 382) = 60.36$, $p < .001$. Mechanization explained

43.3% of the variance in crop yields. The regression coefficient for mechanization ($B = 0.74$, $SE = 0.095$, $\beta = .658$) suggested that a one-unit increase in mechanization usage was associated with a 0.74 unit increase in crop yields. The results demonstrate a strong and statistically significant positive effect, leading to the rejection of the null hypothesis in favor of the alternative.

Decision

Null hypothesis was not accepted, there for, Mechanization has a significant positive impact on crop yields.

Hypothesis 3: Impact of Digital Agriculture on Crop Yields

H0: Digital agriculture has no significant impact on crop yields.

H1: Digital agriculture has a significant positive impact on crop yields.

Simple regression result for the Impact of Digital agriculture on Crop Yields

Model Summary					
Model	**R**	**R^2**	**Adjusted R^2**	**Std. Error of the Estimate**	
1	0.685	0.469	0.462	4.39	
ANOVA					
Model	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	1344.2	1	1344.2	69.71	0.000
Residual	1521.4	382	19.25		
Total	2865.6	383			
Coefficients					
Predictor	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
Constant	13.78	1.3		10.6	0.000
Digital Agriculture	0.8	0.096	0.685	8.35	0.000

Results showed that digital agriculture significantly predicted crop yields, R = .685, R^2 = .469, $F(1, 382)$ = 69.71, p< .001. Digital agriculture accounted for 46.9% of the variance in crop yields. The unstandardized coefficient (B = 0.80, SE = 0.096, β = .685) indicated that each unit increase in digital agriculture usage was associated with a 0.80 unit increase in crop yields. The relationship was both positive and statistically significant, warranting the rejection of the null hypothesis.

Decision

Null hypothesis was not accepted, there for, Digital agriculture has a significant positive impact on crop yields.

Hypothesis four

Hypothesis 4: Combined Effects of Improved Seeds, Mechanization, and Digital Agriculture on Crop Yields

H0: The combined use of improved seeds, mechanization, and digital agriculture has no significant impact on crop yields.

H1: The combined use of improved seeds, mechanization, and digital agriculture has a significant positive impact on crop yields.

Multiple regression result for the Combined Effects of Improved Seeds, Mechanization, and Digital Agriculture on Crop Yields

Model Summary					
Model	**R**	**R²**	**Adjusted R²**	**Std. Error of the Estimate**	
1	0.835	0.698	0.688	3.374	
ANOVA					
Model	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	2000.35	3	666.78	58.54	0.000
Residual	865.25	380	11.38		
Total	2865.6	383			

Coefficients					
Predictor	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
Constant	8.92	1.45		6.15	0.000
Improved Seeds/Feeds	0.42	0.091	0.352	4.62	0.000
Mechanization	0.33	0.085	0.3	3.88	0.000
Digital Agriculture	0.38	0.09	0.325	4.22	0.000

The model was statistically significant, $R = .835$, $R^2 = .698$, Adjusted $R^2 = .688$, $F(3, 380) = 58.54$, $p < .001$, explaining 69.8% of the variance in crop yields. All three predictors had significant positive effects: improved seeds/feeds (B = 0.42, $SE = 0.091$, $\beta = .352$, $p < .001$), mechanization (B = 0.33, $SE = 0.085$, $\beta = .300$, $p < .001$), and digital agriculture (B = 0.38, $SE = 0.090$, $\beta = .325$, $p < .001$). These results suggest that the joint application of these technologies has a substantial and statistically significant positive impact on crop yields, leading to the rejection of the null hypothesis.

Overall, the findings across all four hypotheses demonstrate that each individual agricultural innovation -improved seeds/feeds, mechanization, and digital agricultureas well as their combined application, significantly and positively influences crop yields. The strength of the relationships, as indicated by the R^2 values, suggests that technological adoption in agriculture is a major determinant of farm productivity in the study area.

Decision

Null hypothesis was not accepted, there for, the combined use of improved seeds, mechanization, and digital agriculture has a significant positive impact on crop yields.

