Master Thesis

Title:	**Enabling Agricultural Digitalization through Infrastructure, Literacy, and Governance: A Nigerian Case Study**
Confidential:	*No*

By

Nelson	Leesberg
Student number	i6396703

Study	*Digital Business and Economics*
Thesis supervisor	PhD student, Amar, Sidi
Second reader	Associate professor, Can, Burak

Date & Place	*20.06.2025*

School of Business and Economics

Master

Acknowledgements

I would like to express my gratitude to Sidi Amar, my thesis supervisor, for his help and guidance throughout this process. His guidance helped me to stay motivated at all times.

I also want to thank Burak Can, the second reader of this thesis, for their contribution to the evaluation of my work.

Furthermore, a special thanks to the National Bureau of Statistics for their confidential information included in the General Household Survey, Panel 2023-2024, Wave 5 on Nigerian households, which made this research possible.

Abstract

This study investigates the adoption of data-driven agricultural technologies (DDATs) among smallholder farmers in Nigeria, focusing on the roles of digital infrastructure, digital literacy, and stakeholder collaboration. Using the a large-scale household survey dataset on Nigerian households and logistic regression together with bootstrapped mediation techniques to test three hypotheses. The results show how digital infrastructure, digital literacy, and stakeholder collaboration each have significant direct effects on DDAT adoption. Notably, digital literacy emerges as the strongest predictor. However, contrary to expectations, digital literacy puts a negative mediating effect on the relationship between digital infrastructure and the adoption of DDATs, suggesting a suppression effect possibly related to critical user assessment or misalignments between the stakeholders. Furthermore, stakeholder collaboration does not moderate the relationship between digital infrastructure and the adoption of DDATs. These findings highlight the urgence of considering both digital literacy and stakeholder collaboration dimensions of the adoption of DDATs. This study contributes to the theory by empirically integrating digital literacy and stakeholder collaboration into adoption models and offers practical insights for policymakers and technology providers aiming to improve DDAT adoption in the Global South. The research highlights the need for contextually adapted strategies that go beyond digital infrastructure provision to include digital literacy improvement, trust among stakeholders, and an inclusive design.

Table of Contents

1. Introduction 6
1.1 Background and Context 6
1.2 Problem Statement and Research Gap 8
1.3 Research Objectives and Research Questions 9
1.5 Structure of the Thesis 11
2. Theoretical Framework 11
2.1 Literature Scan 12
2.3 Adoption of Data-Driven Agricultural Technologies (DDATs) as Dependent Variable 13
2.4 Digital Literacy as Mediator 14
2.5 Stakeholder Collaboration as Moderator 14
2.6 Hypothesis Development 14
2.7 Conceptual Model 15
3. Methodology 16
3.1 Research Design 16
3.2 Data Collection 16
3.3 Sample Selection 17
3.4 Operationalization of Variables 18
3.5 Data Analysis Strategy 20
3.6 Ethical Considerations and Limitations of the Data 22
3.7 Sample Characteristics 22
4. Analysis and Results 24
4.1 Correlations 25
4.2 Data Analysis 26
4.2.1 Moderation Analysis 26
4.2.2 Mediation Analysis 28
4.3 Review of Hypotheses 29
5. Conclusion and Discussion 30
5.1 Results of the Direct Relationships 30
5.2 Results of the Indirect Relationships 31
5.3 Relevance of the Study 32

5.4 Answering of the Research Question 33
5.5 Limitations of the Research and Suggestions for Further Research 34
***References* 35**
***Appendix A* 39**
***Appendix B* 40**
***Appendix C* 43**
***Appendix D* 44**
***Appendix E* 46**
***Appendix F* 47**

List of Tables

Table 1: Descriptive Statistics……………………………………………………………15

Table 2: Variables…………………………………………………………………………22

Table 3: Correlations………………………………………………………………………24

Table 4: Hierarchical Regression Analysis………………………………………………..26

Table 5: Bootstrapped Mediation Analysis…………………………………………….…….29

Table 6: Hypotheses………………………………………………………………………30

Table 7: Variance Inflation Factors………………………………………………………..43

List of Figures

Figure 1: Conceptual Model……………………………………………………………15

1. Introduction

In this section, the background and context of the study will be explained, as well as the problem statement and research gap in this field, the objectives and research questions, and finally the structure of this thesis.

1.1 Background and Context

The Global South relies heavily on agricultural production because it sustains economic stability and social structure together with providing livelihoods and food security and national Gross Domestic Product contributions. Suri and Udry (2022) mention that agriculture still accounts for 20 precent of Africa's GDP (four times the global average of 5 percent), and it employs 50 percent of their workforce, despite structural transformation elsewhere in the world. Multiple structural along with environmental hurdles face the sector including low production rates, insufficient infrastructure and minimal market connections and exposure to climatic risks (Gumbi et al., 2023). Continuous operational obstacles have pushed stakeholders to focus on digital transformation as an instrument for agro-ecological development and sustainable growth (Satpathy, 2022).

Digital agriculture which includes mobile apps and digital advisory platforms and precision farming tools and big data systems represents an umbrella term that has shown important potential to address sectoral inefficiencies while driving innovation throughout the agri-food industry according to Porciello et al. (2022) and Duncan et al. (2021). Smallholder farmers benefit from digital solutions which enhance their production levels while decreasing business expenses and connecting them better to larger agricultural networks (Ayim et al., 2020; Aker et al., 2010). The adoption of mobile services in Kenya and mobile-based e-commerce systems in China has produced major benefits that enhance agricultural output levels and boost market access for both regions (Porciello et al., 2022; Wang et al., 2025).

The implementation of digital transformation in agriculture encounters numerous obstacles during its execution phase throughout the Global South. The main obstacles to digital transformation in agriculture include the digital divide and underdeveloped infrastructure alongside fragmented stakeholder landscapes and low digital literacy levels among rural populations (Gumbi et al., 2023; Dibbern et al., 2024). The population in Sub-Saharan Africa faces limited access to electricity (Aker et al., 2010) as well as digital connectivity since only 47% of people have stable connection to these resources (Porciello et al., 2022). Mobile phones have experienced tremendous growth in market penetration (Aker et al., 2010), yet the adoption of agricultural digital services differs widely between users (Ayim et al., 2020).

Digital agriculture presents both technological and systemic challenges which demand coordinated policy frameworks along with stakeholder collaboration and human capital development programs (Satpathy, 2022; Duncan et al., 2021). Research demonstrates key stakeholder participation as essential because government institutions and NGOs alongside tech providers and local residents need to coordinate their efforts to develop scalable and inclusive solutions (Van Tuijl et al., 2024). The absence of well-coordinated implementation plans remains a barrier that hinders sustainable development of digital agriculture ecosystems.

The foundation for digital infrastructure exists as the cornerstone within this system. The infrastructure allows farmers to reach data-driven agricultural technologies (DDATs) and guides information distribution and reception and utilization patterns for small-scale farmers. Digital literacy functions as a critical intervening factor which determines how farmers effectively use digital instruments (Wang et al., 2025; Gumbi et al., 2023). The impact of digital infrastructure on DDAT adoption becomes stronger or weaker when stakeholders actively collaborate or not (Dibbern et al., 2024; Van Tuijl et al., 2024) according to research findings. This study investigates how these multiple components work together in a complex manner.

The current study uses a conceptual model to explore how digital infrastructure (independent variable) affects data-driven agricultural technology adoption (dependent variable) while digital literacy functions as a mediating factor and stakeholder collaboration acts as a moderating factor. The proposed framework integrates three essential agricultural digital transformation elements to fill an important knowledge gap in current research. The proposed framework meets current demands for a structured roadmap which moves beyond technical approaches to implement digitalization through an ecosystem-based strategy designed for Global South contexts.

