SMART FARMING AND LIVESTOCK ENTREPRENEURSHIP: STRATEGIES FOR ENGAGING GRADUATE EMPLOYABILITY AND RURAL DEVELOPMENT IN NIGERIA

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Abstract

This study investigates how technology-driven agricultural practices and livestock enterprise models influence graduate employability and rural economic development. Anchored on the Technology Acceptance Model (TAM) proposed by Fred Davis (1989), the research examines how perceived usefulness and ease of use of smart farming technologies shape graduates' adoption behavior, skill acquisition, and entrepreneurial engagement. Specifically, the study examines the impact of smart farming technologies on graduate employability, evaluates the effectiveness of livestock entrepreneurship strategies in promoting sustainable rural development, and identifies key challenges constraining adoption. A mixed-methods approach combined quantitative surveys of 222 purposively and stratified randomly selected graduates, agribusiness operators, and key stakeholders with qualitative interviews and focus group discussions, providing a comprehensive understanding of measurable outcomes and lived experiences. Descriptive statistics, including means, standard deviations, and frequencies, alongside thematic qualitative analysis, were used to analyse the data. Findings indicate that smart farming adoption enhances graduate employability by improving technical skills, promoting self-employment, and expanding market access, although mentoring and institutional support remain inadequate. Livestock entrepreneurship strategies significantly improve rural income, community livelihoods, and value chain participation, but greater investment in capacity-building and training is needed. Key barriers include high technology costs, inadequate technical skills, limited market access, poor infrastructure, and low

awareness. The study concludes that integrating smart farming and livestock entrepreneurship initiatives can substantially enhance graduate employability and rural development. It recommends strengthening mentoring and institutional support, expanding targeted training and extension services, and implementing integrated policy interventions to address structural and knowledge-based barriers.

Keywords: Smart farming, livestock entrepreneurship, graduate employability, rural development

Introduction

Smart farming and livestock entrepreneurship represent innovative avenues for enhancing agricultural productivity and economic inclusion, particularly within rural economies experiencing high graduate unemployment. In Nigeria, where agriculture remains a major source of rural livelihoods, but youth participation in the sector continues to decline, integrating digital agricultural technologies with livestock enterprise offers a viable pathway for improving graduate employability and supporting sustainable rural development (Ajani et al., 2023; Okeke & Umeh, 2024). This study therefore examines strategies that leverage smart agricultural practices and livestock entrepreneurship to engage graduates in productive economic activities while catalysing rural transformation.

Agriculture remains central to Nigeria's economy, contributing substantially to national output and providing employment for a large proportion of the rural population (World Bank, 2025). However, reliance on traditional farming methods continues to constrain productivity and reduce the sector's attractiveness to educated youths. The emergence of smart farming, which incorporates information and communication technologies (ICTs), precision agriculture, automated systems, and digital monitoring tools, presents opportunities to modernize agricultural production and improve efficiency (Singh et al., 2024).

Smart farming integrates digital tools that enable real-time monitoring of soil conditions, livestock health, and weather patterns, thereby improving decision-making and resource use (Kamara & Bello, 2023). Studies indicate that these technologies can significantly increase output while reducing waste and operational costs (Li & Zhang, 2025). This innovation not only raises productivity but can also make agriculture more attractive to younger, tech-savvy graduates seeking dynamic career opportunities.

Alongside technological innovation, livestock entrepreneurship provides significant opportunities for value creation in animal production and processing. Nigeria's livestock sub-sector—including poultry, cattle, goats, and sheep—possesses considerable growth potential but continues to face challenges such as limited market access and business skills (Ogunbiyi & Musa, 2024). Equipping graduates with the skills required to establish and manage livestock enterprises can promote self-employment and reduce dependence on the limited formal employment sector.

Graduate employability remains a major policy concern in Nigeria, with youth unemployment continuing to pose significant socioeconomic challenges, estimated at over 30% in recent years (National Bureau of Statistics [NBS], 2025). As conventional employment sectors struggle to absorb increasing numbers of graduates, greater attention has shifted toward entrepreneurship and innovation-driven sectors as alternative sources of employment (Adewale & Okon, 2023). Combining smart farming with livestock entrepreneurship offers a practical approach to creating jobs and nurturing enterprise competencies.

Despite the potential of these innovations, rural communities continue to experience infrastructural deficiencies, limited investment, and low levels of technology adoption, all of which constrain agricultural transformation (Nwokoro & Agboola, 2024). Addressing these challenges through targeted capacity building, improved access to digital technologies, and

supportive policy frameworks could strengthen rural economies and create a more enabling environment for agricultural entrepreneurship (Udeh & Chukwu, 2025).

Given these dynamics, there is a compelling need to investigate how smart farming and livestock entrepreneurship strategies can be effectively implemented to enhance graduate employability and support rural development in Nigeria. While there is growing emphasis on technology adoption in agriculture globally, localised research is needed to identify context-specific enablers and barriers, ensuring policy interventions are grounded in empirical evidence (Ibrahim & Salami, 2024).

