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Editorial Note

This issue of *AYIKA* brings together a rich and timely collection of scholarship that underscores a central truth: in Africa, environmental questions are deeply political, and political realities are increasingly shaped by environmental change. The contributions in this volume reflect the growing complexity of this relationship, engaging themes that span governance, technology, security, sustainability, and identity across diverse African contexts and beyond.

A defining feature of this issue is its strong engagement with the role of digitalisation in advancing sustainability. From the systematic review on how digitalisation enables decarbonisation, to analyses of agri-tech adoption in Nigeria and South Africa, the volume highlights the transformative potential of technology in addressing environmental challenges. These contributions move beyond optimism, carefully examining the mechanisms and constraints that shape technological uptake. They remind us that digital solutions are not neutral; their effectiveness depends on policy frameworks, institutional capacity, and socio-economic conditions.

Equally prominent is the question of governance, particularly in relation to service delivery and institutional performance. The examination of water service failures in Gauteng Province offers a sobering account of how governance lapses can translate into environmental and public health crises. Similarly, the discussions on public service reform and parliamentary oversight reveal the persistent challenges of accountability and administrative effectiveness across the continent. Together, these studies point to a critical insight: sustainable environmental outcomes are contingent on capable, transparent, and responsive institutions.

The issue also engages deeply with questions of political order, security, and regional cooperation. Analyses of Zimbabwe's political history, hybrid regimes in Central Africa, and border conflicts involving Nigeria reveal how political instability and governance structures shape environmental management and development trajectories. The exploration of indivisible security within the SADC region further highlights the interconnectedness of peace, cooperation, and sustainable development. These contributions reinforce the idea that environmental sustainability cannot be pursued in isolation from broader political and security dynamics.

Another important strand in this volume is the emphasis on economic strategies and livelihoods, particularly in rural contexts. Articles on organic agribusiness, marketing strategies aligned with climate action, and the challenges faced by women in agribusiness illuminate the everyday realities of sustainability. They foreground the experiences of local actors, especially women entrepreneurs, whose resilience and innovation are often overlooked. By examining the socio-economic factors shaping revenue growth and participation, these studies contribute to a more inclusive understanding of development.

The volume also makes a significant intellectual contribution by foregrounding indigenous knowledge systems and alternative epistemologies. The exploration of

Ubuntu as a framework for regional governance offers a human-centred perspective that challenges dominant policy paradigms. Similarly, the critique of epistemic violence in transboundary conservation highlights the marginalisation of local knowledge and agency. These interventions are particularly important in rethinking whose knowledge counts in environmental governance and how more equitable frameworks can be developed. Urban spaces and cultural expressions are not left out of this conversation. Contributions on city branding in Harare and the intersection of art, space, and identity in Durban demonstrate how environmental and political dynamics are experienced and expressed in urban contexts. These studies expand the scope of environmental politics by incorporating cultural and spatial dimensions, offering fresh insights into how cities in the Global South are responding to climate change.

Notably, this issue also extends its analytical reach beyond Africa, with a study on urban climate initiatives in Brazil and a comparative examination of socio-economic vulnerability in Sub-Saharan Africa and the Pacific Islands. These contributions enrich the volume by situating African experiences within a broader global context, encouraging cross-regional learning and dialogue.

Finally, the inclusion of research on language and education, such as the study on tense substitution errors among Tshivenda-speaking students, serves as a reminder of the interconnectedness of knowledge production, communication, and development. It highlights the importance of education in shaping the capacity to engage with complex environmental and political issues.

Taken together, the articles in this issue reflect a vibrant and interdisciplinary field of inquiry. They challenge simplistic narratives and instead offer nuanced analyses that recognise the interconnected nature of environment and politics in Africa. As the continent continues to navigate the pressures of climate change, population growth, and political transformation, the insights presented here are both timely and necessary. This volume invites scholars, policymakers, and practitioners to think more critically and act more collaboratively. It is our hope that the conversations sparked within these pages will contribute to more just, sustainable, and context-sensitive approaches to environmental governance in Africa and beyond.

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AGRI-TECH AND LIVESTOCK MANAGEMENT: ECONOMIC AND POLICY DRIVERS OF DIGITAL ADOPTION IN NIGERIA AND SOUTH AFRICA

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Abstract

The usage of digital technologies in the agricultural sector is becoming widely recognised as a means of enhancing efficiency, productivity, and sustainability in developing countries. In most countries in sub-Saharan Africa, the adoption of agri-tech innovations is still underutilised, especially in countries where institutional and structural factors prevail. This paper explored economic factors and the policy behind the adoption of digital technology in the management of livestock in Nigeria and South Africa using a comparative and multi-level analytical paradigm. The paper employed the Technology Acceptance Model (TAM), the Diffusion of Innovations Theory (DOI), and the institutional approach. A qualitative research design was adopted for this study, using primary and secondary sources of data gathering. Primary data were gathered

through the conduct of interviews with the livestock farmers in Northern Nigeria, and secondary data from policy and institutional documents in South Africa. Three variables, that is, the perception of the farmers, diffusion, and policy environments in determining the adoption outcomes, were examined. Findings showed that even though farmers show a high level of perceived usefulness of digital technologies, the usage of these technologies was limited due to poor infrastructure, high prices, and poor institutional support. In comparison, the findings of the study showed that South Africa has consistent policy frameworks and better institutional capacity to support greater adoption, whereas there exists low usage due to a disjointed policy environment, despite its positive perception by farmers in Nigeria. The study contributes to the existing literature by integrating diffusion, behavioural, and institutional perspectives into a multi-level framework for understanding the adoption of agri-tech in developing countries. The study concluded that the success of digital agricultural transformation requires robust policy, technological innovation, and institutional systems for its adoption.