1.2 Problem Statement and Research Gap

Despite the increasing proliferation of digital agriculture initiatives across the Global South, the translation of these efforts into scalable and inclusive impacts remains inconsistent and fragmented. Although technologies such as digital extension platforms, mobile financial tools, and precision agriculture systems are widely promoted, their adoption by smallholder farmers is uneven, often limited by infrastructural deficits, insufficient digital skills, and a lack of coordinated stakeholder support (Gumbi et al., 2023; Porciello et al., 2022). These inconsistencies point to a disconnect between digital infrastructure availability and its effective use in practice.

The lack of strong digital infrastructure in rural areas, which continues to limit the reach and efficacy of agricultural innovations, is a significant bottleneck in making this transition. According to Aker et al. (2010), mobile phones often act as rural populations' first contact with digital technology, however, the advantages are limited by inadequate electricity supplies, poor connectivity, and restricted platform interoperability. Furthermore, although the use of mobile devices is increasing, the transition to data-driven technologies (like geographical data systems or advisory tools powered by artificial intelligence) requires more sophisticated infrastructure support, which is still lacking in many areas (Dibbern et al., 2024; Satpathy, 2022).

However, infrastructure alone does not guarantee effective technology adoption. Digital literacy significantly influences how farmers interpret, engage with, and apply technological solutions (Wang et al., 2025). Yet, most research on digital agriculture focuses on the supply side, developing and deploying tools, while overlooking how end-users interact with these innovations. As a result, digital literacy often remains understudied in empirical models of adoption (Gumbi et al., 2023).

Furthermore, digital transformation strategies are usually poorly implemented or overlook the importance of stakeholder collaboration. Although multi-stakeholder models are frequently supported in policy discussions, there are few empirical studies examining how these partnerships affect the relationship between infrastructure and technology adoption. Studies show that digital solutions may not reach their intended users or may not acquire enough traction if public, private, and civil society actors do not efficiently collaborate (Van Tuijl et al., 2024; Dibbern et al., 2024).

This study addresses these gaps by examining the interactions between digital infrastructure and the adoption of DDATs, with a focus on how digital literacy mediates this relationship and how stakeholder collaboration moderates it. The research is positioned within the bigger picture of sustainable agricultural development in the Global South and aims to contribute a more integrated and contextualized understanding of digitalization dynamics. By mapping the dependencies and interactions between these variables, the study seeks to inform both policy and practice, offering a thorough roadmap for the design and implementation of inclusive digital agriculture strategies.

1.3 Research Objectives and Research Questions

This study aims to investigate how the availability of digital infrastructure influences the adoption of DDATs by smallholder farmers in the Global South, and to identify the key factors that hinder the successful implementation of digitalization in agriculture. Given the multifaceted nature of agricultural digitalization (including technological, socio-economic, and institutional dimensions) this research adopts an integrated framework that includes digital literacy as a mediating variable and stakeholder collaboration as a moderating variable.

This study aims to investigate how the availability of digital infrastructure influences the adoption of DDATs by smallholder farmers in the Global South, and to identify the key factors that hinder the successful implementation of digitalization in agriculture. Given the multifaceted nature of agricultural digitalization (including technological, socio-economic, and institutional dimensions), this research adopts an integrated framework that includes digital literacy as a mediating variable, a variable that explains the mechanism through which digital infrastructure (independent variable) affects adoption (dependent variable), and stakeholder collaboration as a moderating variable, which influences the strength or direction of this relationship.

The specific objectives of the study are:

1. To examine the influence of digital infrastructure availability on the adoption of DDATs by smallholder farmers.
2. To explore the role of digital literacy in shaping farmers' ability to adopt and benefit from DDATs.
3. To assess how stakeholder collaboration moderates the relationship between digital infrastructure and DDAT adoption.
4. To identify systemic barriers (technological, socio-economic, and institutional) that hinder the successful implementation of digital agriculture in the Global South.

Based on these objectives, the central research question is:

How does the availability of digital infrastructure influence the adoption of data-driven agricultural technologies by smallholder farmers in the Global South, and what key factors hinder the successful implementation of digitalization in agriculture in the Global South?

This central question is supported by the following sub-questions:

1. *What is the relationship between digital infrastructure availability and DDAT adoption among smallholder farmers?*
2. *How does digital literacy mediate the influence of digital infrastructure on the adoption of DDATs?*
3. *How does stakeholder collaboration shape or moderate the impact of digital infrastructure on DDAT adoption?*
4. *What are the primary institutional, infrastructural, and social barriers to digital agriculture implementation in the Global South?*

These questions aim to bridge existing knowledge gaps by offering a holistic view of digital transformation in agriculture and by informing more inclusive and effective digitalization strategies tailored to the needs of the Global South.

1.5 Structure of the Thesis

This thesis is organized into five chapters that collectively explore how the availability of digital infrastructure influences the adoption of DDATs by smallholder farmers in the Global South, while also identifying key barriers to successful digitalization. Chapter 1 introduces the research topic by outlining the background, problem statement, research questions, and the scientific and managerial relevance of the study. Chapter 2 presents the theoretical framework, where the key concepts (digital infrastructure, digital literacy, stakeholder collaboration, and DDAT adoption) are defined and contextualized based on existing literature. It also elaborates on the relationships between these variables and formulates the hypotheses guiding the empirical analysis. Chapter 3 describes the methodological approach, including the data sources, measurement of variables, and analytical techniques used to test the conceptual model. Given the study's reliance on secondary data, this chapter also discusses the criteria for data selection and addresses potential limitations. Chapter 4 provides the analysis and results, offering a detailed account of the empirical findings in relation to the stated hypotheses and research questions. Finally, Chapter 5 presents the discussion and conclusion, where the findings are interpreted in light of the theoretical framework and broader literature. This chapter also reflects on the study’s limitations, outlines implications for policy and practice, and offers recommendations for future research.

2. Theoretical Framework

This chapter lays the theoretical foundation for the study by reviewing and synthesizing literature on digitalisation in agriculture, particularly in the context of the Global South. The goal is to establish clear definitions of the core constructs, identify relevant theoretical perspectives, and formulate the hypothesized relationships between variables as shown in the conceptual model. The chapter concludes with the formulation of testable hypotheses that guide the empirical analysis.

2.1 Literature Scan

Google Scholar was the main tool used to conduct the literature scan, which was centered on peer-reviewed journal articles. To find suitable research, the following keywords were used both separately and in combination:

- Data-driven agricultural technologies
- Digital infrastructure
- Digital literacy
- Agricultural digitalization
- Sub-Saharan Africa
- Global south
- Smallholder farmers
- Agricultural technology adoption
- Stakeholder collaboration

As for the selection criteria, peer-reviewed publications were given preference. Some sources were found by looking through the reference lists of important or often cited studies alongside to the direct search results. This method helped in finding appropriate research that has influenced the field but may not have shown up in the top search results.

2.2 Digital Infrastructure as Independent Variable

Digital infrastructure refers to the foundational technologies and systems that enable access to and use of digital services. In agricultural contexts, this includes mobile connectivity, internet access, data platforms, electricity, and ICT devices such as smartphones or sensors (Porciello et al., 2022; Aker & Mbiti, 2010).

In rural Africa lacking infrastructure, such as electricity and internet access, can cause significantly contrain farmers in the use of digital technology (Mhlanga & Ndhlovu, 2023). Awour and Rambim (2022) argue that with this poor access to information and lacking extension services, the gap in the adoption of new technologies becomes bigger and usually leads to lower productivity. This infrastructure is often divided and unevenly distributed, disproportionately disadvantaging these rural and remote communities (Gumbi et al., 2023). Empirical evidence suggests that digital infrastructure plays a critical enabling role in facilitating access to digital tools, information, and markets (Ayim et al., 2020; Satpathy, 2022).

The adoption of DDAT is thought to be primarily driven by digital infrastructure as an independent variable, especially in situations where device access and connectivity are necessary for digital engagement (Duncan et al., 2021; Satpathy, 2022). Other factors like digital literacy or stakeholder collaboration have limited ability to influence adoption in the absence of the baseline presence of infrastructure like mobile networks, electricity, or internet-enabled devices (Porciello et al., 2022; Wang et al., 2025). As a result, digital infrastructure is a prerequisite for other aspects of agricultural digitalization.