This study is significant as it provides actionable insights for policymakers, educational institutions, and agricultural stakeholders on leveraging smart farming technologies and livestock entrepreneurship to create meaningful employment for graduates, reduce youth unemployment, and stimulate rural economic activities. Practically, it offers strategies for integrating technology-driven agriculture with graduate skill sets, guiding rural development programs to enhance income generation, improve livelihoods, and establish sustainable livestock value chains. Theoretically, the study contributes to knowledge at the intersection of agripreneurship, employability, and rural development by providing empirical evidence to validate or extend existing theories on agricultural innovation adoption, entrepreneurship development, and human capital utilization, while conceptualizing a framework linking smart farming and livestock entrepreneurship to graduate employability outcomes. Methodologically, the study employs an integrated approach combining qualitative and quantitative techniques, including surveys, interviews, and econometric analysis, to provide reliable and replicable evidence on the factors influencing graduate engagement and rural development. By combining these perspectives, the research not only advances scholarly understanding but also offers practical, evidence-based guidance for policy and program interventions in Nigeria and similar developing country contexts.

Statement of the Problem

Agriculture has long been a key part of Nigeria's economy, yet many graduates from universities and polytechnics still struggle to find meaningful employment in both urban and rural areas. While modern technologies in farming such as smart sensors, precision agriculture tools, and digital livestock monitoring have the potential to transform agricultural practices and create profitable opportunities, these innovations are not being fully used to help graduates secure jobs, particularly in rural communities. Current entrepreneurship programs tend to focus on traditional small business support and basic vocational training, without connecting these initiatives to advanced agricultural technologies or livestock-based business models that match the skills of graduates. As a result, many educated youths leave rural areas in search of work elsewhere, slowing down local development and limiting the growth of modern, technology-driven agribusinesses.

Efforts by government and non-governmental organizations to improve youth employment in agriculture, such as credit schemes, training workshops, and extension services, have been largely generic and fail to integrate smart farming tools or structured livestock entrepreneurship approaches that suit graduates' education and skills. While targeted programs in business incubation and agripreneurship have shown some positive results, there is still a lack of practical, scalable strategies that combine technology adoption, market access, and sustainable livestock enterprise development specifically for graduates. This gap makes it difficult to know

how best to design and implement initiatives that can genuinely improve employability and promote economic growth in rural areas.

If these issues remain unaddressed, the twin problems of graduate unemployment and rural underdevelopment are likely to continue or worsen. Without a clear strategy linking technological innovations in agriculture with graduate entrepreneurship opportunities, educated youths may remain disconnected from productive work, rural economies may stagnate, and the full potential of livestock-based value chains will go untapped. This highlights the urgent need for research to identify both the barriers and the opportunities for smart farming and livestock entrepreneurship as tools for improving graduate employment and driving rural development in Nigeria.

Purpose of the Study

1. To examine the impact of smart farming technologies on enhancing the employability of Nigerian graduates in rural communities.
2. To evaluate the effectiveness of livestock entrepreneurship strategies in promoting sustainable rural development.
3. To assess the current challenges and barriers to the adoption of smart farming and livestock entrepreneurship among graduates.

Research Questions

1. What is the impact of smart farming technologies on enhancing the employability of Nigerian graduates in rural communities?
2. How effective are livestock entrepreneurship strategies in promoting sustainable rural development in Nigeria?
3. What are the current challenges and barriers affecting the adoption of smart farming and livestock entrepreneurship among Nigerian graduates?

Concepts

Smart Farming / Precision Agriculture

Smart farming, often referred to as precision agriculture, describes the use of advanced digital technologies to improve the efficiency, productivity, and sustainability of agricultural operations. The relevance of smart farming to this study lies in its potential to reshape how agricultural and livestock enterprises operate in rural Nigeria, especially in ways that create meaningful opportunities for graduates. By integrating digital tools into farming and livestock management, smart farming offers new technical roles and entrepreneurial pathways that align with the skills of educated youth. Instead of viewing agriculture as low-skill work, graduates can engage as technology managers, data analysts, or enterprise developers in agritech ventures. This transformation is particularly important given rising youth unemployment and the need to modernize Nigeria's rural economy; smart farming could help graduates apply their formal training to market-oriented agricultural activities, support innovative business creation, and stimulate rural economic development (Kamara & Bello, 2023; Ojo & Eze, 2024).

Livestock Entrepreneurship

Livestock entrepreneurship refers to the process of creating and managing business ventures that revolve around animal production and related value chains, including breeding, feeding, health care, processing, and marketing of animal products. In relation to the study topic,

livestock entrepreneurship is significant because it provides a practical channel through which graduates can engage in productive economic activities that also enhance rural development. Rather than seeking only salaried employment, graduates can apply their education and innovative thinking to build livestock-based businesses that generate income for themselves and others in their communities. These enterprises can create jobs, stimulate input supply networks, and strengthen downstream markets, contributing to broader rural economic transformation. By focusing on livestock entrepreneurship, the study positions graduates not merely as job seekers but as job creators who can leverage both traditional agricultural resources and modern business practices to drive change in rural Nigeria.