Keywords: Digital agriculture; Agri-tech adoption; Livestock systems; Technology adoption; Institutional capacity; Agricultural policy; Sub-Saharan Africa

1. Introduction

Agriculture has become a viable means of promoting economic development, food security and the promotion of a better life for people in rural areas of sub-Saharan Africa (Lasisi et al., 2025). Countries like Nigeria and South Africa are two important nations whose economies thrive through agricultural productivity in livestock management (Ngobeni & Muchopa, 2023; Nwankwo et al., 2024). Beyond its economic contribution, livestock farming plays an important role in supporting rural development and fostering greater development impact through the reduction of poverty and job creation (Banda & Tanganyika, 2021). Nevertheless, the livestock farming industry still grapples with structural challenges such as theft, disease outbreaks, poor monitoring, and exposure to climate factors, negatively impacting productivity (Gumbi et al., 2023; Ikuemonisan, 2024). These challenges reveal the inefficiency of

traditional livestock management methods and the increasing need of technological driven interventions.

Agriculture practices have recently witnessed digital innovations, such as the adoption of Internet of Things (IoT), Global Positioning Systems (GPS), and Radio-Frequency Identification (RFID), thereby opening up new opportunities in modifying the management of livestock systems. These technological tools foster geofencing, real-time monitoring, data-driven decision-making and traceability, thus minimising operational risks and enhancing efficiency (Brown-Brandl et al., 2019; Alonso et al., 2020; Ilyas & Ahmad, 2020). Empirical study reveals that these innovations have a significant relationship with disease management strategies, livestock productivity, and loss reduction (Bailey et al., 2018; McGranahan et al., 2018). Despite these advantages, the adoption of digital agricultural technologies in most African areas has been

disproportionate, due to the high cost of implementation, inadequate institutions, lack of infrastructure, and limited digital literacy (Dhillon & Moncur, 2023; Mhlanga & Ndhlovu, 2023).

Extant literature has extensively reviewed the operational advantages and technical capacity of the technologies; however, few have laid emphasis on the areas related to policy, institutional, and governance that determine their successful usage in developing countries. Some studies are technologically deterministic and tend to believe that innovation will simply be translated into effect and application. This ignores the multifaceted socio-economic and policy contexts under which farmers are involved, especially in sub-Saharan Africa, where structural constraints are deeply embedded (Gumbi et al., 2023; Ikuemonisan, 2024). Furthermore, there is limited evidence of comparative studies that systematically investigate how national policy frameworks affect agri-tech adoption in African nations, thus creating a significant gap in the literature.

This paper adopted the Technology Acceptance Model (TAM) (Davis, 1989) and Diffusion of Innovations Theory (DOI) (Rogers, 1962/2003) to investigate the adoption of digital livestock technologies in Nigeria and South Africa. TAM focuses on the perceived usefulness and ease of use in determining specific adoption choices; DOI is more concerned about social and institutional influences, such as compatibility, complexity, and observability. Nevertheless, this paper assumes that these frameworks, as they have been applied traditionally, have

not adequately considered the roles of state capacity, policy coherence and institutional support in influencing the technology adoption in developing settings. This paper, therefore, builds on these theoretical frameworks by adding a comparative institutional lens to better understand the differences in agri-tech adoption across countries.

More particularly, the paper poses the following question: to what extent do economic and policy conditions affect the adoption of digital livestock technologies in Nigeria and South Africa, and why are there disparities in the two settings? Using a comparative method, the study aims to reveal the role of differences in policy systems, institutional setups and infrastructural capacities in the process of diffusion and adoption of agri-tech innovation in livestock management.

The paper adopted a qualitative comparative research design that utilises both primary data from semi-structured interviews with livestock farmers in northern Nigeria and a desk-based analysis of agricultural policy and policy structures in South Africa. Thematic analysis was employed to determine the key patterns associated with the adoption of technology, barriers, and perceived benefits, whereas comparative policy mapping allows for systematic analysis of cross-country differences in governance systems and institutional support.

The paper contributes significantly to the body of knowledge in three key areas. First, it adds to theoretical discussions by incorporating institutional and policy variables in some of the existing models of technology adoption, thus breaking the

boundaries of individualistic explanations. Second, it provides empirical data on the reality of the life of farmers and the realities of agri-tech application in resource-starved communities. Third, it contributes to comparative studies on digital farming in Africa by conducting a sophisticated examination of two large economies with diverse policy paths and institutional strengths.

2. Theoretical and Analytical Framework

To get a clear understanding of the adoption of digital technologies in livestock management, there is a need to have a conceptual framework that considers the individual decision-making processes as well as the institutional environment in which the process finds itself. With that goal in mind, this study drew on the Technology Acceptance Model and the Diffusion of Innovations Theory as complementary theoretical lenses. Nevertheless, due to the nature of agribusiness systems in developing economies, the paper expands on these by including the institutional and policy-focused lens to fully explain cross-national disparities in agri-tech adoption.

2.1 Technology Acceptance Model (TAM)

The Technology Acceptance Model as a model was developed by Davis (1989), with the opinion that the acceptance of new technology depends on two main factors: perceived usefulness and perceived ease of use. Perceived usefulness is the degree to which a person thinks that the application of a certain technology will improve his or her performance, whilst perceived ease

of use is the level to which the technology is effortless. Such perceptions determine the attitude and intentions of users towards behaviour, and this in turn affects the actual adoption of the technology.

Regarding livestock management, TAM provides a valuable framework in terms of understanding the way farmers assess digital technologies like GPS trackers, RFID tags, and IoT-based monitoring systems. As an example, farmers will also be willing to use such technologies when they feel confident that they will help them to reduce cattle theft, monitor diseases, and increase productivity (McGranahan et al., 2018; Ilyas & Ahmad, 2020). Ease of use, in turn, becomes a crucial factor in rural environments where the digital literacy rate might be lower, and the complexity of technologies might serve as an obstacle to their use (Mhlanga & Ndhlovu, 2023).