2.3 Adoption of Data-Driven Agricultural Technologies (DDATs) as Dependent Variable

Data-driven agricultural technologies refer to tools and platforms that use data to support agricultural decision-making. Examples include digital extension services, precision farming tools, remote sensing, market information systems, and artificial intelligence-driven (AI) advisory platforms (Duncan et al., 2021; Wang et al., 2025). These technologies can improve productivity, reduce costs, and increase resilience to climate shocks. However, adoption rates remain low in many low-income regions, often due to infrastructural and institutional constraints (Dibbern et al., 2024; Porciello et al., 2022).

In this study, the adoption (DDATs is treated as the dependent variable, meaning it is the outcome the research aims to explain. The study examines how this adoption is influenced by three key factors: digital infrastructure, stakeholder collaboration, and digital literacy. Previous research has shown that these factors play a major role in whether smallholder farmers decide to use digital tools and platforms (Dibbern et al., 2024; Wang et al., 2025; Ayim et al., 2020). Understanding what enables or limits the adoption of DDATs is essential for supporting more inclusive and sustainable agricultural development in the Global South (Gavrilova, 2022; Porciello et al., 2022).

2.4 Digital Literacy as Mediator

Digital literacy encompasses the knowledge, skills, and attitudes required to effectively engage with digital technologies. It includes not only the ability to use ICT devices but also to critically interpret and apply digital content (Wang et al., 2025). Several studies have shown that even when digital infrastructure is available, a lack of digital literacy can hinder technology adoption (Gumbi et al., 2023). As such, digital literacy is expected to mediate the relationship between infrastructure and DDAT adoption: infrastructure provides access, but literacy determines whether and how that access is used.

2.5 Stakeholder Collaboration as Moderator

Stakeholder collaboration refers to the coordinated efforts among actors such as governments, NGOs, technology providers, and farming communities to support the adoption and effective use of digital tools in agriculture (Van Tuijl et al., 2024). Effective collaboration can boost the impact of infrastructure by ensuring that technologies are context-appropriate, scalable, and well-integrated into local ecosystems (Dibbern et al., 2024). On the other hand, divided initiatives and scattered leadership frequently lead to low adoption and little impact. Hence, stakeholder collaboration is conceptualized as a moderator that strengthens or weakens the infrastructure-adoption link.

Stakeholder collaboration is seen as a moderator, something that can make the relationship between digital infrastructure and the adoption of DDATs stronger or weaker. When organizations like governments, NGOs, and tech companies work together well, they can help farmers get more out of digital tools and services (Van Tuijl et al., 2024; Porciello et al., 2022). But when these groups are not well-coordinated, or don’t communicate properly, even good digital infrastructure may not lead to more adoption (Dibbern et al., 2024).

2.6 Hypothesis Development

Based on the literature reviewed, the following hypotheses are proposed:

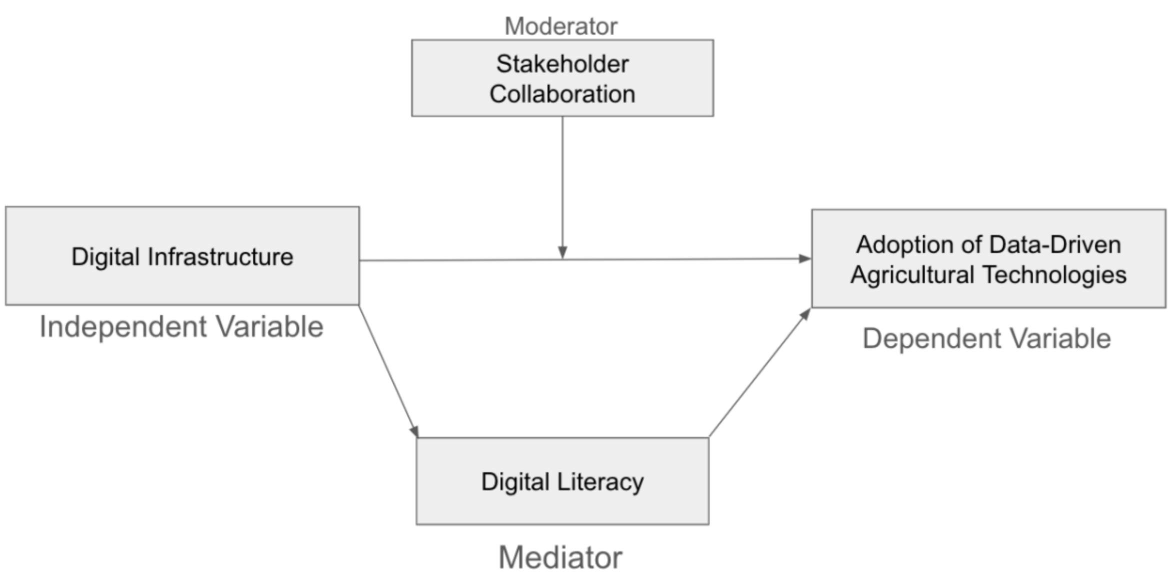
- **H1:** The availability of digital infrastructure is positively associated with the adoption of data-driven agricultural technologies by smallholder farmers.
- **H2:** Digital literacy has a positive mediating effect on the relationship between digital infrastructure and the adoption of data-driven agricultural technologies.
- **H3:** Stakeholder collaboration has a positive moderating effect on the relationship between digital infrastructure and the adoption of data-driven agricultural technologies

2.7 Conceptual Model

The conceptual model is structured around a direct relationship between digital infrastructure and DDAT adoption, mediated by digital literacy and moderated by stakeholder collaboration.

Figure 1

Conceptual model



3. Methodology

This section will cover the methodology of this research. First, the research design, then the data collection, followed by the sample selection, after which the operationalization of the variables will be covered, then the ethical considerations and limitations of the data, and finally the sample characteristics will be covered.

3.1 Research Design

In order to understand how digital infrastructure affects smallholder farmers' adoption of DDATs in the Global South, this study applies a quantitative, explanatory research design. It focusses on stakeholder collaboration's moderating effect and the mediating role of digital literacy in this relationship. Given the study's emphasis on determining and measuring the causal mechanisms between the variables rather than just summarising trends or experiences, an explanatory design is appropriate.

The study is based on a conceptual framework that holds that the adoption of DDAT (dependent variable) is fundamentally supported by digital infrastructure (independent variable). While stakeholder collaboration is viewed as a moderator that can either strengthen or weaken the impact of infrastructure on adoption, digital literacy is believed to mediate this relationship by influencing farmers' capacity to use digital tools. These concepts are taken from the body of research that highlights how user capabilities, institutional support, and technological access interact in digital agriculture (Gavrilova, 2022; Porciello et al., 2022; Van Tuijl et al., 2024).

The study tests these relationships empirically using secondary data from a nationally representative household survey. The design is deductive in nature, using statistical modelling to test theories-based hypotheses. This methodology allows the study to make a contribution to current policy and scholarly discussions about sustainable agriculture and digital transformation in low- and middle-income nations.

3.2 Data Collection

This study uses secondary data from the Nigeria General Household Survey – Panel (GHS-Panel) Wave 5 (2023-2024), which is a part of the World Bank-sponsored Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) program. Rich, nationally representative micro-level data on household demographics, agricultural activities, technology use, and socioeconomic conditions are available to the public through the Nigerian National Bureau of Statistics (see Appendix A for the survey).

Due to the fact that it records variables that are directly related to the study's conceptual model, such as digital infrastructure (such as ownership of a mobile phone or access to electricity), stakeholder collaboration (such as interacting with extension services), digital literacy (comfort in using digital tools for farming), and DDATs (such as using agricultural apps and platforms), the GHS-Panel is especially suitable for this research.

This dataset was chosen for a number of reasons: (1) Scope and Representativeness: It offers a thorough understanding of rural livelihoods in Nigeria, a significant Sub-Saharan African nation where efforts to digitally transform agriculture are becoming more and more important (2) Relevance to Study Variables: It contains indicators that correspond to the variables of this study: digital infrastructure, DDAT adoption, digital literacy proxies, and stakeholder collaboration. (3) Data Quality: Peer-reviewed research on agriculture and development regularly uses the LSMS-ISA surveys, which are rigorously methodological and well-documented.