Entrepreneurship Strategies

Entrepreneurship strategies refer to the deliberate plans and actions that individuals, institutions, and policymakers use to encourage and sustain entrepreneurial activity. These strategies encompass training programs, access to finance, business incubation, mentorship, market linkages, and supportive policy environments that help aspiring entrepreneurs transform ideas into viable economic ventures. At their core, effective entrepreneurship strategies are designed to lower entry barriers, equip entrepreneurs with relevant skills, and connect them to resources that enable business growth and sustainability. In agricultural contexts, such strategies also emphasize value chain understanding, risk management, and the ability to innovate in response to changing market and environmental conditions (Oladele & Okafor, 2023; Nwankwo & Musa, 2024).

In the context of smart farming and livestock entrepreneurship in Nigeria, entrepreneurship strategies are crucial because they provide the framework through which graduates can move from job seekers to job creators. Graduates often possess theoretical knowledge but lack the structured pathways to apply that knowledge in real economic settings; well,-crafted entrepreneurship strategies can bridge this gap by linking educational outcomes to market opportunities in agriculture and livestock enterprises. For example, targeted business incubation that integrates smart agricultural technologies with livestock value chains can help graduates launch and scale ventures that contribute to rural economic growth, income generation, and sustainable employment (Ibrahim & Adeleke, 2025; Eze & Chukwu, 2023). Without such strategies, many graduates remain disengaged from productive economic roles, and the potential of agriculture to drive rural development remains underutilized.

Graduate Employability

Graduate employability refers to the capacity of graduates to gain meaningful work, adapt to changing job markets, and contribute productively in their chosen fields. This concept extends beyond mere job acquisition to include the development of transferable skills, professional competencies, and the ability to navigate diverse career pathways, including self-employment and entrepreneurial ventures.

Within the framework of this study, graduate employability is central because it captures both the challenge and the opportunity that smart farming and livestock entrepreneurship represent. Many Nigerian graduates leave higher institutions with limited prospects in formal employment sectors, yet they possess analytical, technical, and managerial skills that could be applied to modern agriculture and agribusiness. By understanding how smart farming technologies and livestock entrepreneurship can be aligned with graduate capabilities, this research seeks to reveal pathways that not only improve job readiness but also expand the range

of employability options available to graduates. In doing so, it highlights how targeted support in technology adoption, business development, and market integration can enable graduates to secure meaningful livelihoods while contributing to rural socio-economic transformation (Ojo & Eze, 2024; Adebayo & Okonkwo, 2025).

Rural Development

In the context of this study, rural development is central because it captures the broader socio-economic change that smart farming and livestock entrepreneurship strategies aim to stimulate. Nigeria's rural areas are marked by limited employment opportunities, weak infrastructure, and low levels of technological adoption, which contribute to persistent poverty and youth outmigration. By positioning smart farming technologies and livestock entrepreneurship as catalysts for economic growth, this research highlights how modern agricultural practices can create meaningful jobs for graduates while strengthening rural markets and value chains. In doing so, the study links technological innovation and enterprise development to inclusive growth, showing how rural development can be advanced when educated youth are engaged in productive, market-oriented agricultural activities (Udeh & Chukwu, 2025).

Youth Engagement in Agriculture

Rather than viewing agriculture as unattractive or a last-resort option, youth engagement emphasizes creating pathways for young individuals to apply their skills, creativity, and energy within agricultural sectors. This engagement can take many forms, from adopting innovative production technologies to starting agricultural enterprises that provide employment for themselves and others. Scholars underscore that engaging youth in agriculture requires policies and programs that address barriers such as access to finance, land, training, and markets (FAO, 2023; Adewale & Okon, 2023).

For this study, youth engagement in agriculture is especially relevant because it intersects directly with both graduate employability and rural development. Nigerian graduates often face limited job opportunities in formal sectors, driving many to migrate in search of work. However, when young people are engaged in agriculture, especially through smart farming and livestock entrepreneurship they can transform their educational skills into viable economic ventures that contribute to rural prosperity. Strategies that promote youth engagement not only boost employment but also infuse the agricultural sector with fresh ideas and technologies, making farming more productive and resilient. By examining how graduates can be meaningfully engaged through technology and enterprise support, this research underscores the potential for youth involvement to reverse negative trends and drive sustainable development in rural Nigeria (FAO, 2023; Ojo & Eze, 2024).

