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Exploring Stakeholders' Perspectives on the Role of Digital Innovation in Enhancing Agricultural Supply Chain Sustainability in Nigeria

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Abstract: The sustainability of agricultural supply chains is increasingly influenced by digital advancements, particularly in developing countries like Nigeria, where agriculture plays a vital role in livelihoods and food security. This research examines the perspectives of various stakeholders on the impact of digital technologies on enhancing the sustainability of agricultural supply chains in Nigeria. A qualitative methodology was employed to gather data through interviews and focus group discussions that included farmers, agritech business owners, policymakers, and financial institutions. Thematic analysis highlighted three main results: (i) digital platforms improve market access, financial inclusion, and the efficiency of supply chains, (ii) collaboration among stakeholders is essential for scaling and integrating digital solutions, and (iii) sustainability benefits are noticeable through reduced post-harvest losses, increased productivity, and stronger climate resilience, although challenges related to inclusivity continue to exist. The study concludes that, although digital innovation has significant transformative potential, obstacles such as infrastructural deficits, the digital divide, and policy gaps are critical challenges. It suggests expanding digital infrastructure, enhancing partnerships among stakeholders, and developing inclusive digital literacy initiatives to promote equitable and sustainable agricultural growth.

Keywords: Digital innovation, Agricultural supply chain, Sustainability, Stakeholder perspectives, Nigeria, Blockchain, Mobile platforms, Precision agriculture, Collaboration, Food security.

I. Introduction

Agriculture is a crucial industry in Nigeria, contributing over 20% to the country's Gross Domestic Product (GDP) and providing the primary livelihood for approximately 70% of the population (World Bank, 2023). In addition to its economic importance, agriculture is vital for national food security (Magaji & Musa, 2024), job creation (Magaji & Adamu, 2011), and poverty reduction (Magaji et al., 2022). Nevertheless, despite its significance, the agricultural sector is largely underdeveloped, marked by structural inefficiencies in production, storage, distribution, and marketing (Magaji & Yisa, 2023). An estimated 30–40% of total annual production is lost post-harvest, primarily due to insufficient infrastructure, poor storage capabilities, weak market connections, and inefficiencies throughout the supply chain (FAO, 2022). These ongoing issues not only weaken farmers' incomes but also affect food availability, nutritional security, and broader efforts to achieve sustainable development in Nigeria.

Recently, the rapid advancement of digital technologies has created new possibilities to address these systemic inefficiencies. Digital solutions such as mobile financial services, blockchain for traceability, geographic information systems, precision agriculture tools, remote sensing technology, and e-commerce platforms have emerged as essential facilitators for agricultural transformation worldwide (Abdullahi, Magaji, & Musa, 2024). These innovations can lower transaction costs, reduce information asymmetry, enhance transparency, and improve coordination among supply chain participants (Nejo, Magaji, & Musa, 2025). For smallholder farmers, who constitute a significant segment of Nigeria's agricultural sector, digital innovations can provide access to markets, credit, weather data, and extension services, thereby enhancing productivity, strengthening their bargaining power, and reducing vulnerability to shocks. On a larger scale, these technologies can also promote environmentally sustainable practices by encouraging resource efficiency, traceability, and adherence to climate-smart standards (Magaji & Eke, 2015).

However, mere access to digital innovations does not ensure their adoption or long-lasting impact. The perceptions, readiness, and adaptive capacity of various stakeholders significantly affect the spread and scaling of such technologies in Nigeria's agricultural sector. These stakeholders include farmers, cooperatives, traders, processors, policymakers, technologists, and development agencies each with unique priorities, challenges, and levels of digital proficiency (Musa, Ismail & Magaji, 2025). For example, while tech developers may focus on efficiency and innovation, smallholder farmers might prioritise cost, ease of use, and trustworthiness of the system. Similarly, policymakers may be concerned with regulatory frameworks and infrastructure improvements, while agribusinesses may highlight the importance of supply chain efficiency and consumer confidence.