Although TAM provides significant information about individual-level adoption behaviour, it does not explain the adoption situation well in situations where structural constraints, including poor infrastructure, unavailability of funds, and poor institutional support, play a crucial role. These external constraints make farmers in most developing nations, such as Nigeria, willing to use the technology, but not necessarily use it (Dhillon & Moncur, 2023). Therefore, the individual perceptions focus of TAM, although important, cannot be used to describe the wider scope of agri-tech adoption in resource-limited settings.

2.2 Diffusion of Innovations Theory (DOI)

The Diffusion of Innovations Theory (DOI), originally developed by Rogers (1962) and later refined in later editions (Rogers, 2003), is a well-organised theory that explains the diffusion of innovations within the social system over time. The theory defines some of the main characteristics of innovations that determine adoption, such as relative advantage, compatibility, complexity, trialability, and observability.

DOI can be applied most effectively to agricultural systems to understand digital livestock technology diffusion, including information about how digital livestock technologies (GPS, RFID and IoT systems) are diffused among farmers via social networks, peer-to-peer learning, and institutionally mediated. The apparent relative advantage of these technologies, including decreased livestock theft and enhanced productivity, may impact the adoption greatly, whereas the compatibility with the current farming practices defines whether they will be adopted practically (Gumbi et al., 2023). Besides, the observability of successful results in the initial adopters can enhance the process of diffusion in terms of demonstration and collective learning effects.

Despite its advantages, DOI is limited in explaining technology adoption in the context of developing countries. Although it recognises the place of social systems, it does not place as much emphasis on formal institutional frameworks, policy frameworks and the capacity of the state. These institutional factors play a significant role in

determining the result of adoption in the context of state intervention in agricultural transformation, where subsidies and regulatory procedures are present in strong mediating relationships (Ikuemonisan, 2024). In this way, using DOI only can narrow the structural limitations that determine the process of innovation diffusion in a country like Nigeria and South Africa.

2.3 Integrating Institutional and Policy Perspectives

Based on the weaknesses of TAM and DOI and with an attempt to offer a more analytical approach, the study introduced an institutional viewpoint. The institutions, which are the formal and informal rules, policies and organisational structures which dictate the economic and social interactions, are central in defining the adoption and diffusion of agricultural technologies. The institutional factors of digital agriculture are government policies, regulatory frameworks, infrastructure accessibility, financial systems, and extension services.

In countries such as South Africa, digital livestock monitoring systems have been created and implemented due to relatively stronger institutional capacity and policy coherence (Department of Agriculture, Forestry and Fisheries, 2015). These institutional arrangements provide an enabling environment that facilitates the adoption of technology through lessening uncertainty, offering incentives, and increasing access to resources. Conversely, in Nigeria, disjointed policy frameworks, poor infrastructure, and lack of institutional support have limited the adoption of

such technologies (Gumbi et al., 2023; Ikuemonisan, 2024).

This institutional approach fills a grave gap in the current literature that tends to believe that the overall concept of technological adoption is chiefly motivated by personal choice or social diffusion mechanisms. In contrast, this paper states that in developing situations, the ability of the state and consistency of policy systems are determinants that drive the relationship between the availability of technology and the realised adoption outcomes.

2.4 Analytical Framework for Comparative Analysis

Drawing on TAM, DOI, and institutional theory, this study develops an integrated analytical framework to guide the comparative analysis of Nigeria and South Africa. The framework operates across three interrelated levels:

1. **Micro-level (Individual/Farmer Level):** Focuses on farmers' perceptions of usefulness and ease of use (TAM), as well as their attitudes towards digital technologies.
2. **Meso-level (Social and Network Level):** Examines diffusion dynamics, including peer learning, social influence, and the role of local farming communities (DOI).

3. **Macro-level (Institutional and Policy Level):** Analyses the role of government policies, institutional capacity, infrastructure, and financial support systems in enabling or constraining adoption.

By integrating these levels, the framework makes possible a more sophisticated perspective of agri-tech adoption, one that is not only technological or behavioural in the nature of its explanation. It facilitates the comparative analysis of the ways in which various constellations of the individual perception, social processes and institutional conditions determine the adoption patterns and the impacts of the digital livestock technologies in Nigeria and South Africa.

When implementing this framework, the paper examines the interaction between policy coherence variations, infrastructural development, and institutional support and the perceptions of farmers to drive different adoption patterns in the two countries. This multi-level method is not only more effective in explaining the results of the analysis but also in advancing the theoretical discussion on the question of technology adoption in developing settings, by filling the gap between the micro-level behavioural theories and the macro-level governance systems.