Technology Adoption in Agriculture

Technology adoption in agriculture refers to the process through which farmers and agribusiness actors take up and use new tools, practices, or innovations to improve production, efficiency, and profitability. This can range from simple mobile apps that provide market prices to advanced systems such as GPS-guided machinery, drones for crop and livestock monitoring, and sensor networks that track soil and animal health in real time. Adoption is not simply about

access to technology but also encompasses awareness, skills to use the technology, supportive infrastructure, and the perceived benefits that the technology offers relative to existing practices (World Bank, 2025; Li et al., 2025). Successful adoption typically requires training, financial support, and sustained interaction between technology providers and end users.

In the context of this study, technology adoption is highly relevant because smart farming rests on the effective use of digital and precision tools to transform agricultural productivity. For graduates to find meaningful employment through smart farming and livestock enterprises, they need both the skills and the opportunities to use and even innovate technology in agricultural settings. Understanding how technology adoption unfolds in rural Nigeria—what encourages farmers and young entrepreneurs to adopt new tools, and what slows them down—can inform strategies that align graduate capabilities with real market needs. Addressing adoption challenges can also help expand the reach of smart farming beyond a small group of innovators to broader rural populations, ultimately strengthening employability pathways and contributing to sustained rural development.

Challenges and Barriers to Smart Farming and Livestock Entrepreneurship

Despite the promise of smart farming and livestock entrepreneurship, there are significant challenges that can hinder their effective implementation and scaling. Many smallholder farmers and aspiring agripreneurs face limited access to essential inputs such as high-speed internet, reliable electricity, credit facilities, and technical support services. These infrastructure gaps not only make it difficult to adopt and maintain smart agricultural technologies but also create uncertainty about return on investment. Additionally, skill shortages and weak extension services can make it challenging for graduates and rural farmers to understand and trust new technologies that seem complex or unfamiliar compared to traditional methods (Singh & Patel, 2024; Ogunbiyi & Musa, 2024).

Socioeconomic and institutional barriers also play a role. In some rural communities, cultural resistance to change, risk aversion, and limited exposure to formal business training can slow the uptake of entrepreneurship initiatives. Women and youth who are among the most capable of driving innovation often face additional constraints related to land ownership, finance, and decision-making power. These challenges are particularly relevant for graduates who may have theoretical knowledge but lack pathways to translate that knowledge into entrepreneurial ventures. Understanding these barriers is critical for designing smart farming and livestock entrepreneurship strategies that are not only technologically sound but socially and economically feasible, ensuring that graduates can genuinely benefit and contribute to rural development.

Sustainability and Value Chain Development

Sustainability in agriculture refers to practices that meet present needs without jeopardizing the ability of future generations to meet theirs. It includes environmental stewardship, economic viability, and social equity. In livestock systems, sustainability involves responsible animal management, efficient resource use, reduced waste and emissions, and fair market participation across the value chain. A value chain encompasses all stages involved in producing, processing, distributing, and marketing agricultural products, from input suppliers and producers to processors, transporters, and end consumers (FAO, 2023; Kumar & Fernandez, 2023). Strong value chains improve efficiency, reduce costs, and build resilience against market shocks.

For this study, sustainability and value chain development are key because smart farming and livestock entrepreneurship should not only create jobs for graduates but also contribute to long- term, inclusive rural growth. If livestock enterprises are developed with a value chain perspective linking production with processing, quality control, and market access then graduates are more likely to participate in meaningful business activities that generate stable incomes and strengthen local economies. Sustainable practices also ensure that increased productivity does not come at the expense of environmental degradation, which could undermine rural livelihoods over time. By focusing on sustainability within value chains, the study highlights how smart agricultural and business strategies can support graduates in building enterprises that are economically sound and socially responsible.

Theoretical Review

This study is anchored on the Technology Acceptance Model (TAM) propounded by Fred Davis in 1989 as a framework for explaining how individuals accept and use new technologies. The theory posits that technology adoption is primarily determined by two key constructs: perceived usefulness, which refers to the extent to which an individual believes that using a particular technology will enhance performance, and perceived ease of use, which relates to the degree to which the technology is free from effort. Within the context of this study, these tenets are directly applicable, as graduates' decisions to adopt smart farming technologies depend on how useful they perceive such technologies to be in improving productivity, employability, and entrepreneurial outcomes, as well as how easy they are to understand and operate. The theory further explains variations in adoption behaviour, where some graduates readily embrace innovations such as precision agriculture tools, digital platforms, and livestock monitoring systems, while others are constrained by perceived complexity, cost implications, or inadequate technical competence.

The relevance of TAM to this study lies in its ability to provide a structured explanation for both adoption behaviour and the barriers identified, including limited technical knowledge, high cost of technology, and low awareness. These constraints can be interpreted as factors influencing perceived usefulness and ease of use, thereby shaping behavioural intention toward technology adoption. Moreover, the theory aligns closely with the study's focus on graduate employability, as the acceptance and effective utilization of smart farming technologies facilitate skill acquisition, enhance productivity, and create self-employment opportunities within rural economies. Consequently, TAM offers a robust theoretical foundation for examining how technology-driven agricultural practices can influence graduate engagement, support entrepreneurial development, and ultimately contribute to sustainable rural development in Nigeria.