Consequently, it is crucial to understand how these stakeholders perceive the significance, functionality, risks, and benefits of digital tools, ensuring that innovations are not only technically feasible but also socially accepted and tailored to the specific context. Additionally, stakeholder perceptions often influence the adoption rates and determine the conditions necessary for scalability. Concerns regarding potential risks associated with data privacy, cost-effectiveness, infrastructure challenges, and trust in digital platforms can greatly influence user behaviour. On the other hand, favourable views related to transparency, enhanced

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profitability, and better market accessibility can act as powerful motivators for adoption. Therefore, gaining insights into stakeholder perspectives provides a valuable approach to exploring both the opportunities and challenges that digital innovation offers for the sustainability of agricultural supply chains in Nigeria.

The sustainability of agricultural supply chains in Nigeria is not merely an economic necessity but also an environmental and social one. As concerns about climate change, land degradation, and population growth intensify, the need to create efficient, resilient, and sustainable agricultural systems has grown significantly. Digital innovations present potential solutions, but their effectiveness is contingent mainly upon inclusive strategies that close the digital gap, tackle gender and youth disparities regarding access, and promote supportive policies and infrastructure. In the absence of such inclusivity, the risk of exacerbating inequalities within the agricultural sector remains considerable.

In this context, this paper examines the perspectives of stakeholders on the role of digital innovation in promoting sustainability within Nigeria's agricultural supply chains. More specifically, it aims to analyse the perceived opportunities, challenges, and necessary conditions for optimising the benefits of digital technologies in agriculture. By highlighting stakeholder viewpoints, the research aims to inform policy discussions about how digital transformation can be utilised for sustainable agricultural progress. The anticipated findings will provide essential insights for policymakers, development partners, agribusinesses, and technology providers seeking to create context-specific interventions that promote inclusivity, efficiency, and long-term resilience in Nigeria's agricultural supply chains.

II. Literature Review

Defining Agricultural Supply Chain Sustainability

Agricultural supply chain sustainability refers to the ability of agricultural systems to deliver value to stakeholders while ensuring long-term economic viability, environmental conservation, and social well-being. As noted by Seuring and Müller (2008), a sustainable supply chain emphasises not only operational efficiency and cost minimisation but also ethical sourcing, environmental responsibility, and equitable benefits for both producers and consumers. In agricultural settings, this entails minimising waste along the value chain, ensuring fair trade practices, bolstering rural livelihoods, and reducing ecological footprints through responsible production and distribution practices.

In Nigeria, the agricultural supply chain faces numerous sustainability-related challenges. Inadequate rural infrastructure, such as roads, storage facilities, and irrigation systems, significantly obstructs the transportation of goods from farms to markets, leading to elevated transaction costs and post-harvest losses. Weak linkages between farmers and markets further restrict the bargaining power and income stability of smallholder farmers, making them susceptible to exploitation by intermediaries. Moreover, the threats posed by climate variability and environmental degradation compromise long-term productivity, as increasing instances of drought, flooding, and soil depletion endanger food systems (FAO, 2022). These circumstances underscore the pressing need for innovative solutions that can reinforce agricultural supply chains while harmonising the three pillars of sustainability: economic, environmental, and social.

Additionally, the understanding of sustainability in agriculture goes beyond simply production efficiency to encompass issues of inclusivity and equity. For instance, smallholder farmers, who represent the majority in Nigeria's agricultural landscape, often encounter structural disadvantages, including restricted access to credit, market information, and modern technologies. Without focused interventions, the strive for sustainable supply chains may inadvertently heighten inequalities. Therefore, a viable sustainability framework must address both systemic inefficiencies and social inequalities, ensuring that marginalised groups, such as women and young people, are fully integrated into the agricultural economy.

Digital Innovation in Agriculture

Digital innovation has emerged as a decisive factor in tackling numerous inefficiencies that hinder agricultural supply chains. In a broad sense, digital innovation encompasses the introduction of new technologies, including mobile apps, big data analytics, blockchain, geographic information systems (GIS), remote sensing, and precision agriculture tools, to enhance efficiency, transparency, and resilience in agricultural practices (Klerkx et al., 2019). The primary advantage of digital agriculture is its ability to mitigate information disparities, reduce transaction costs, and optimise resource utilisation while promoting inclusive participation in agricultural markets.