In order to identify relevant indicators for the variables, the codebook and survey documentation for the dataset were systematically reviewed. This made it easier to relate survey questions and indicators to the conceptual framework's theoretical constructs. Modules regarding technology access, agricultural practices, and institutional interactions were prioritised due to their relevance to the research questions of the study.

3.3 Sample Selection

Data from several Nigeria General Household Survey (GHS) modules, which offer comprehensive details on farming methods, digital tools, and support service accessibility, are used in this study. Using a number of inclusion criteria, a subset of households was chosen in order to create a dataset that was relevant and analytically correct.

The chosen households had to have answered questions about digital infrastructure, adoption of data-driven agricultural technologies (DDATs), stakeholder collaboration, and digital literacy, all of which are relevant to the study's conceptual model. Additionally, only respondents who answered "yes" to either the question if the cultivate crops or are involved in keeping livestock were selected for this study to ensure that only data on farmers would be used. Also, only respondents between the ages of 15 to 64 were selected for this study, as the general working population ranges between the ages of 15 to 64 in Nigeria (National Bureau of Statistics, 2018). By going over the GHS codebook and comparing the relevant post-harvest and ICT-related sections, these variables were found. This ensured that our main target group was selected, and that the rest of the key variables were also covered. By going over the GHS codebook and comparing the relevant post-harvest and ICT-related sections, these variables were found. This ensured that our main target group was selected, and that the rest of the key variables were also covered. This filtering process left a sample of 14039064 respondents.

Furthermore, households were checked for unusable or missing responses. Only those that had enough information to calculate the primary indicators were kept for examination. This stage reduces bias in the estimation process and guarantees the completeness of the data.

3.4 Operationalization of Variables

Five essential concepts are measured in order to examine the relationships in the conceptual model: digital literacy (mediating variable), adoption of DDATs (dependent variable), digital infrastructure (independent variable), and stakeholder collaboration (moderating variable). Following an examination of the codebook and survey forms, certain survey questions from the GHS dataset are used to measure these concepts.

Digital infrastructure (independent variable): the fundamental digital tools and services required for farmers to use digital technologies. The following indicators are employed:

- Whether electricity is available in the household
- Whether the individual has a mobile phone
- Whether the household has access to the internet
- Whether ICT tools are used for communication

These are combined into a composite index, which shows the amount of digital infrastructure in the household by adding up all of the responses into a single score. For instance: a household receives a score of four if they have all four items, if they only have two, they receive a score of two.

Adoption of DDATs (Dependent Variable): indicates if the household uses digital farming tools. Apps or services for finding prices, weather data, or expert advice are a few examples. The survey's relevant questions concern:

- Types of digital tools used
- Why are the tools used (for what purpose)
- Which digital services are used?

A binary variable (0 = not using, 1 = using) or a score that indicates the amount of technology being used can be created using this data.

Digital literacy (mediating variable): The ability to comprehend and operate digital devices. This is measured by asking questions concerning:

- Respondents' reported comfort when using digital tools for farming

People are more likely to embrace new digital tools if they feel comfortable using them. These enquiries help in explaining the connection between adoption and infrastructure.

Stakeholder Collaboration (Moderating Variable): This refers to the extent to which the household receives support by other parties, such as cooperatives, NGOs, or extension agents. Among the most important questions are:

- Were they trained or given assistance?
- Who assisted them? (The government, NGOs, etc.)
- Which topics were discussed?

Since the support type is a categorical variable, every response corresponds to a distinct group. For instance, "1" could represent the government, "2" an NGO, "3" the private sector, and so forth. Each source was coded as binary (received support:1, otherwise: 0), these were them combined for a collaboration score.

The study can test the research questions by using these survey responses in statistical models by converting them into indices and coded variables.

3.5 Data Analysis Strategy

This study will use a quantitative analysis approach to explore how digital infrastructure affects the adoption of DDATs, and how this relationship is influenced by digital literacy and stakeholder collaboration. The analysis will be conducted in five steps, namely:

Step 1: Descriptive Statistics

First, basic summaries of the data will be presented. This includes:

- Examined names, frequencies, and distributions of all key variables
- Presented summary tables in correlation matrices to describe sample

These summaries help to describe the sample and provide context. Visualizations of variable distributions are included as histograms in Appendix B.

Step 2: Reliability analysis

The Cronbach's alpha will be used to assess the reliability of the measured concepts of the study. Cronbach's alpha measures the internal consistency of multi-item constructs to see if the concepts in the data are reliable and that what is trying to be measured is indeed measured. Daud et al. (2018) argue that a Cronbach's alpha above 0,6 is moderate and academically sufficient.

Furthermore, a multicollinearity test will be conducted. Multicollinearity means that 2 or more variables in a regression model are highly correlated and likely carry overlapping data. To asses potential multicollinearity among the variables, a variance inflation factor (VIF) will be calculated. Kock (2021) mentions that the VIF score should not exceed 3.3.

Step 3: Bivariate Analysis

Next, simple correlations between groups:

- Between digital infrastructure, DDAT adoption, digital literacy, and stakeholder collaboration variables

Helps to see which factors matter most.

Step 4: Multivariate Analysis (logistic Regression)

The main analysis will use logistic regression because the dependent variable (adoption of DDATs) is binary. Logistic regression is a method that shows how different factors (like infrastructure, digital literacy, and collaboration) increase or decrease the chances of adopting DDATs. This method allows the model to test:

- The direct effect of digital infrastructure (independent variable)
- The indirect effect of digital infrastructure (independent variable) on the adoption of DDATs (dependent variable) through digital literacy (mediator)

Step 4: Mediation and Moderation analysis

- To test mediation, an additional regression will check if digital infrastructure (independent variable) effects digital literacy (mediator), and if digital literacy then effects adoption of DDATs (dependent variable)
- To test moderation, an interaction term between digital infrastructure (independent variable) and stakeholder collaboration (moderator) will be added to the regression model

Step 5: Mediation analysis.

- To test whether digital literacy (mediator) mediated the relationship between digital infrastructure (independent variable) and the adoption of DDATs (dependent variable), a bootstrapped analysis will be performed.

Due to the large size of the merged dataset (over 3 million rows), analysis requiring intensive computation will be performed using random subsamples (e.g. 10000 random respondents) to ensure feasibility.

All analyses will be conducted in Jupyter Notebook, which supports logistic regression and basic mediation/moderation analysis.

3.6 Ethical Considerations and Limitations of the Data

This study makes use of secondary data from the General Household Survey Panel Wave 5 (GHS-Panel), which was carried out by the World Bank and Nigeria's National Bureau of Statistics (NBS). The original data collectors ensured ethical protections. Survey participation was entirely voluntary, and participants were made aware of the purpose of the study. To maintain confidentiality, respondents identities were anonymised. This study follows the NBS Microdata Library's data use guidelines.

Although the data provides insights that are nationally representative, there are still limitations. First, the variables in this secondary dataset were not specifically adapted to the conceptual framework of this study, necessitating the use of proxy indicators, namely digital literacy (became comfort using DDATs). Second, causal inference is limited by the cross-sectional nature of the data. Lastly, response consistency may be impacted by regional differences in survey implementation. These factors are taken into account in the interpretation of results.

3.7 Sample Characteristics

Table 3.1 shows the descriptive statistics of the final sample. The gender distribution is approximately balanced (48,9% male, 51,1% female). The mean age is 30,86 years, with a standard deviation of 13,42 years. The sample covers a wide range of regions in Nigeria, with the highest representation from Bauchi (15,6%).