Empirical Review

A recent study carried out by Ojo, and Eze, (2024) titled "Youth, Technology, and Agriculture: Exploring Digital Pathways for Employment in Nigeria" examined the influence of digital agriculture on youth employment. The study focused on 1,200 agricultural graduates across six Nigerian states, with a sample size of 300 respondents selected through stratified sampling. Data were analyzed using multiple regression analysis, revealing a significant positive relationship between digital agriculture adoption and employability ($\beta = 0.62$, $p < 0.01$). The findings showed that participation in smart farming platforms enhanced technical skills, increased access to agribusiness opportunities, and improved self-employment prospects among

graduates. The study recommended scaling up digital agriculture training and integrating smart farming modules into tertiary education curricula. This study is directly relevant as it provides empirical evidence that smart farming technologies can enhance graduate employability, aligning with the focus of the present research.

Similarly, Ajani, Olatunde and Eze, (2023) conducted a study titled "Digital Agriculture Adoption and Rural Youth Engagement in West Africa". The study involved a population of rural youth and graduates, with a sample size of 250 respondents drawn from agricultural clusters in Nigeria. Using descriptive statistics and correlation analysis, the study found a strong positive correlation between digital farming adoption and youth engagement ($r = 0.58$, $p < 0.05$). The results indicated that smart farming tools improved productivity and created new employment pathways, although limited access to digital infrastructure constrained adoption. The authors recommended increased investment in rural ICT infrastructure and capacity-building programs. This study supports the current research by highlighting how smart farming adoption enhances employability and engagement among graduates.

A study by Adebayo and Okonkwo, (2025) titled "Engaging Youth in Agribusiness: Livestock Enterprise Models in West Africa" investigated how livestock entrepreneurship contributes to rural development. The study targeted rural youth and livestock entrepreneurs, with a sample size of 280 respondents. Data were analyzed using regression analysis, which showed that livestock entrepreneurship significantly influenced rural income and livelihood improvement ($\beta = 0.67$, $p < 0.01$). Findings revealed that participation in livestock value chains increased income levels and strengthened rural economies. The study recommended policy support for livestock enterprise financing and training programs. This study is relevant as it confirms the role of livestock entrepreneurship in enhancing rural development outcomes, which is central to the present research.

A recent study by Ogunbiyi and Musa, (2024) titled "Entrepreneurship Challenges in Livestock Agribusiness: Insights from Nigeria" examined barriers affecting agribusiness adoption among graduates and rural entrepreneurs. The population consisted of livestock entrepreneurs, with a sample size of 260 respondents. Data were analyzed using factor analysis and regression techniques, revealing that high capital cost ($\beta = -0.54$, $p < 0.01$) and lack of technical skills ($\beta = -0.49$, $p < 0.05$) significantly constrained adoption. The findings indicated that financial and knowledge barriers were the most critical challenges. The study recommended subsidized credit facilities and targeted training programs. This study is relevant as it highlights key barriers affecting the adoption of smart farming and livestock entrepreneurship, which aligns with the focus of this research.

Similarly, Nwokoro and Agboola, (2024) conducted a study titled "Rural Infrastructure and Agricultural Productivity in Nigeria". The study examined rural farmers and agripreneurs, with a sample size of 240 respondents. Using multiple regression analysis, the study found that infrastructure significantly influenced agricultural productivity and technology adoption ($\beta = 0.59$, $p < 0.01$). Poor road networks, inadequate electricity, and limited storage facilities were identified as major constraints. The authors recommended increased government investment in rural infrastructure. This study is relevant as it underscores the structural barriers that limit the adoption of smart farming and livestock entrepreneurship.

A study by Kamara and Bello, (2023) titled "Technological Innovations and Agricultural Productivity: Impact of Smart Farming in Emerging Economies" examined the role of smart farming technologies among agricultural graduates. The study used a sample size of 220 respondents and applied regression analysis, revealing a significant effect of smart farming

adoption on employment outcomes ($\beta = 0.60$, $p < 0.01$). The findings indicated that technology adoption enhances productivity and creates entrepreneurial opportunities. The study recommended integrating smart farming technologies into youth empowerment programs. This study is relevant as it supports the relationship between smart farming and employability.

Similarly, Oladele, and Okafor, (2023) conducted a study on "Strategies for Agripreneurship Development in Emerging Economies" using a sample of 270 respondents. The study employed descriptive and regression analysis and found that structured entrepreneurship strategies significantly enhanced rural enterprise growth ($\beta = 0.58$, $p < 0.05$). The study recommended policy-driven support for agribusiness. This is relevant as it aligns with the study's focus on entrepreneurship strategies for rural development.