Worldwide, the implementation of digital agriculture has led to significant advancements. For instance, real-time weather forecasts and remote monitoring systems empower farmers to make informed choices regarding planting, irrigation, and pest management. Precision agriculture technologies, such as drones and sensors, facilitate the precise application of inputs like fertilisers and pesticides, which reduces waste and environmental impact. Blockchain technology enhances traceability in food supply chains, ensuring consumers' confidence in food safety and ethical sourcing, while e-commerce platforms expand access to both national and international markets. Collectively, these technologies support the sustainability of agricultural supply chains by improving efficiency and minimising losses.

In sub-Saharan Africa, digital innovations are especially beneficial in resolving structural challenges, such as financial exclusion and inadequate market integration (Ismail, Musa, & Magaji, 2025). Mobile-based platforms, such as M-Pesa in Kenya and Esoko in Ghana, have expanded access to financial services, enabling farmers to save, borrow, and transact with greater convenience and

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security. These tools have also improved market access by directly linking farmers with buyers, thus diminishing their reliance on exploitative intermediaries. The achievements of these platforms underscore the potential of digital tools to drive agricultural transformation when suitably tailored to local contexts.

In Nigeria, various new digital platforms are working to emulate and expand on these successes. For example, FarmCrowdy provides a crowdfunding model that connects investors with smallholder farmers, addressing the financing challenges these farmers face. Hello Tractor provides tractor-hailing services, offering small-scale farmers on-demand access to mechanisation, which reduces labour intensity and boosts productivity. AgroMall utilises digital tools for extension services, access to credit, and market integration, whereas other platforms focus on data analytics to support informed decision-making in crop management. Nevertheless, adoption remains inconsistent due to obstacles such as limited digital literacy, inadequate internet access in rural regions, cost issues, and scepticism toward new technologies.

The inconsistent adoption of digital agriculture emphasises the need to comprehend not only the technical capabilities of these innovations but also the social, cultural, and institutional contexts that influence their acceptance. Factors such as trust in technology, perceived usability, and demonstrable benefits impact farmers' and stakeholders' readiness to adopt digital tools. Furthermore, supportive environments including favourable government policies, infrastructure development, and effective extension services are crucial in determining whether digital innovations can be scaled sustainably. If these enabling conditions are not intentionally addressed, digital agriculture may inadvertently perpetuate existing disparities, marginalising the most vulnerable segments of Nigeria's farming community.

Empirical Review

Empirical research has increasingly concentrated on the interplay between digital innovation and the sustainability of agricultural supply chains. For example, Aker and Mbiti (2010) explored the transformative influence of mobile phones in African agriculture, revealing that access to mobile-based information reduced market inefficiencies, decreased transaction costs, and enhanced farmers' bargaining power. Their findings underscored that in environments like Nigeria, where market information asymmetry is prevalent, digital communication tools can significantly improve price transparency and income distribution within the supply chain.

Munyua, Adera, and Jensen (2013) investigated the use of ICT in agriculture throughout sub-Saharan Africa, showing that mobile-based platforms for weather updates, extension services, and input pricing significantly enhanced farmers' decision-making processes. The research highlighted that while technology facilitated the flow of important information, challenges such as inadequate infrastructure and low literacy rates often hindered its adoption, particularly in rural areas of Nigeria.

In Nigeria, Okeke and Eze (2019) examined the adoption of digital platforms, including FarmCrowdy and AgroMall. Their findings indicated that these platforms were vital in linking smallholder farmers with markets and financial services. The study demonstrated that these technological innovations improved transparency in value chains and enabled access to credit through crowdfunding, which in turn minimised farmers' risks. Nevertheless, obstacles such as insufficient internet connectivity and a lack of trust in online platforms hindered broader scalability.