The descriptive statistics for the final sample of 14039064 respondents can be found below in table 3.1

Table 3.1

Descriptive statistics

Variable	Frequency (%)	Mean ($\bar{x}$)	sd
1. Gender			
Male	48,9		
Female	51,1		
2. Age		30,86	13,42

3. Region

3.01 Bauchi	15,6
3.02 Adamawa	10,9
3.03 Katsina	7,2
3.04 Kano	6,3
3.05 Jigawa	5,1
3.06 Taraba	5,1
3.07 Kaduna	4,4
3.08 Kwara	3,7
3.09 Gombe	3,6
3.10 FCT	3,5
3.11 Niger	3,0
3.12 Kogi	2,6
3.13 Plateau	2,5
3.14 Yobe	2,4
3.15 Edo	2,4
3.16 Borno	2,2
3.17 Sokoto	1,7
3.18 Benue	1,7
3.19 Akwa Ibom	1,6
3.20 Zamfara	1,5
3.21 Abia	1,4
3.22 Ebonyi	1,3
3.23 Ekiti	1,2
3.24 Imo	1,0
3.25 Enugu	1,0
3.26 Oyo	0,9
3.27 Anambra	0,9
3.28 Rivers	0,8
3.29 Osun	0,7
3.30 Bayelsa	0,7

3.31 Nasarawa	0,7
3.32 Delta	0,6
3.33 Kebbi	0,6
3.35 Cross River	0,5
3.36 Ondo	0,5
3.37 Ogun	0,2
3.38 Lagos	<0,1

Note: n = 14039064, $\bar{x}$ = mean in years, sd = standard deviation in years

4. Analysis and Results

This chapter presents the findings of the study in four stages, like mentioned in chapter 3: descriptive statistics, bivariate correlations, multivariate (logistic) regression results including mediation, and moderation analysis. Each section ties back to the previously developed hypotheses and methodology.

Table 4.1

Variables

Variable	$\bar{x}$	sd	Min	Max
Digital infrastructure	1,378	2,247	0	8
Digital literacy	0,095	0,293	0	1
Stakeholder collaboration	0,030	0,238	0	4
DDAT adoption	0,166	0,372	0	1
Age	30,858	13,420	15	64

Note: n = 14039064, $\bar{x}$ = mean, sd = standard deviation

4.1 Correlations

Table 4.2 below shows the correlations amoung the four key variables of this study. The data in the table represents the relations between these variables. It is important to know that there are five degrees of correlation: very weak or no correlation (0,0 to 0,2), weak (0,2 to 0,4), moderate (0,4 to 0,6), strong (0,6 to 0,8), and very strong (0,8 to 1,0) (Lui, 2021).

Digital literacy holds the strongest correlation with DDAT adoption (r = 0,724), suggesting that farmers who report greater comfort with using digital tools (proxy for digital literacy) are more likely to adopt DDATs. Digital infrastructure shows weak to no correlation with DDAT adoption (r = -0,033). Stakeholder collaboration is weakly correlated with DDAT adoption (r = 0,020). If one of the predictors holds a strong correlation with another (|r| below 0,60), multicollinearity can be a concern (Lui, 2021). In table 4.2 it can be seen that digital literacy is strongly correlated with digital infrastructure (r = 0,64).

Multicollinearity between concepts in this study is also measured. For this, the variance inflation factor (VIF) has been measured, which can be used to evaluate whether there is a strong relation between variables in the dataset. Kock (2021) mentions that the VIF score should not exceed 3.3. None of the VIF factors in this study exceed this threshold (see Appendix C), so it can be concluded that this data does not suffer from significant multicollinearity issues. This means that the data provides reliable insights into the relationships that is being studied.

Finally, the reliability of the scales, indicated by Cronbach's alpha, could only be calculated for two of the four variables, namely, digital infrastructure and stakeholder collaboration. Digital infratstructure provided a Cronbach's alpha of 0,699 and stakeholder collaboration a Cronbach's alpha of 0,610. This means that they both met the acceptable threshold of 0,6 to be academically sufficient (Daud et al., 2018). For the other two variables, DDAT adoption and digital literacy, the survey questions used were evaluated to see if they indeed measured what they were used for. DDAT adoption is tested in the survey through asking respondents whether they used a mobile phone to seek information or advice on their farm in the following ways: a phone call, SMS, WhatsApp, Facebook, mobile application, internet search by self-/Google/ Youtube/etc, other. This is a clear indicator of whether the farmers used digital (data-driven) tools for agricultural purposes and is seen as reliable and valid for this study.

Digital literacy was not explicitly surveyed, but a proxy was found: respondent's level of comfort using digital tools for farming. Respondents were asked to indicate their level of comfort using digital tools for farming after their interaction with them. Even though this does not explicitly indicate how capable a person is at handling digital tools, however, the self-reported survey approach is populair when measuring digital literacy/skills, often using comfort/confidence levels when utilizing digital tools (Dine, 2024). Therefore, comfort levels are seen as a reliable and valid proxy for digital literacy within this study.

Table 4.2

Correlations

Correlation Matrix				
	Digital infrastructure	DDAT adoption	Digital literacy	Stakeholder collaboration
Digital infrastructure	(0,699)	-0,033***	-0,064***	-0,002***
DDAT adoption	**-0,033*** **	(n/a)	0,724***	0,020***
Digital literacy	**-0,064*** **	**0,724*** **	(n/a)	0,026***
Stakeholder collaboration	**-0,002*** **	**0,020*** **	**0,026*** **	(0,610)

Note: DDAT = Data-Driven Agricultural Technologies, n/a = not applicable, *p<0,05; **p<0,01; ***p<0.001, Cronbach's alpha is in between brackets. Cronbach's alpha is only reported for multi-item constructs, single-item constructs (DDAT adoption/Digital litarecy) are marked n/a

4.2 Data Analysis

4.2.1 Moderation Analysis

The hierarchical regression analysis for the Adoption of Data-Driven Agricultural Technologies is shown in table 4.3 on page 27.

In model 1, the predictors digital infrastructure (DI), stakeholder collaboration (SC), and digital literacy (DL) are all included, all three variables are statistically significant (p<0,001). Digital infrastructure shows a small but positive effect (b = 0,031; z = 72,25), stakeholder collaboration has a smaller positive effect (b = 0,024; z = 5,21), and digital literacy shows a strong positive effect (b = 18,931; z = 5,48) the model explain a substantial portion of the variation in the adoption of DDATs with a pseudo R^2 of 0,444, and the model is statistically significant (p<0,001).

In model 2, the interaction term for digital infrastructure and stakeholder collaboration (DI x SC) is added to the three predictor variables to test for a potential moderating effect. This shows a very small negative effect which is found to be non-significant (b < -0,001; z = -0,24). The b-values for digital infrastructure, stakeholder collaboration, and digital literacy remain practically unchanged, however, the z-value for stakeholder collaboration notably drop from 5,21 in model 1 to 4,49 in model 2. This could indicate multicollinearity, however this can be ruled out at VIF<3,3 for all variables (see Appendix C), and the change from 5,21 to 4,49 is not large enough to have an impact on the significance level. Furthermore, the model does not improve, with the pseudo R^2 remaining at 0,444, and the model remains statistically significant (p<0,001).

In summary, the hierarchal regression analysis shows that digital infrastructure, stakeholder collaboration, and digital literacy are significant predictors for DDAT adoption in the baseline model. However, the expected moderating effect of stakeholder collaboration on the relationship between digital infrastructure and adoption of DDATs is not supported by the model as the interaction term is not statistically significant.

Table 4.3

Hierarchical Regression analysis

Dependent variable: Adoption of Data-Driven Agricultural Technologies		
	Predictor variables	Predictor variables + interaction effect DI x SC

	Model 1		Model 2	
Predictors variables	b	z	b	z
DI	0,031***	72,25	0,031**	71,73
SC	0,024***	5,21	0,024***	4,49
DL	18,931***	5,84	18,930***	5,84
Interaction				
DI x SC			<-0,001	-0,24
Pseudo R^2	0,444		0,444	
AIC	7026297,4		7026299,4	
DF (df1, df2)	(4 ; 14039059)		(5 ; 14039058)	

Note: n=14039064. *p<0,05; **p<0,01; ***p<0,001. DI = Digital Infrastructure, SC = Stakeholder Collaboration, DL = Digital Literacy, DI X SC = Digital Infrastructure x Stakeholder Collaboration

4.2.2 Mediation Analysis

To test if digital literacy mediates the relationship between digital infrastructure and the adoption of DDATs, a bootstrapped mediation analysis was performed.