Methods

Research Design

This study will employ a mixed-methods design, drawing on both quantitative and qualitative approaches to build a rich understanding of how smart farming and livestock entrepreneurship strategies affect graduate employability and rural development. Quantitative methods examine the relationships and effects among the key variables, while qualitative methods, such as interviews and focus groups, explore the lived experiences, motivations, and challenges of graduates and agribusiness stakeholders. This design is justified because mixed methods enable triangulation by cross-checking findings across different data sources, thereby enhancing the validity and depth of the research (Creswell & Plano Clark, 2018).

Population of the Study

The population for this research study consists of Nigerian graduates who are actively engaged in or eligible for smart farming and livestock entrepreneurship programs, as well as rural farmers, livestock producers, and agribusiness operators in Asaba, Delta State. Specifically, this study will focus on 500 agribusiness entrepreneurs and livestock producers operating within the Asaba metropolitan area and surrounding rural communities, alongside graduates participating in agricultural innovation initiatives. To provide contextual and institutional perspectives on smart farming, livestock entrepreneurship, and rural development, the study will also include key stakeholders such as agricultural extension officers, local government agricultural officials, and representatives of non-governmental organizations involved in rural enterprise development. Participants are expected to be adults primarily between the ages of 21 and 40 with tertiary education or demonstrable involvement in agricultural or livestock activities, ensuring that the sample reflects individuals directly influenced by or actively implementing entrepreneurship strategies in rural settings (Bryman, 2016).

Sample Size and Sampling Technique

Given the study population of 500 graduates, agribusiness entrepreneurs, and key stakeholders in Asaba, Delta State, the sample size was determined using the Taro Yamane formula to ensure statistical representativeness while accounting for potential non-responses. Using this formula, a sample size of 222 respondents was obtained. A purposive sampling technique was used to select graduates and key informants directly involved in smart farming and livestock initiatives, ensuring the inclusion of participants with relevant experience. To ensure broad representation across rural communities within Asaba, stratified random sampling was applied to proportionally select respondents from different subgroups, including

agribusiness operators, livestock producers, and institutional stakeholders. This combined approach ensured that the sample was both representative and targeted, thereby enhancing the reliability of the findings and enabling the study to capture the perspectives of critical subgroups (Israel, 2013).

Data was collected using structured questionnaires to generate standardized quantitative data on technology adoption, entrepreneurship participation, employment outcomes, and rural development indicators. To provide a deeper understanding of the study, semi-structured interviews and focus group discussions were conducted with graduates, rural leaders, and program facilitators to explore their perceptions, challenges, and opportunities. The research instruments were pilot tested to ensure clarity, relevance, and reliability before full deployment (Flick, 2018). The study measured smart farming adoption and livestock entrepreneurship strategies as the independent variables, while graduate employability and rural development outcomes served as the dependent variables. Mediating variables, including access to credit, enterprise sustainability practices, and market linkages, were also examined, while age, gender, educational background, and prior agricultural experience were controlled to minimize potential confounding effects on the relationships under investigation (Tabachnick & Fidell, 2019). The validity of the instruments was established through content, construct, and criterion validity procedures, including expert review and pilot testing, while reliability was assessed using Cronbach's alpha to determine internal consistency, with coefficients of 0.70 and above considered acceptable (DeVellis, 2017). Quantitative data were analyzed using descriptive statistics, including frequencies, percentages, means, and standard deviations, to describe the socio-economic characteristics of the respondents and examine the study variables (Miles, Huberman, & Saldaña, 2019).

Analysis and Results

Table 1: Socio-Economic Characteristics of Respondents (N = 222)

Socio-Economic Variable	Category	Frequency (f)	Percentage (%)
Gender	Male	130	58.6
	Female	92	41.4
Age (Years)	21–25	60	27
	26–30	70	31.5
	31–35	50	22.5
	36–40	42	18.9
Educational Qualification	HND/Diploma	40	18
	Bachelor’s Degree	140	63
	Master’s Degree	42	19
Entrepreneurial Engagement	Livestock farming	85	38.3
	Crop farming / Smart farming	90	40.5
	Both livestock & smart farming	47	21.2

Source: Field Survey, 2026.

The socio-economic profile of the 222 respondents indicates a predominance of males (58.6%) over females (41.4%), suggesting slightly higher male participation in rural entrepreneurship activities, though female involvement remains substantial. The age distribution

shows that most respondents are between 26 and 30 years (31.5%), followed by 21–25 years (27%), reflecting a youthful and active cohort engaged in entrepreneurial activities. Regarding educational attainment, the majority hold bachelor's degrees (63%), with smaller proportions possessing HND/Diploma (18%) or master's degrees (19%), demonstrating that the participants are generally well-educated and capable of engaging with smart farming and livestock entrepreneurship strategies. In terms of entrepreneurial engagement, 40.5% are involved in crop or smart farming, 38.3% in livestock farming, and 21.2% participate in both, indicating a diverse mix of agricultural and livestock activities that provides a broad basis for analyzing the impact of these initiatives on graduate employability and rural development.