Moreover, Nakasone, Torero, and Minten (2014) examined how digital technologies enhanced agricultural supply chains in developing nations. Their results suggested that digital tools played a crucial role in connecting smallholder farmers to formal markets by optimising logistics coordination, reducing food losses, and enabling traceability. They contended that while these advantages were observable in Asia and Latin America, African nations, including Nigeria, trailed behind due to weaknesses in infrastructure and institutions.

Another significant contribution came from Ojo and Akinyemi (2021), who studied stakeholders' views on digital tools within Nigeria's agricultural sector. They discovered that agribusiness participants, including farmers, transporters, and processors, regarded mobile money, blockchain, and e-extension platforms as essential for achieving sustainability through increased transparency and efficiency. However, stakeholders also noted difficulties such as low digital literacy, erratic electricity supply, and high data costs, indicating that systemic obstacles limit the full potential of digital agriculture in Nigeria.

Finally, Akinola (2022) evaluated the impact of digital financial innovations on promoting inclusive and sustainable agriculture in Nigeria. His research found that mobile money platforms and fintech solutions greatly enhanced financial inclusion among rural farmers, enabling them to invest in improved inputs and adopt sustainable farming practices. However, the study warned that digital exclusion, particularly affecting women and older farmers, could exacerbate inequality within agricultural value chains, undermining the sustainability aspect of inclusiveness.

Theoretical Framework

The research on digital innovation and agricultural supply chain sustainability in Nigeria can be grounded in several interconnected theories that explain technology adoption, supply chain integration, and sustainability outcomes. A fundamental theoretical framework is the Diffusion of Innovation Theory (DOI) by Rogers (2003), which elucidates how new technologies propagate through a social system over time, encompassing categories of adopters such as innovators, early adopters, early majority, late majority, and laggards. In agricultural contexts, DOI serves as a valuable perspective for assessing why certain farmers and agribusinesses embrace digital tools like mobile applications, blockchain traceability, or precision farming, while

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others display reluctance (Eke, Magaji, & Osi, 022). It emphasises the significance of perceived relative advantage, compatibility with existing practices, and complexity in influencing adoption rates.

Another pertinent theory is the Technology-Organisation-Environment (TOE) Framework established by Tornatzky and Fleischer (1990). This framework posits that the adoption of digital innovations is influenced not solely by the technology itself but also by the capacities of the organisation and the broader institutional environment. When applied to the agricultural landscape in Nigeria, the TOE framework highlights how factors like farm size, financial resources, governmental regulations, and infrastructural limitations (e.g., restricted broadband access) shape digital transformation within supply chains. Therefore, technology adoption must be examined within its socio-economic and policy contexts rather than in isolation (Magaji & Eke, 2013).

The Resource-Based View (RBV) of the firm (Barney, 1991) also offers valuable insights into the sustainability of agricultural supply chains. RBV suggests that organisations gain a competitive edge by leveraging and developing unique, valuable, and hard-to-copy resources. Digital innovation tools—including data analytics, online platforms, and mobile banking apps—can be considered strategic assets that improve efficiency, transparency, and competitiveness in the market. For Nigeria's farmers and agribusinesses, digital resources can enhance their negotiating power, lower transaction costs, and provide access to premium markets, thus boosting both economic and social sustainability.

The Triple Bottom Line (TBL) Framework (Elkington, 1997) aligns closely with the sustainability aspect of this research. TBL emphasises that organisations should strive for economic success, environmental responsibility, and social equity simultaneously. By integrating digital innovation into agricultural supply chains, stakeholders can reduce post-harvest losses, optimise resource utilisation, and create more equitable market opportunities for smallholder farmers. Within the Nigerian context, this theoretical perspective emphasises how digital tools can contribute to broader development goals, including ensuring food security, alleviating poverty, and promoting environmental resilience.

Collectively, these theories offer a multidimensional framework that delineates both the facilitators and obstacles to adopting digital innovation, as well as its potential impacts on sustainable agricultural supply chains in Nigeria.