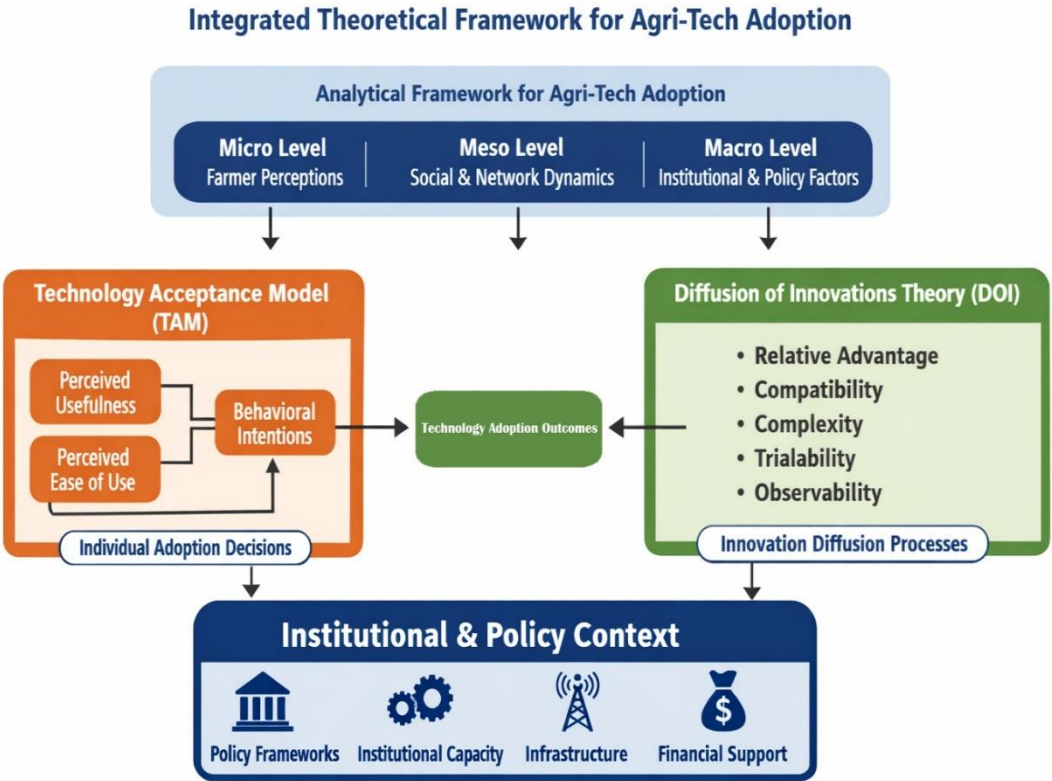


Figure 1: Integrated Theoretical Framework for Agri-Tech Adoption

Figure 1 shows the analytical framework integrated into this study. It integrates the TAM on the micro level with the DOI on the meso level, and institutional and policy-related aspects on the macro level. This multi-level model describes the relationship between farmer perceptions, social diffusion processes, and institutional enabling conditions to explain the agri-tech adoption outcomes in Nigeria and South Africa.

3. Literature Review

Recently, the relationship between digital technologies and agricultural systems has received more attention, especially in the areas of sustainability, productivity enhancement, and food security in developing countries. This section reviews existing literature in three thematic classifications: (i) digital

agriculture and livestock management, (ii) technology adoption in developing countries, and (iii) agricultural policy and institutional capacity. This approach enables a more integrated understanding of agri-tech adoption while identifying key gaps that this study seeks to address.

3.1 Digital Agriculture and Livestock Management

Digital agriculture has become a new paradigm of modern agriculture, which is characterised by the application of high-tech solutions to agricultural production: the introduction of IoT, GPS, and RFID into the agricultural production process. These technologies make it possible to monitor everything in real-time, make data-driven decisions, and enhance traceability in livestock management (Alonso et al.,

2020; Ilyas & Ahmad, 2020). According to empirical evidence, these innovations can enhance productivity, optimisation, and minimise losses related to livestock theft and disease outbreaks. (Bailey et al., 2018; McGranahan et al., 2018).

GPS-tracked location and RFID-enhanced identification technologies have been especially useful in livestock systems in managing the problem of large grazing and poor monitoring systems (Brown-Brandl et al., 2019; Zantsi & Nkunjana, 2021). In the same manner, livestock farming can be precised with the help of IoT-enabled sensor technologies that will help to continually monitor the health and environmental conditions of animals (Ekuewa et al., 2022). In addition to its technical abilities, the recent scholarship emphasises that digital agriculture is to be perceived as a part of a larger system of agricultural innovation in relationships between farmers, institutions, and markets (Klerkx et al., 2022; Food and Agriculture Organisation [FAO], 2023).

Despite these developments, the use of digital technologies in sub-Saharan Africa has been limited due to its high costs, low-level of technical expertise, and poor infrastructure (Mhlanga & Ndhlovu, 2023). Additionally, a great deal of literature is technologically deterministic in its approach, addressing the functionality of innovations, but regarding its applicability, it lacks the socio-economic and institutional preconditions of successful application. This establishes a gaping imperative in the knowledge of how digital agriculture can be effectively

incorporated in resource-limited settings.

3.2 Technology Adoption in Developing Contexts

The adoption of agricultural technologies in developing countries has been widely analysed using behavioural and diffusion-oriented frameworks, particularly through TAM and DOI (Davis, 1989; Rogers, 2003), highlighting usefulness, ease of use, relative advantage, and compatibility as determinants of adoption decisions.

Empirical evidence shows that farmers pay more attention to digital technologies when they feel obvious economic and operational advantages, that is, improved productivity and minimised risks (Gumbi et al., 2023). Social forces, such as peer pressure, knowledge-sharing in farming societies, among others, are also important determinants of adoption patterns, especially in the rural settings that are typified by information asymmetry (Mhlanga & Ndhlovu, 2023). Findings indicate the significance of the social network and the individual perceptions in the diffusion of agri-tech innovations.

Nevertheless, the relevance of these models to developing situations has been increasingly challenged. TAM and other behavioural models have been criticised on the basis of their limited capacity to explain structural constraints, and such challenges include poverty, infrastructural deficit, and financial limitations (Dhillon & Moncur, 2023). On the same note, it can be said that where DOI offers a wider perspective regarding the diffusion

processes, it falls short of adequately explaining the influence of institutional and policy settings on the outcomes of adoption.