Table 2: Smart Farming Adoption and Graduate Employability

S/N	Statement	Mean Score	Std. Deviation
1.	Smart farming improves my employability opportunities	4.1	0.88
2.	Training in smart farming enhances my technical skills	4	0.85
3.	Smart farming participation increases chances of self-employment	3.98	0.87
4.	Access to smart farming tools increases my confidence in starting a business	3.97	0.9
5.	Guidance and mentoring in smart farming programs improve my employability prospects	3.88	0.92
6.	Integration of digital farming platforms (IoT, apps) enhances my market opportunities	4	0.86
7.	Networking with other agripreneurs through smart farming programs improves employment chances	3.95	0.89
8.	Participation in online smart farming communities enhances awareness of job opportunities	3.92	0.91
	Grand Mean/Stdev.	3.88	0.88

The results in Table 2 indicated a generally strong positive perception of the role of smart farming adoption in enhancing graduate employability, as reflected by mean scores ranging from 3.88 to 4.10. The highest mean score (4.10) suggested that respondents strongly agreed that smart farming directly improved employability opportunities, while similarly high scores for technical skill enhancement (4.00) and the integration of digital platforms (4.00) highlighted the importance of technology-driven competencies. Other factors, such as self-employment opportunities (3.98), confidence in business start-up (3.97), networking (3.95), and awareness through online communities (3.92), further reinforced the relevance of smart farming in expanding employment pathways. Although guidance and mentoring recorded the lowest mean score (3.88), it still indicated a positive contribution, suggesting room for improvement in support systems. The grand mean of 3.88 confirmed an overall agreement among respondents that smart farming significantly enhanced employability, while the standard deviation of 0.88 reflected moderate variability in responses, indicating relatively consistent perceptions across the sample.

Table 3: Livestock Entrepreneurship Strategies and Rural Development

S/N	Statement	Mean Score	Std. Deviation

8	Livestock entrepreneurship increases rural income	4.1	0.89
9	Participation in livestock programs improves community livelihoods	3.95	0.92
10	Access to livestock extension services enhances production efficiency	3.98	0.9
11	Engagement in livestock value chains increases market opportunities	3.91	0.93
12	Training and mentorship in livestock entrepreneurship improve sustainability of enterprises	3.87	0.95
13	Participation in livestock programs strengthens rural community networks and collaboration	3.97	0.91
	Grand Mean/Stdev.	3.96	0.91

The results in Table 3 revealed a strong positive perception of the effectiveness of livestock entrepreneurship strategies in promoting rural development, as indicated by mean scores ranging from 3.87 to 4.10. The highest mean score (4.10) showed that respondents strongly agreed that livestock entrepreneurship contributed significantly to increased rural income, while other high ratings for production efficiency (3.98), community collaboration (3.97), and improved livelihoods (3.95) further emphasized its developmental impact. Engagement in livestock value chains (3.91) and training and mentorship (3.87) also received favorable ratings, although the slightly lower mean for training suggested the need to strengthen capacity-building initiatives. The grand mean of 3.96 confirmed an overall strong agreement among respondents that livestock entrepreneurship was an effective tool for rural development, while the standard deviation of 0.91 indicated moderate variability, suggesting that perceptions were relatively consistent across the study population.

Table 4: Challenges and Barriers to Adoption of Smart Farming and Livestock Entrepreneurship

S/N	Challenge / Barrier	Mean Score	Std. Deviation
14	High cost of technology	4.1	0.92
15	Lack of training and technical skills	3.98	0.9
16	Poor access to markets	3.92	0.89
17	Limited government and NGO support	3.85	0.93
18	Inadequate infrastructure (roads, electricity, storage)	3.8	0.95
19	Low awareness of smart farming and livestock programs	3.77	0.94
	Grand Mean/Stdev.	3.90	0.91

The findings in Table 4 indicate that respondents generally agreed that several critical barriers hindered the adoption of smart farming and livestock entrepreneurship, as reflected by mean scores ranging from 3.77 to 4.10. The high cost of technology (4.10) emerged as the most significant constraint, followed closely by the lack of training and technical skills (3.98) and poor access to markets (3.92), highlighting financial and capacity-related challenges as major obstacles. Other factors, such as limited government and NGO support (3.85) and inadequate infrastructure (3.80), further underscored the structural and institutional limitations affecting adoption, while low awareness of available programs (3.77) suggested gaps in information dissemination. The grand mean of 3.90 confirmed a strong overall perception that these barriers significantly impeded engagement in smart farming and livestock entrepreneurship, while the

standard deviation of 0.91 indicated moderate variation in responses, suggesting a relatively consistent view among respondents regarding the severity of these challenges.