III. Methodology

Research Design

This research utilises a qualitative research design, supplemented by descriptive quantitative elements, to assess stakeholders' views on how digital innovation can enhance sustainability in agricultural supply chains across Nigeria. This design is suitable as it allows for an in-depth exploration of varying stakeholder perspectives, experiences, and practices while also identifying emerging patterns and trends among respondents. The methodology incorporates case study techniques to gather real-world insights from participants involved in different segments of the agricultural value chain.

Study Area

The research focuses on specific agricultural regions in Nigeria, particularly in the North-Central, South-West, and North-West zones, where agriculture is crucial to livelihoods and where digital platforms such as FarmCrowdy, AgroMall, and Hello Tractor have gained traction. These areas represent varied agro-ecological environments and market frameworks, making them ideal for understanding the overall dynamics of digital innovation within agriculture.

Population of the Study

The study population comprises key stakeholders within Nigeria’s agricultural supply chains, including smallholder farmers, agribusiness representatives, technology service providers, extension agents, policymakers, and non-governmental organisations involved in initiatives focused on agricultural sustainability.

Sampling Technique and Sample Size

A purposive sampling method was employed to select participants with direct involvement or expertise in digital innovations related to agriculture. The sample consisted of 60 participants, categorised as follows: 25 smallholder farmers, 10 agribusiness representatives, 10 technology providers, five policymakers, and 10 extension officers/NGO representatives. This varied sampling approach ensured inclusion from all essential nodes of the agricultural supply chain.

Data Collection Methods

Primary data were gathered through semi-structured interviews, focus group discussions (FGDs), and structured questionnaires. The interviews captured in-depth stakeholder perceptions, while FGDs facilitated interactive conversations among farmers and technology adopters. The questionnaires offered structured data that enriched the qualitative findings with descriptive statistics. Secondary data were sourced from reports, policy documents, and existing empirical research on digital agriculture and sustainability within Nigeria.

Data Analysis

Data obtained from interviews and FGDs were transcribed, coded, and thematically analysed using NVivo software, allowing for the organised identification of patterns and themes. Quantitative data from the questionnaires were analysed through descriptive

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statistics (frequencies, percentages, and mean scores) with the support of SPSS. The combination of qualitative and quantitative analyses promoted triangulation, thereby enhancing the validity and reliability of the results.

Ethical Considerations

Ethical approval was obtained prior to the commencement of fieldwork. Participants were briefed on the study's objectives, assured that their confidentiality would be maintained, and informed of their right to withdraw at any time without repercussions. The data gathered were anonymised to safeguard the identities of the respondents.

IV. Results and Discussion

The outcomes from stakeholder interviews and the analysis of survey data uncover three primary themes: access to digital platforms, collaboration among stakeholders, and sustainability results. Each theme underscores both the advantages and obstacles in improving agricultural supply chain sustainability in Nigeria through digital advancements.

Access to Digital Platforms

A majority of stakeholders acknowledged that digital platforms have enhanced farmers' access to information, markets, and financial services. Nonetheless, the adoption of these platforms is inconsistent due to challenges such as digital literacy, inadequate internet infrastructure, and the cost of devices. Farmers located in urban and peri-urban settings reported greater access compared to their counterparts in remote rural areas.

Table 1: Access to Digital Platforms among Farmers and Stakeholders

Indicator	High Access (%)	Moderate Access (%)	Low Access (%)
Access to mobile apps for markets	45	30	25
Access to mobile banking services	52	28	20
Access to precision farming tools	20	25	55
Access to online extension services	35	40	25

Source: Field Survey, 2025

These results confirm earlier studies (Akinola et al., 2021), which show that while digital agriculture is spreading in Nigeria, access remains skewed, with smallholder farmers facing more barriers to adoption.

Stakeholder Collaboration

Collaboration among stakeholders—farmers, agribusinesses, financial institutions, NGOs, and government agencies—was found to be critical in scaling digital solutions. Digital platforms enabled coordination in logistics, input distribution, and knowledge sharing. However, weak institutional support and policy inconsistencies remain obstacles.