This criticism is supported by recent literature that has shown that structural inequalities, such as access to infrastructure and education disparities, financial systems, etc., are the strongest mediating factors in digital adoption in developing economies (Aker & Cariolle, 2023; World Bank, 2023). These structural barriers, in most cases, form a disconnection between the intentions of farmers to make use of new technologies and their real possibilities (Ikuemonisan, 2024). This makes the necessity of more detailed analytical frameworks that combine the behavioural, social, and institutional aspects of technology adoption more apparent.

3.3 Agricultural Policy and Institutional Capacity

The agri-tech adoption largely depends on the agricultural policy and institutional capacity, which define the facilitating environment in which technological innovations may be introduced and used. The introduction of digital initiatives in agriculture is informed by governmental policies and regulatory frameworks, as well as governmental investments and human development. In this respect, policy coherence and institutional quality play a key role in the process of promoting or limiting technological change in the agricultural sector.

In South Africa, there are fairly robust institutional arrangements and policy consistency that have facilitated the use of digital technologies in agricultural systems. Policy tools such as the

Agricultural Policy Action Plan (APAP) focus on agricultural growth and innovation, value chain development, and technological advancement as the primary drivers of agricultural growth (Department of Agriculture, Forestry and Fisheries, 2015). Such efforts have made it possible to take up technologies such as RFID-based traceability systems that improve the accessibility of the market and the ability to meet international standards.

In Nigeria, on the other hand, the agricultural policy environment is marked by inconsistency in policy adoption and inadequate institutional capacity to implement digital technology (Ikuemonisan, 2024). Constant problems such as poor infrastructure, poor extension services, and lack of access to financing continue to inhibit the adoption of technology (Gumbi et al., 2023). Recent policy-related literature has stressed that the success of digital transformation in African agriculture relies on regulatory consistency and the long-term investment in infrastructure and innovation infrastructures by the state (Organisation for Economic Co-operation and Development [OECD], 2022; African Development Bank [AfDB], 2023).

Despite the recognised importance of policy, existing literature often treats it as a background variable rather than a central explanatory factor in technology adoption. This limits the ability of current studies to fully explain cross-country variations in agri-tech adoption and outcomes, particularly in developing regions.

3.4 Synthesis and Research Gap

A number of important insights emerge in the above review. To begin with, although the potential of digital technologies in revolutionising livestock management is high, their application in developing settings is unequal and limited by numerous factors that interact with each other. Second, literature in the field of technology adoption focuses more on behavioural and social determinants and fails to capture the structural and institutional context that predetermines the consequences of adoption. Third, the place of agricultural policy is under-analysed in the analysis of digital agriculture, despite its paramount significance. More recent critiques also suggest that mainstream discourses of digital agriculture are likely to ignore the problem of inequality, governance and power relations, thus supporting the view of the necessity of more context-specific and institutionally based analyses.

This study addresses these gaps by adopting a comparative and multi-level analytical framework that integrates technological, behavioural, and institutional perspectives, examining the interplay between farmer perceptions, diffusion dynamics, and policy environments in Nigeria and South Africa. The study contributes to bridging the divide between micro-level adoption studies and macro-level policy analysis, thereby advancing scholarship on digital agriculture in sub-Saharan Africa.

4. Methodology

This paper adopts the qualitative comparative research design, focused on investigating economic and policy-

related issues that drive the adoption of digital livestock technologies in South Africa and Nigeria. Due to the exploratory and situation-specific nature of agri-tech adoption, a qualitative study is suitable to get a picture of the lived experiences of farmers, institutional and policy contexts that condition technology adoption. The comparative design allows one to identify similarities and differences across countries, thus giving further insights into the effect of differences in institutional settings on adoption outcomes.

4.1 Research Design

The paper is rooted in a qualitative and multi-case comparative framework, based on Nigeria and South Africa as two of the most advanced economies in sub-Saharan Africa with diverse agricultural policy settings and institutional capabilities. Nigeria is a setting that is defined by the emergent levels of agri-tech awareness and high levels of structural limitations, whereas South Africa offers a more developed policy and institutional environment that favours digital agriculture.

This study explores a comparative examination of similar technologies in varying institutional settings. The study aims to identify and analyse how policy frameworks and institutional capabilities influence agri-tech adoption in these countries.

4.2 Data Sources

Data used in the study were gathered using both primary and secondary sources of data:

- **Primary Data (Nigeria):**
Primary data was collected

using semi-structured interviews with livestock farmers in northern Nigeria, a region with large pastoral and agro-pastoral systems. First-hand information about the awareness, perception, and experience of farmers related to digital livestock technologies was offered by the interviews.

- **Secondary Data (South Africa):** Due to the comparative nature of the study, the secondary data comprises South Africa's analysis of most of the existing empirical analysis of digital agriculture and livestock management using government policy reports, institutional reports, and existing empirical analysis of the analysis. Most important are the policy frameworks and related institutional publications like the Agricultural Policy Action Plan (APAP).

This combination of sources of data enables a subtle comparison between the development of policy-driven changes in South Africa and the experiences of farmers in Nigeria.

4.3 Sampling and Participants

This study employed a purposive sampling method in selecting participants for the study. Participants cut across livestock farmers with awareness of agricultural technologies. The study involved small and medium-scale livestock farmers involved in cattle rearing. A total of 25 farmers were interviewed, using the following criteria in choosing the participants:

1. Participation in livestock farming.
2. Knowledge or application of digital livestock technology (e.g., GPS, RFID)
3. Willingness to take part in the study.

This sampling strategy ensures that the data collected are both relevant and information-rich, enabling in-depth exploration of adoption dynamics.

4.4 Data Collection

Semi structure interviews were used to collect data; this method provides flexibility in exploring participants' views yet maintains consistency across major themes. The interviews were done face-to-face and over the telephone, depending on the availability and logistical factors.