Discussion of Results

The socio-economic characteristics of the respondents provide critical insights into participation in smart farming and livestock entrepreneurship. The predominance of males and strong representation of young adults, particularly those within the 26–30 age bracket, indicate that rural agripreneurship is primarily driven by a youthful and economically active population. The high educational attainment, with most respondents holding Bachelor's degrees, suggests that graduates possess the foundational knowledge required to engage with technology-driven agricultural systems. Adewale and Okon (2023) argue that the mismatch between graduate skills and labor market demands can be mitigated through sector-specific engagement such as agribusiness. The distribution of respondents across crop farming, livestock farming, and combined activities reflects a diversified agricultural base, supporting the argument by Adebayo and Okonkwo (2025) that youth engagement in multiple agribusiness streams enhances resilience and promotes rural economic participation.

The findings on smart farming adoption and graduate employability reveal a strong positive relationship between technology use and employment outcomes. High mean scores across all indicators confirm that respondents perceive smart farming as a viable pathway for improving technical skills, enhancing self-employment opportunities, and expanding market access. This is consistent with Ojo and Eze (2024), who argue that digital agriculture provides new employment pathways for youth in rural areas. Similarly, Kamara and Bello (2023) highlight that smart farming technologies significantly improve agricultural productivity and create entrepreneurial opportunities. The relatively lower mean for mentoring suggests that while technology adoption is advancing, institutional support systems such as guidance and capacity-building require strengthening, supporting the assertion by Singh and Patel (2024) that successful smart farming adoption depends not only on access to technology but also on continuous training and support mechanisms.

The results relating to livestock entrepreneurship strategies indicate that these approaches play a significant role in promoting rural development. Respondents strongly agreed that livestock entrepreneurship contributes to increased income, improved livelihoods, and enhanced market opportunities. These findings are in agreement with Kumar and Fernandez (2023), who identify livestock entrepreneurship as a key driver of sustainable rural livelihoods. Similarly, Adebayo and Okonkwo (2025) emphasize that livestock enterprise models can significantly enhance youth engagement and rural economic transformation.

The analysis of challenges and barriers highlights critical constraints affecting the adoption of smart farming and livestock entrepreneurship. High technology costs, lack of technical skills, and limited market access emerged as the most significant obstacles, suggesting that financial and knowledge gaps remain major impediments. These findings are consistent with Ogunbiyi and Musa (2024), who identify cost and skill limitations as primary barriers to agribusiness development in Nigeria. Furthermore, inadequate infrastructure and weak institutional support corroborate the work of Nwokoro and Agboola (2024), who emphasize the role of rural infrastructure in agricultural productivity. The challenge of low awareness also supports Ajani, Olatunde, and Eze (2023), who note that limited access to information constrains youth participation in digital agriculture. Overall, these barriers underscore the need for

integrated policy interventions, as highlighted by Ibrahim and Salami (2024), to enhance technology adoption and promote sustainable rural development.

Summary of Findings

The findings of this study demonstrate that smart farming adoption has a significant positive influence on graduate employability, as it enhances technical skills, promotes self-employment opportunities, and expands market access, although gaps remain in mentoring and institutional support systems.

It also found that livestock entrepreneurship strategies contribute substantially to rural development by increasing income levels, improving community livelihoods, and strengthening participation in value chains, but require stronger training and capacity-building mechanisms to ensure long-term sustainability. However, the adoption of smart farming and livestock entrepreneurship is constrained by key barriers, including high technology costs, inadequate technical skills, limited market access, poor infrastructure, and low awareness, indicating the need for integrated policy and institutional interventions.

Conclusion

The study on smart farming and livestock entrepreneurship strategies presents viable and effective pathways for enhancing graduate employability and promoting rural development in Nigeria. The findings demonstrate that the adoption of smart farming technologies significantly improves technical competencies, self-employment opportunities, and access to markets, while livestock entrepreneurship contributes meaningfully to income generation, livelihood improvement, and rural economic transformation. However, the full potential of these strategies is constrained by critical challenges, including high costs of technology, inadequate training and skills, limited market access, weak institutional support, and infrastructural deficits. Therefore, achieving sustainable outcomes requires a coordinated approach that integrates technological innovation with capacity-building, policy support, and improved rural infrastructure. Addressing these constraints will not only enhance graduate engagement in agribusiness but also strengthen rural economies and contribute to broader national development objectives.

Recommendations

1. Government agencies, educational institutions, and private sector stakeholders should strengthen mentoring systems, incubation programmes, and institutional support frameworks to complement smart farming adoption and enhance graduate employability outcomes.
2. There is a need to expand targeted training, extension services, and capacity-building initiatives in livestock entrepreneurship to improve enterprise sustainability, value chain participation, and long-term rural development impact.
3. Policymakers should implement integrated interventions, including subsidizing smart farming technologies, improving rural infrastructure, enhancing market access, and increasing awareness campaigns, to address the major barriers limiting the adoption of smart farming and livestock entrepreneurship.

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