The mediation was tested in two steps. First, digital literacy was regressed on digital infrastructure to ensure “A path” (A path: digital literacy ~ digital infrastructure). Second, DDAT adoption was regressed on both digital infrastructure and digital literacy to estimate the “B path” (B path: DDAT adoption ~ digital infrastructure + digital literacy). This was then repeated one thousand times using bootstrapped resampling with replacement, for each resample, the product of the coefficients (A x B) was calculated to estimate the indirect effect.

The results of this analysis are in table 4.4 on page 29. Out of 1000 bootstrapped samples, 608 were estimated successfully. The average coefficient (b) for path A is -0,099 (95% confidence interval: [-0,130 ; -0,068]), and for path B the average coefficient (b) is 23,509 (95% confidence interval: [11,066 ; 36,864]), both statistically significant as their confidence intervals do not include zero. The main indirect effect (A x B) has a average coefficient (b) -2,310, with a

95% confidence interval of [-3,900 ; -0,970], also statistically significant as zero in not within the confidence interval.

This indicated that digital literacy plays a significant mediating role in the relationship between digital infrastructure and the adoption of DDATs. This is however significantly negative. Indicating that digital literacy has a surprising impact on the adoption of DDATs in relation to digital infrastructure. A possible explanation for this negative effect is that although the availability of digital infrastructure is necessary, higher digital literacy may lead to more selective or critical use of technology, potentially lowering adoption of DDATs under certain conditions.

Table 4.4

Bootstrapped mediation analysis

Path	b	95% CI	Significant (yes/no)
A	-0,099	[-0,130 ; -0,068]	Yes
B	23,509	[11,066 ; 36,864]	yes
Indirect effect (A x B)	-2,310	[-3,900; -0,970]	yes
Successful Bootstraps	608		

Note: A path = digital literacy ~ digital infrastructure, B path = DDAT adoption ~ digital infrastructure + digital literacy, CI = confidence interval, n = 1000, confidence intervals that do not include zero indicate statistical significance at the 95% level

4.3 Review of Hypotheses

Table 4.5 shows the overview of the hypotheses of this study, and if they are supported by the analysis of the data. The hypotheses are only supported if that is by the analysis, and they are significant.

Table 4.5

Hypotheses

Hypothesis	**Supported (yes/no)**
H1: The availability of digital infrastructure is positively associated with the adoption of data-driven agricultural technologies by smallholder farmers	Yes
H2: Digital literacy has a positive mediating effect on the relationship between digital infrastructure and the adoption of data-driven agricultural technologies	No
H3: Stakeholder collaboration has a positive moderating effect on the relationship between digital infrastructure and the adoption of data-driven agricultural technologies	No

5. Conclusion and Discussion

The main focus of this research is the direct relationship between digital infrastructure and the adoption of Data-Driven Agricultural Technologies (DDATs), and the indirect relationships. In this section, the direct relationships, the indirect relationships, relevance of the study answering of the research question, and limitations of the study and recommendations for further search will be discussed.

5.1 Results of the Direct Relationships

The study identified three direct relationships key to understanding the adoption of DDATs among smallholder farmers. First, digital infrastructure showed a small but statistically significant positive relationship with the adoption of DDATs, indicating improved access to digital tools and connectivity improved the likeliness of smallholder farmers to adopt DDATs, like hypothesized (see H1 in table 4.5 on page 30). Second, stakeholder collaboration also showed a statistically significant, but weaker positive effect on the adoption of DDATs, suggesting that when institutions and actors work together, they can create environments that encourage the adoption of DDATs. Third, digital literacy has shown to be the strongest predictor, with a statistically significant positive effect on the adoption of DDATs.

5.2 Results of the Indirect Relationships

In order to study the indirect relationships, a bootstrapped mediation analysis was conducted as well as a hierarchical regression analysis for testing moderation was conducted.

It was hypothesized that digital literacy would have a positively mediating effect on the relation between digital infrastructure and the adoption of DDATs. This was however false. The mediating effect of digital literacy on the relationship between digital infrastructure and the adoption of DDATs was indeed statistically significant, but its direction was negative, suppressing the likeliness of the adoption of DDATs, even though digital infrastructure enables access to DDATs, increased digital literacy appears to reduce the likelihood of adoption in some cases. Possible explanations for this negative effect could be that higher digital literacy can potentially lead to farmers becoming critical of data-driven technologies, becoming more aware of their risks and shortcomings. For example, people with a high level of digital literacy might start to see threats of job replacement by technology, or see concerns with data privacy and refrain from adopting these new technologies (Ehui & Odeh, 2025). Lui et al. (2025) argue that farmers' risk aversion can hinder the adoption of new agricultural technologies. Yeo and Keske (2024) argue that more informed farmers are quicker to become skeptical of DDATs, especially if they doubt the functionality of the technology or the people/institutions promoting it. Altogether, improved digital literacy can lead farmers to be more cautious adopters of new technologies, where lower digital literacy can lead to farmers overlooking these risks, leading to a negatively mediating effect.

Furthermore, the hierarchical regression analysis tested whether stakeholder collaboration moderates the relationship between digital infrastructure and the adoption of DDATs. The results of the analysis showed that the interaction term of digital infrastructure x stakeholder collaboration was not statistically significant and the coefficients were so low that it suggested that stakeholder collaboration has no moderating impact on the relationship between digital literacy and the adoption of DDATs, not supporting H3 (see table 4.5 on page 30). Possible explanations are that in theory, collaboration among governments, technology providers, extension agents, and farmers should improve local capacity and trust, creating a strong combined impact on top of digital infrastructure. In real life, however, coordination barriers can weaken these benefits. For example, poor coordination across key actors can weaken the impact of efforts, leading to a misalignment between the solution and the needs of the farm (Twum, 2025). If these actors work in isolation opposed together, even great and well-funded DDATs can fail to address the local realties, limiting their adoption. Like mentioned before, trust issues among actors are also likely to hinder adoption (Twum, 2025; Yeo & Keske, 2024). A study by Ontario even shows that under-resourced extension and training programs lead to low digital literacy and even a loss of trust in farm technology, and that weak extension support remains as a significant barrier to the adoption of digital tools (Twum, 2025). Altogether, if stakeholders suffer from poor coordination, lacking trust, or limited capacity, they might miss to amplify the effect of digital infrastructure on the adoption of DDATs.

5.3 Relevance of the Study

The findings of this study hold great relevance for both academic theory and practical implementation in the field of the digitalization of agriculture.

From an academic perspective, the findings of this research contribute to the debate on digital transformation in agriculture by addressing key gaps concerning the interplay between digital infrastructure, digital literacy, and stakeholder collaboration. While a lot of literature exists on technological design or adoption in isolation, few studies offer models that empirically test how digital infrastructure and digital literacy influence the adoption of technology together (dibbern et al., 2024; Porciello et al., 2022). This study adds value by positioning digital literacy as a mediator and stakeholder collaboration as a moderator, concepts that are often references but rarely tested together in empirical studies (Wang et al., 2025; Gumbi et al., 2023).

Furthermore, this study addresses a significant gap by focusing on the Global South, Nigeria in particular, where agriculture remains socioeconomically vital, yet technologically underdeveloped. By putting the analysis in this context and adapting its variables to reflect local realities, this study contributes to more globally relevant frameworks for digital adopting in emerging economies (Ayim et al., 2020; Satpathy, 2022).

From a managerial and policy oriented perspective, this study offers guidance for designing, scaling, and contextualizing DDATs. For policymakers, this study highlights the importance of investing not only in digital infrastructure, but also in digital literacy, especially in these rural areas where this may be very low (Duncan et al., 2021; FOA, 2023). These findings also highlight the importance of recognizing institutional and collaborative barriers (beyond technical barriers) that impact adoption rates. For technology developers and service providers, the insights into the dynamics between stakeholders can help to understand local contexts to improve product development and effectiveness. Development agencies may also benefit from the findings this study provides, using it to prioritize digital literacy and building trust between stakeholders.