The interview guide was designed in such a way that the following themes were used:

1. Knowledge and recognition of digital livestock technologies. Perceived usefulness and benefits.
2. Barriers to adoption (e.g., cost, infrastructure, knowledge)
3. Technology use (where applicable) experiences.
4. Institutional and policy-related issues.

Each interview lasted approximately 30–60 minutes and was recorded (with participants' consent) and subsequently transcribed for analysis.

4.5 Data Analysis

Thematic analysis was used to analyse the qualitative data, using a systematic

process of identifying, analysing, and interpreting patterns (themes) within the data. The analysis was done in three phases:

1. **Open Coding:** The data was initially coded to produce significant ideas and patterns of the data.
2. **Axial Coding:** The similar codes were combined into larger ones, the example of which is the category of perceived usefulness, the barriers of adoption, and the constraints of an institution.
3. **Selective Coding:** The key themes were located and associated with the theoretical framework of the study, especially the Technology Acceptance Model and the Diffusion of Innovations Theory.

Analysis was done manually so that close interaction with the data is obtained, but the coding process was based on the existing qualitative research protocols that guaranteed rigour and consistency.

4.6 Comparative Analytical Strategy

To provide a cross-country comparison, the study uses a systematic reference method of comparison that is founded on the synthesised framework developed in Section 2. The review is structured around three important dimensions:

1. **Micro-level (Farmer Perceptions):** Studies the perceptions and use of digital

technologies amongst the Nigerian farmers.

2. **Meso-level (Diffusion Dynamics):** Examines the contribution of social networks, knowledge-sharing, and demonstration effects on adoption.
3. **Macro-level (Institutional and Policy Context):** Comparisons of policy frameworks, institutional capacity and infrastructural support in Nigeria and South Africa.

These differences and similarities across these dimensions are evaluated systematically in a comparative matrix, which allows a consistent and clear analysis of the adoption of agri-tech in the two countries.

4.7 Validity, Reliability, and Ethical Considerations

In a bid to facilitate the credibility and reliability of the study, a number of measures were considered. To begin with, data triangulation was utilised in this case by using primary interview data incorporated with secondary policy and institutional data. Second, the semi-structured interview guide provided consistency in the interviews but allowed for the depth of the context. Third, the analysis was interpreted in a well-understood theoretical framework, which increased the analytical coherence.

The research was done with respect to ethical considerations. All participants' consents were obtained, and participation in the study was voluntary. Respondents were assured of confidentiality and anonymity, and no

personal details were revealed when reporting the findings.

5. Empirical Findings and Analysis

This section presents empirical findings of the research based on qualitative data from the interviews with the livestock farmers in northern Nigeria and secondary evidence of the policy in South Africa. The analysis follows a four-part format: (i) the views of the Nigerian farmers, (ii) South African policy and institutional environment, (iii) comparative analysis, and (iv) application and use of technology and its results. The analysis results are viewed in the context of the synthesising analytical model presented in Section 2.

5.1 Nigerian Farmers' Perspectives on Agri-Tech Adoption

The results indicate an increase in the awareness of digital livestock technologies among the farmers in the northern part of Nigeria, but their practical use is limited. The majority of the respondents were conversant with the application of certain technologies like GPS tracking and mobile-based monitoring systems, which they were introduced to mainly via informal networks, extension agents or through the media.

One of the themes that emerged in all interviews was the perceived usefulness of digital technologies, especially in solving cattle theft and enhancing herd management:

“If I can track my cattle with GPS, I will not worry about losing them again. Theft is our biggest problem.” (Farmer 7, Kaduna State)

“Technology can help us know when animals are sick early, but many of us don’t know how to use it properly.” (Farmer 12, Kano State)

These reactions are consistent with the Technology Acceptance Model, since agri-tech has the potential to have positive impacts, which were highly believed by farmers. Nevertheless, perceived ease of use turned out to be a considerable setback, especially when working with older farmers who are poorly digitally literate:

“These things are complicated. We need training before we can use them.” (Farmer 3, Katsina State)

In addition to the individual perceptions, structural constraints were observed to be the greatest barriers to adoption. High device prices, lack of access to the internet, and lack of access to finance were noted:

“Even if I want to buy the device, I cannot afford it. There is no support from the government.” (Farmer 15, Sokoto State)

“Network is a big problem here. Without internet, how will the system work?” (Farmer 9, Zamfara State)

These barriers are further increased by institutional challenges. According to the respondents, there were no specific government programmes, poor extension services, and little awareness campaigns:

“We hear about these technologies, but nobody is coming to teach us or support us.” (Farmer 18, Kaduna State)

Overall, while there are positive attitudes towards agri-tech among

Nigerian farmers, the adoption of agri-tech by the farmers is limited by a mixture of technological complexity, economic constraints, and a lack of strong institutionalisation.

5.2 South African Policy and Institutional Context

Unlike in Nigeria, South Africa proves to be more policy-directed in adopting agri-tech initiatives. Policy frameworks such as the Agricultural Policy Action Plan (APAP) focus on innovation, value chains development, and the integration of digital technologies into agricultural systems. Policy-document evidence and existing research have shown that digital livestock technologies, especially RFID-based traceability systems, have been widely implemented in South Africa. These systems are directly connected with market access and particularly the export-based livestock industries, where traceability is a regulatory measure.

The institutional support mechanisms, such as extension services, public-private partnerships and research institutions, are critical towards supporting adoption. Moreover, the availability of relatively improved digital infrastructure and access to finance increases the ability of farmers to embrace and use these technologies.

Nevertheless, the experience is still difficult, especially for smallholder farmers who might have the impediments as witnessed in Nigeria, but this time, to a smaller degree. These include a lack of financial resources and unequal access to technological resources. However, agri-tech adoption in South Africa is more supported by enabling environmental conditions.