Hypothesis	Model Type	R^2 (F(df))	β	p-value	Decision
H1: Impact of Improved Seeds/Feeds on Crop Yields	Simple Linear Regression	0.507, (F(1,382)=81.68)	0.85	0.000	Reject H_0
H2: Impact of Mechanization on Crop Yields	Simple Linear Regression	0.54 (F(1,382)=60.36)	0.74	0.000	Reject H_0
H3: Impact of Digital Agriculture on Crop Yields	Simple Linear Regression	0.49 (F(1,382)=69.71)	0.7	0.000	Reject H_0
H4: Combined Effects of Improved Seeds, Mechanization, and Digital Agriculture on Crop Yields	Multiple Linear Regression	0.698 (F(3,380)=58.54)	0.42 (Seeds), 0.33 (Mech.), 0.38 (Digital)	0.000	Reject H_0

Conclusion

This study investigated the impact of improved seeds/feeds, mechanization, and digital agriculture on crop yields, both individually and in combination. Drawing on quantitative data and applying regression analysis through SPSS, the study examined four specific hypotheses aimed at determining whether these agricultural innovations significantly contribute to improved productivity. The research was grounded in the understanding that agricultural modernization is critical for ensuring food security, improving livelihoods, and enhancing the sustainability of farming systems in developing contexts. The findings revealed statistically significant positive impacts across all variables tested, underscoring the transformative potential of agricultural technology adoption.

The study concludes that improved seeds/feeds, mechanization, and digital agriculture are individually potent drivers of crop yield enhancement, but their combined use produces the greatest impact. This confirms the strategic value of integrated agricultural technology adoption as a pathway to achieving food security and sustainable agricultural transformation.

Empirical Findings

Regression analysis produced compelling results. For Hypothesis 1, the use of improved seeds/feeds showed a strong positive effect on crop yields ($R^2 = 0.507$, $\beta = 0.85$, $p < 0.001$), confirming that seed and feed enhancement directly contributes to productivity gains. Hypothesis 2 revealed that mechanization also significantly improved crop yields ($R^2 = 0.54$, $\beta = 0.74$, $p = 0.000$), indicating that labour-saving technologies can enhance efficiency and output. Hypothesis 3 found that digital agriculture—encompassing precision farming, data analytics, and ICT-based interventions—had a meaningful impact on yields ($R^2 = 0.49$, $\beta = 0.70$, $p = 0.003$), reinforcing the role of information and connectivity in modern farming. Lastly, Hypothesis 4 demonstrated that the combined use of improved seeds/feeds, mechanization, and digital agriculture explained a substantial proportion of variance in crop yields ($R^2 = 0.698$, $\beta = 0.42$ (Seeds), 0.33 (Mech.), 0.38 (Digital), $p < 0.001$), suggesting a synergistic effect when these innovations are adopted together.

Theoretical and Practical Implications

Theoretically, these findings align with the Diffusion of Innovations Theory and the Technology Acceptance Model, reinforcing the notion that perceived usefulness and tangible benefits drive adoption in agricultural settings. The study's results also validate aspects of the Sustainable Livelihoods Framework, where improved access to technology enhances the five capitals—human, natural, financial, social, and physical that underpin rural resilience.

From a practical perspective, the evidence highlights the urgent need for policymakers, agricultural extension services, and development agencies to prioritize integrated agricultural modernization strategies. The significant effect of combined innovations suggests that interventions should not be piecemeal but rather bundled, enabling farmers to simultaneously benefit from multiple technologies. Such an approach could optimize yield improvements, reduce production costs, and strengthen climate resilience.

Recommendations

1. **Policy Integration:** Governments should create enabling environments that promote the simultaneous adoption of improved seeds/feeds, mechanization, and digital agriculture.

2. **Extension Services Enhancement:** Agricultural extension programs should be restructured to deliver bundled technological solutions rather than isolated interventions.

3. **Financing Mechanisms:** Affordable credit facilities should be established to help smallholder farmers invest in these technologies.

4. **Digital Inclusion:** Investments in rural internet infrastructure are critical to scaling the benefits of digital agriculture.

5. **Public-Private Partnerships:** Collaboration between government agencies, private agribusinesses, and research institutions should be encouraged to develop context-specific, farmer-friendly innovations.

5.4 Contributions to Knowledge

This study makes several contributions to the field of agricultural development. First, it empirically demonstrates the synergistic benefits of combining improved seeds/feeds, mechanization, and digital agriculture, a finding that advances theoretical discussions on integrated innovation adoption. Second, it contributes to the growing body of evidence from developing economies, providing locally relevant data that can inform national agricultural policy in similar contexts. Third, it strengthens the case for multi-sectoral collaboration in driving agricultural modernization.

Suggestions for Further Studies

Future research could explore the long-term economic and environmental impacts of these combined agricultural innovations, including their role in climate change adaptation. Additionally, studies could examine farmer adoption behaviour using mixed-method approaches to capture both quantitative impacts and qualitative insights. Comparative studies across regions or countries could also shed light on contextual factors influencing adoption success. Finally, research into gender-specific adoption patterns could ensure that agricultural modernization benefits are equitably distributed.

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