Altogether, this study shows how digital infrastructure interacts with digital literacy and stakeholder collaboration to shape the adoption of DDATs. By doing so, the study supports the development of more inclusive, effective, and contextual approaches to the integration of DDATs in the Global South.

5.4 Answering of the Research Question

The central research question of this study:

How does the availability of digital infrastructure influence the adoption of data-driven agricultural technologies by smallholder farmers in the Global South, and what key factors hinder the successful implementation of digitalization in agriculture in the Global South?

The central research question is answered through the sub-research questions:

1. *What is the relationship between digital infrastructure availability and DDAT adoption among smallholder farmers?*

2. *How does digital literacy mediate the influence of digital infrastructure on the adoption of DDATs?*
3. *How does stakeholder collaboration moderate the impact of digital infrastructure on DDAT adoption?*
4. *What are the primary institutional, infrastructural, and social barriers to the adoption of DDATs in the Global South?*

The findings show that the three key factors (digital infrastructure, digital literacy, and stakeholder collaboration) have statistically significant direct effects on the adoption of DDATs. Digital literacy is most influential. However, the expected indirect and interaction effects were not as impressive. Digital literacy mediated the effect of digital infrastructure in the adoption of DDATs, however in a negative direction, suggesting a negative relation. Stakeholder collaboration, while important as direct driver, does not influence the strength of the relationship between digital infrastructure and the adoption of DDATs. These concepts do shape the adoption of DDATs, but not always in the expected ways. Furthermore, the primary barriers to the adoption of DDATs in the Global South include weak coordination among stakeholders, poor digital infrastructure, low digital literacy, limited trust among stakeholders and in DDATs, and a mismatch in technology design and local farmer needs.

5.5 Limitations of the Research and Suggestions for Further Research

While very relevant, the study also holds limitations. First, the study relies on secondary data which made it harder to measure the variables. The variable digital literacy was based on proxy items that may not fully capture the indented concept. Second, the cross sectional nature of the data limits causal inference, especially in the mediation analysis.

Future research could build on this work by incorporating longitudinal or mixed-method approached to better capture how digital literacy develops over time and how stakeholders can influence adoption rates. Furthermore, more detailed and locally adopted measures of digital literacy and stakeholder collaboration could potentially refine the findings and allow for a better policy recommendations. For example researching how gender, age, or regional differences impact adoption of DDATs could provide valuable insights into the adoption of DDATs.

References

Aker, J. C., & Mbiti, I. M. (2010). Mobile phones and economic development in Africa. *Journal of Economic Perspectives, 24*(3), 207–232. https://doi.org/10.1257/jep.24.3.207

Awuor, F. M., & Rambim, D. A. (2022). Adoption of ICT-in-agriculture innovations by smallholder farmers in Kenya. https://doi.org/10.4236/ti.2022.133007

Ayim, C., Kassahun, A., Tekinerdogan, B., & Addison, C. (2020). Adoption of ICT innovations in the agriculture sector in Africa: A systematic literature review. *Wageningen University.*

Daud, K. A. M., Khidzir, N. Z., Ismail, A. R., & Abdullah, F. A. (2018). Validity and reliability of instrument to measure social media skills among small and medium entrepreneurs at Pengkalan Datu River. *International Journal of Development and sustainability*, *7*(3), 1026-1037.

Dibbern, T., Romani, L. A. S., & Massruhá, S. M. F. S. (2024). Main drivers and barriers to the adoption of digital agriculture technologies. *Smart Agricultural Technology, 8*, 100459. https://doi.org/10.1016/j.atech.2024.100459

Dine, J. (2024, May 26). *Measuring Digital Literacy Gaps is the first step to closing them*. Measuring Digital Literacy Gaps Is the First Step to Closing Them. https://itif.org/publications/2024/04/26/measuring-digital-literacy-gaps-is-the-first-step-to-closing-them/

Duncan, E., Abdulai, A.-R., & Fraser, E. D. G. (2021). Modernizing agriculture through digital technologies: Prospects and challenges. In *Handbook on the human impact of agriculture* (pp. 138–140). Edward Elgar Publishing.

Ehui, S. K., & Odeh, K. (2025, May 20). *Digital Solutions in agriculture drive meaningful livelihood improvements for African Smallholder Farmers*. Digital solutions in agriculture drive meaningful livelihood improvements for African smallholder farmers. https://www.brookings.edu/articles/digital-solutions-in-agriculture-drive-meaningful-livelihood-improvements-for-african-smallholder-farmers/#:~:text=Despite%20these%20successes%2C%20challenges%20persist,control%20over%20their%20data%20while

Gavrilova, N. G. (2022, February). Impediments to the digitalization of agriculture in Africa. In IOP Conference Series: Earth and Environmental Science (Vol. 981, No. 3, p. 032014). IOP Publishing. https://doi.org/10.1088/1755-1315/981/3/032014

Gumbi, N., Gumbi, L., & Twinomurinzi, H. (2023). Towards sustainable digital agriculture for smallholder farmers: A systematic literature review. *Sustainability, 15*(16), 12530. https://doi.org/10.3390/su151612530

Kock, N. (2020). Harman's single factor test in PLS-SEM: Checking for common method bias. Data Analysis Perspectives Journal, 2(2), 1-6. https://scriptwarp.com/dapj/2021_DAPJ_2_2/Kock_2021_DAPJ_2_2_HarmansCMBTest.pdf

Liu, H. (2021). Chapter 7-Description methods of spatial wind along railways. Wind *Forecasting in Railway Engineering*, 251-282. https://doi.org/10.1016/B978-0-12-823706-9.00007-7

Liu, H., Chen, Z., Wen, S., Zhang, J., & Xia, X. (2025). Impact of Digital Literacy on Farmers' Adoption Behaviors of Green Production Technologies. *Agriculture*, *15*(3), 303. **https://doi.org/10.3390/agriculture15030303**

Mhlanga, D., & Ndhlovu, E. (2023). Digital technology adoption in the agriculture sector: Challenges and complexities in Africa. Human Behavior and Emerging Technologies, 2023(1), 6951879. https://doi.org/10.1155/2023/6951879

National Bureau of Statistics. (2018). *Reports: National Bureau of Statistics*. Reports | National Bureau of Statistics. https://www.nigerianstat.gov.ng/elibrary/read/856#:~:text=%2D%20The%20economically%20active%20or%20working,115.5million%20in%20Q3%2C%202018

Porciello, J., Coggins, S., Mabaya, E., & Otunba-Payne, G. (2022). Digital agriculture services in low- and middle-income countries: A systematic scoping review. *Global Food Security, 34*, 100640. https://doi.org/10.1016/j.gfs.2022.100640

Satpathy, B. (2022). Digital transformation for sustainable agriculture: A progressive method for smallholder farmers. *Current Science, 123*(12), 1436–1440. https://doi.org/10.18520/cs/v123/i12/1436-1440

Suri, T., & Udry, C. (2022). Agricultural technology in Africa. *Journal of Economic Perspectives*, *36*(1), 33-56. https://doi.org/10.1257/jep.36.1.33

Twum, K. O. (2025, May). *Barriers to Adoption: Digital Agriculture in Ontario's Food Production Landscape*. A Research Report prepared for CAPI by Kwaku Owusu Twum. https://capi-icpa.ca/wp-content/uploads/2025/05/2025-05-23-Kwaku-Twum-Digital-Agriculture-EN.pdf#:~:text=3,sensitive%20innovations%2C%20particularly%20for

Van Tuijl, E., et al. (2024). Digitalization, frugal innovation, and sustainable development in the Global South: Opportunities and challenges of a frugal smart water pump. https://doi.org/10.1007/978-3-031-58795-5_4