5.3 Comparative Analysis: Nigeria vs South Africa

A comparative analysis reveals significant differences in agri-tech adoption between the two countries, largely driven by variations in institutional capacity and policy coherence.

Dimension	Nigeria	South Africa
Awareness	Moderate	High
Adoption Level	Low	Moderate to High
Policy Framework	Fragmented	Coherent and structured
Institutional Support	Weak	Strong
Infrastructure	Poor	Relatively developed
Access to Finance	Limited	Moderate
Extension Services	Weak	More established

On the micro level, farmers in both countries acknowledge the potential utility of digital technologies, which means that

the perceived usefulness is not the key differentiating factor. Meso-level diffusion processes are more successful in South

Africa because of greater institutional networks and knowledge-sharing systems.

The greatest divergence is at the macro level with variations in policy frameworks, institutional capacity and infrastructure level, establishing different environments of adoption. Nigeria has structural obstacles that reduce the positive perceptions into actual adoption. Supportive policies and institutional setups in South Africa encourage wider adoption.

5.4 Technology Applications and Adoption Outcomes

The digital technologies used to manage livestock are quite different in the two settings. The adoption is mostly experimental and restricted to a few and early adopters in Nigeria. Technologies such as GPS tracking are used sporadically, often without institutional support or integration into broader systems.

South Africa, on the contrary, is more systematic, especially in such aspects as livestock traceability and health tracking. RFID systems are embedded in national and regional systems, enabling compliance with international standards and enhancing market access.

In both settings, the agri-tech potential benefits can be seen as comprising:

1. Reduction in livestock theft
2. Improved disease detection and management
3. Enhanced productivity and efficiency
4. Better market integration

Nonetheless, the enabling environment is very important in the realisation of these benefits. Technology only offers the means of change, but it is institutional and policy factors that determine the effectiveness of these tools.

5.5 Synthesis of the Findings

This study revealed that the adoption of agri-tech in sub-Saharan Africa is not only limited by the lack of awareness or adverse attitudes but also by structural and institutional factors. Although behavioural models, including TAM, reveal the willingness of farmers to adopt, and DOI explain the dynamics of diffusion, the sole decisive role of the institutional context is not fully captured by either of them.

Combining these viewpoints, the study shows that effective agri-tech adoption demands coordination on the micro level of perceptions, meso-level diffusion mechanisms, and macro-level institutional environments. Lack of this alignment, as witnessed in Nigeria, results in poor adoption, despite its perceived high benefits. On the other hand, as seen in South Africa, such alignment makes the implementation and results more effective.

6. Discussion

This section elucidates the empirical research findings against the theoretical construct and literature available, bearing in mind identifying the conceptual contribution of the study. Based on the Technology Acceptance Model, Diffusion of Innovations Theory and the institutional perspective elicited in Section 2, the discussion advances a multi-level explanation of agri-tech adoption in Nigeria and South Africa.

6.1 Reassessing Technology Acceptance in Resource-Constrained Contexts

The findings specifically corroborate TAM's assumptions of perceived usefulness. The Nigerian farmers showed a great awareness of the possible benefits of the digital livestock technologies, particularly in dealing with cattle theft and herd management. This is in line with existing studies, which state that one of the main factors influencing technology adoption is the perceived usefulness (Davis, 1989; Gumbi et al., 2023).

Nevertheless, the results are contrary to the adequacy of TAM in explaining the adoption results in the developing setting. Farmers had positive attitudes towards the agri-tech; however, there was low adoption of agri-tech. This indicates a lack of relationship between behavioural intention and actual usage, and this is mainly because of structural constraints, among them being high costs, inadequate infrastructure and lack of institutional support. In this regard, the study reinforces criticism that TAM tends to overemphasise individual agency, while underestimating the impact of external limitations (Aker & Cariolle, 2023; Dhillon & Moncur, 2023).

The implication is that within a resource-constrained environment, perceived usefulness and ease of use are necessary, but not sufficient conditions to be adopted. Instead, they need to be supplemented by facilitating structural circumstances that enable farmers to change their intention to practice.

6.2 Diffusion Dynamics and the Limits of Social Systems

The findings also partially confirm the Diffusion of innovations Theory (DOI), especially regarding the influence of the social networks and observability on the adoption. Agritech awareness in Nigeria was, in most instances, mediated by informal means such as peer networks and local knowledge-sharing systems. This is a demonstration that diffusion processes are of the essence in conveying information about new technology (Rogers, 2003).

The study, however, shows that diffusion is not enough to lead to widespread adoption in a situation where there is weak institutional support. Although DOI focuses on the importance of the attributes of innovation and social systems, it fails to explain the structural barriers that restrict access to technologies appropriately. As it was witnessed in Nigeria, although farmers know and want to embrace the use of digital tools, financial and infrastructural

constraints are major impediments to adoption.

On the contrary, diffusion processes are more effective in South Africa due to the existing institutional networks, extension services, and policy frameworks. This implies that diffusion is not a social process but is embedded in institutional settings that may either support or inhibit the diffusion of innovations.

6.3 Institutional Capacity as the Missing Link

The greatest impact of this study is that it shows that institutional capacity and policy coherence take centre stage in the agri-tech adoption. The comparison analysis indicates that the differences between Nigeria and South Africa are not necessarily regarding the attitude of the farmers, but the enabling environment in which the adoption is taking place.

South Africa has a relatively good institutional framework and policies that support technology adoption, and an improved infrastructure that creates an environment enabling the adoption of technology. Strategic direction and institutional support of agriculture innovation are offered through programmes like the Agricultural Policy Action Plan (APAP). These results are consistent with the policy-focused literature, which highlights the significance of state capacity and governments in technological change (OECD, 2022; AfDB, 2023).