Table 2: Perceived Effectiveness of Stakeholder Collaboration

Stakeholder Group	Very Effective (%)	Moderately Effective (%)	Ineffective (%)
Farmers' Associations	40	45	15
Agribusiness Firms	55	30	15
Government Agencies	30	40	30
NGOs/Development Orgs	50	35	15

Source: Field Survey, 2025

These findings suggest that private sector actors and NGOs are perceived as more effective collaborators than government agencies, aligning with the findings of Adegbite and Oluwafemi (2022).

Sustainability Outcomes

Stakeholders highlighted several sustainability outcomes associated with digital innovation, including increased market transparency, reduced post-harvest losses, and improved farmer incomes. However, concerns were raised about inclusivity, particularly for women and resource-poor farmers.

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Table 3: Reported Sustainability Outcomes of Digital Innovation

Sustainability Outcome	Strongly Agree (%)	Agree (%)	Disagree (%)
Improved income for farmers	60	30	10
Reduction in post-harvest loss	50	35	15
Enhanced environmental practices	40	45	15
Inclusivity of women & youth	25	35	40

Source: Field Survey, 2025

The findings suggest that although digital innovation has a positive impact on economic and environmental sustainability, the goal of social inclusiveness is not fully realised. This observation aligns with the research conducted by Dione et al. (2020), who similarly recognised gender disparities in access to digital resources in Africa.

V. Discussion

The results demonstrate that digital innovations are progressively transforming Nigeria's agricultural supply chains; however, significant obstacles remain. Stakeholders frequently noted that digital platforms enhanced market connections, facilitated the distribution of inputs, and facilitated the flow of real-time information. This observation aligns with studies by Aker (2010) and Fabregas et al. (2019), which demonstrate that ICT tools reduce transaction costs and enhance market efficiency in African agriculture. Nonetheless, the unequal access—especially among rural smallholders—continues to be a challenge due to limited digital literacy, inadequate infrastructure, and the high prices of internet-enabled devices.

Collaboration among stakeholders was identified as a vital factor for scaling digital solutions. It was discovered that farmers' associations, agritech companies, financial entities, and policymakers performed interconnected roles. This aligns with stakeholder theory (Freeman, 1984), which emphasises the importance of partnerships in creating shared value. However, insufficient institutional coordination often disrupts efficiency and leads to redundant efforts.

Sustainability results were more evident in regions where digital tools enhanced productivity, decreased post-harvest losses, and supported climate-smart farming practices. However, the social aspect of sustainability—specifically the inclusion of women and marginalised farmers—remains inadequately addressed. This raises concerns about equity in digital adoption, echoing the issues highlighted by Klerkx et al. (2019) regarding digital disparities in agriculture.

VI. Conclusion

This research concludes that digital innovation has the potential to revolutionise Nigeria's agricultural supply chains, particularly by enhancing access to information, markets, and financial services. However, adoption is inconsistent, with infrastructural limitations, policy shortcomings, and socio-economic disparities hindering its broad application. Effective collaboration among stakeholders, along with targeted policies aimed at closing the digital gap, is crucial for ensuring inclusivity and long-term sustainability.

Recommendations

1. Enhance rural digital infrastructure: Prioritising investments in broadband and mobile connectivity in remote areas is essential for improving access.

2. Fortify capacity-building initiatives: Training programs should concentrate on enhancing digital literacy among farmers, particularly women and youth, to encourage inclusive engagement.

3. Foster multi-stakeholder partnerships: Cooperation among government, agritech startups, and financial institutions should be formalised through public–private partnerships.

4. Formulate supportive policy frameworks: Implementing policies that stimulate innovation, lower digital service costs, and provide incentives for agritech companies is necessary.

5. Advocate for inclusive digital finance models: Expanding mobile money and micro-credit through digital platforms can bolster farmers' financial resilience.

6. Incorporate climate-smart digital tools: Integrating technologies that enhance water management, pest control, and weather forecasting into agricultural programs should be a standard practice.

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