On the contrary, the policy environment and disjointed institutional hinder adoption in Nigeria, despite farmers' awareness and perceived use of the tools. This points to a significant gap in the literature, which often treats policy as a background variable rather than a central determinant of adoption outcomes.

This study contributes to TAM and DOI in several ways by forecasting institutional factors; it illustrates that the use of technology in developing situations should

be defined as a product of interactions between individual perceptions, social forces and institutional forces.

6.4 Toward a Multi-Level Understanding of Agri-Tech Adoption

Combining TAM, DOI, and the institutional theory allows creating a multi-level approach to the explanation of agri-tech adoption. The results indicate that full adoption can only be successful when there is an alignment at three levels:

- **Micro-level (Individual):** Positive perceptions of usefulness and ease of use
- **Meso-level (Social):** Effective diffusion through networks and knowledge-sharing
- **Macro-level (Institutional):** Supportive policies, infrastructure, and financial systems

In the absence of such alignment, as is the case in Nigeria, adoption is low even when the attitude is favourable. In areas with greater alignment, as in South Africa, adoption is more prevalent and successful.

This multi-level approach helps in filling the gap between the micro-level behavioural framework and macro-level policy analysis to provide a more holistic approach to the study of digital agriculture in developing settings.

6.5 Implications for Theory and Research

The study makes three key theoretical contributions. First, it breaks the hegemony of individualistic theories of technology adoption by showing the relevance of structural and institutional processes. Second, it broadens the use of DOI by providing emphasis on the importance of formal institutions in the process of diffusion. Third, it postulates a multi-layer analytical approach, which incorporates behavioural, social, and institutional aspects.

For future research, the findings suggest the need for more empirical studies that examine the interaction between these levels, particularly in diverse African contexts. Quantitative studies could further test the relationships identified in this study, while longitudinal research could explore how institutional reforms influence adoption over time.

7. Policy Implications

The findings of this study point to the fact that the adoption of agri-tech in sub-Saharan Africa is contingent on the interplay of behavioural, technological and institutional factors. In line with the findings of previous studies, the findings show that despite the substantial potential of digital technologies to enhance the productivity and resilience of livestock, the acceptance of digital technologies depends on facilitating policy environments and institutional support systems (African Development Bank [AfDB], 2023; Mhlanga & Ndhlovu, 2023).

To begin with, this paper highlights focus on the role of infrastructural construction, especially on the digital connection and energy availability, as a condition to adopt agri-tech. The issues of network coverage and the lack of digital means, as identified by the Nigerian farmers, are in line with general findings, according to which infrastructural shortages continue to be one of the key constraints to digital agriculture in Africa (World Bank, 2023). This suggests that policy interventions should prioritise rural broadband expansion and investment in digital infrastructure as foundational enablers of agricultural transformation.

Second, access to finance becomes a major impediment to technology adoption in agriculture. The expensive nature of the digital livestock technologies aligns with the existing literature that highlights financial exclusion as one of the major barriers to the use of technologies in smallholder farmers (Aker & Cariolle, 2023; Dhillon & Moncur, 2023). Specific

financial instruments like subsidies, credit schemes, and public-private financing are needed to reduce entry barriers and encourage inclusive adoption.

Third, the study emphasises institutional capacity and extension services. The low awareness and technical assistance among Nigerian farmers indicate structural flaws in the farm extension system, as extensively reported in the literature (Gumbi et al., 2023). Strengthening extension services to incorporate digital literacy training and technology demonstration programmes could advance both awareness and proper utilisation of agri-tech innovations. On the contrary, institutional frameworks in South Africa are relatively more robust, which promotes the current arguments that coordinated policy and institutional support are key to scaling digital agriculture (OECD, 2022).

Fourth, the study highlights the necessity of policy consistency and harmonisation of regulations. The comparative analysis reveals that fragmented policy regimes, which can be seen in Nigeria, undermine the successful execution of agri-tech initiatives. This is in line with the existing literature, which emphasises the importance of coherent policy frameworks in promoting innovation and technological diffusion (Klerkx et al., 2022). Governments must thus place more emphasis on implementing digital agriculture in the national development plans, warranting cohesion among the various sectors, including agriculture, telecommunications, and the finance sector.

Lastly, the paper highlights the significance of context-sensitive and all-inclusive policy formulation. The latest criticism of digital agriculture warns against universal solutions that cannot consider local socio-economic realities and disparities. Policies should be tailored to the needs of smallholder farmers, taking into account variations in resource access, technological capacity, and cultural practices.

In summary, successful policy action in response to agri-tech adoption should not only focus on technology promotion; it should also target the wider institutional and structural contexts that influence the outcomes of adoption. This would entail a comprehensive approach which involves development of infrastructure, financial inclusiveness, institutional fortification and policy alignment.

8. Conclusion

This paper attempted to explore the economic and policy implications on use of digital technology in livestock management in Nigeria and South Africa using a comparative and multi-level analysis. The combination of the Technology Acceptance Model, the Diffusion of innovations Theory, and the institutional theory helps the study gain a more in-depth insight into the adoption of agri-tech in sub-Saharan Africa.

The findings indicate that farmers in both countries are aware of the potential benefits of digital technologies, but there are significant variations in adoption as a result of institutional capacity, policy consistency, and infrastructural development. In Nigeria, structural factors such as limited access to finance, poor infrastructure and poor institutional support limit adoption. While South Africa, on the contrary, is characterised by comparatively higher adoption rates, as there are more coherent systems of policies and more effective institutions.

In conclusion, the paper established that the success of digital agriculture in sub-Saharan Africa depends not just on technological innovation but also on the institutional and policy environment that supports it. These structural dimensions must be addressed so as to realise the full potential of agri-tech to support sustainable agricultural development and enhance the livelihoods of people living in rural areas.

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