Wang, Y., Xu, G., Cao, J., Chen, Y., & Wu, J. (2025). Does digital literacy affect farmers' adoption of agricultural social services? An empirical study based on China Land

Economic Survey data. *PLOS ONE, 20*(4), e0320318. https://doi.org/10.1371/journal.pone.0320318

Yeo, M. L., & Keske, C. M. (2024). From profitability to trust: factors shaping digital agriculture adoption. *Frontiers in Sustainable Food Systems*, *8*, 1456991. https://doi.org/10.3389/fsufs.2024.1456991

Appendix A

Due to the large size of the questionnaire, here is a link to find the full dataset and questionnaires: https://microdata.nigerianstat.gov.ng/index.php/catalog/82/related-materials

This study used the sections:

Secta_plantingW5.dta

Variables: hhid, ag1, ag3

Sect1_plantingw5.dta

Variables: hhid, state, s1q2, s1q6

Secta5b_harvestw5.dta

Variables: hhid, sa5bq1

Sect5b_plantingw5.dta

Variables: hhid, s5bq8, s5bq14, s5bq15os

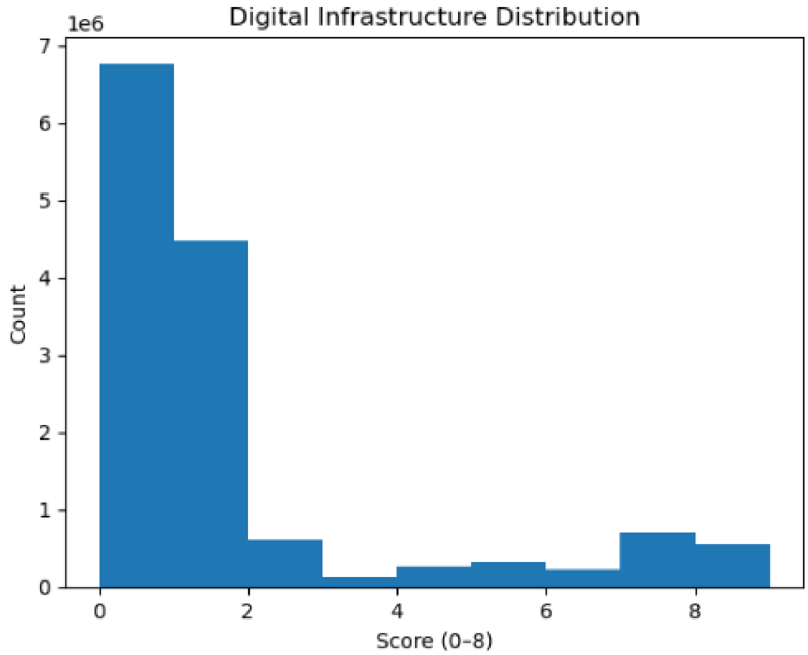
Secta12_harvestw5.dta

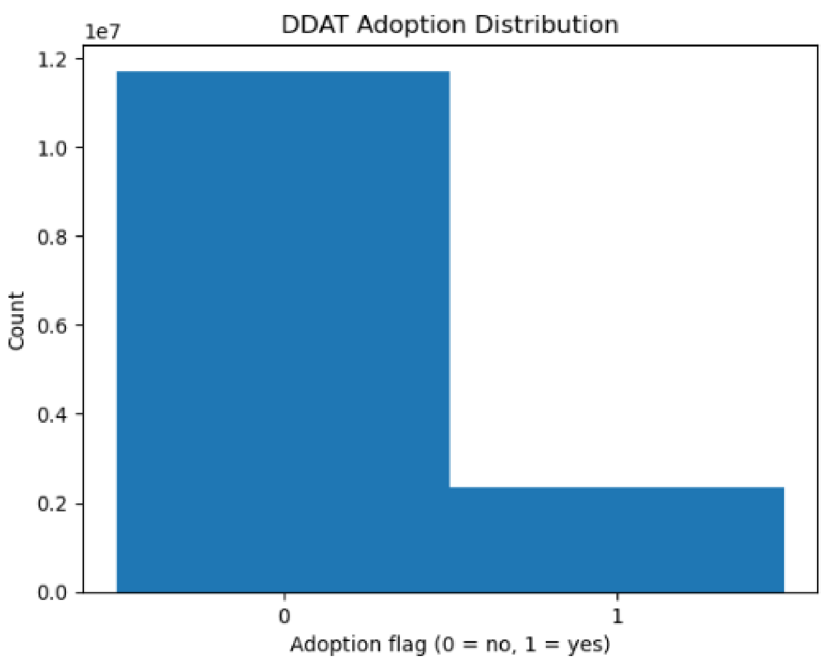
Variables: hhid, s12q2__1, s12q2__2, s12q2__3, s12q2__4, s12q2__5, s12q2__6, s12q2__7, s12q2__8

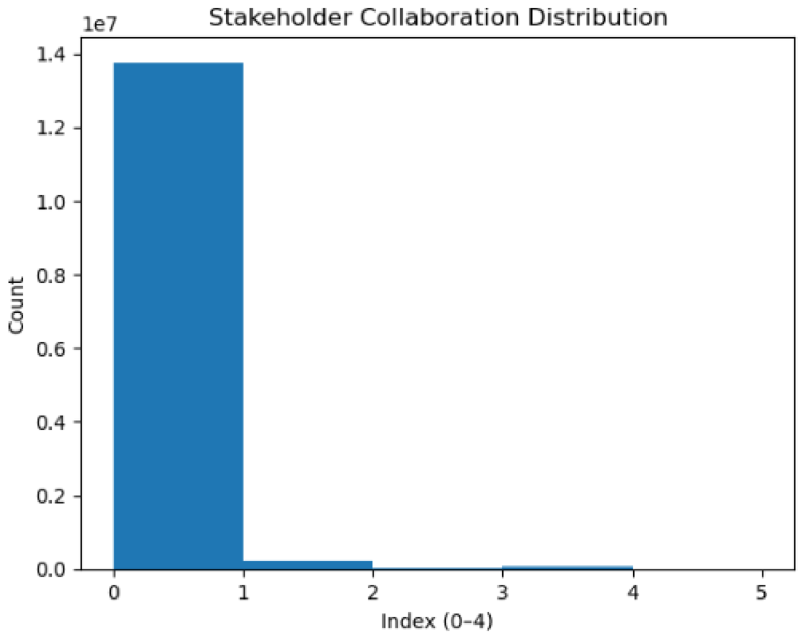
Sect12_plantingw5.dta

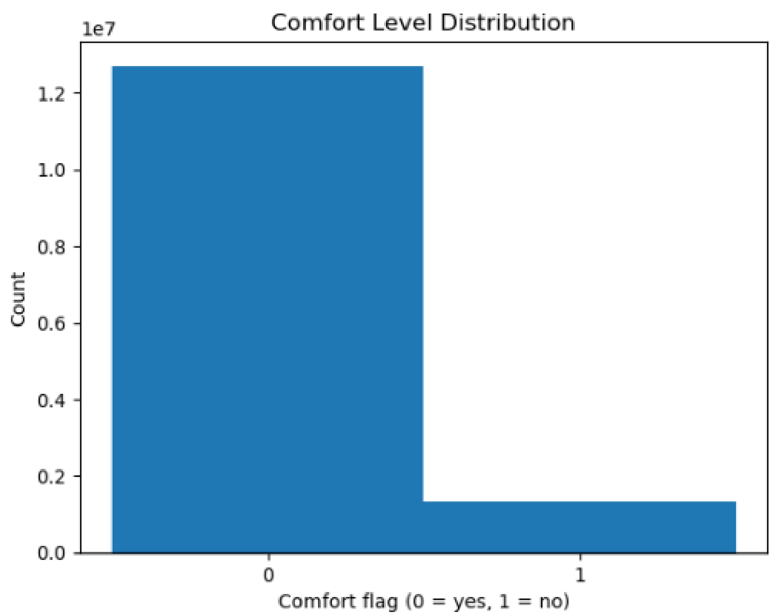
Variables: hhid, s12q2, s12q15

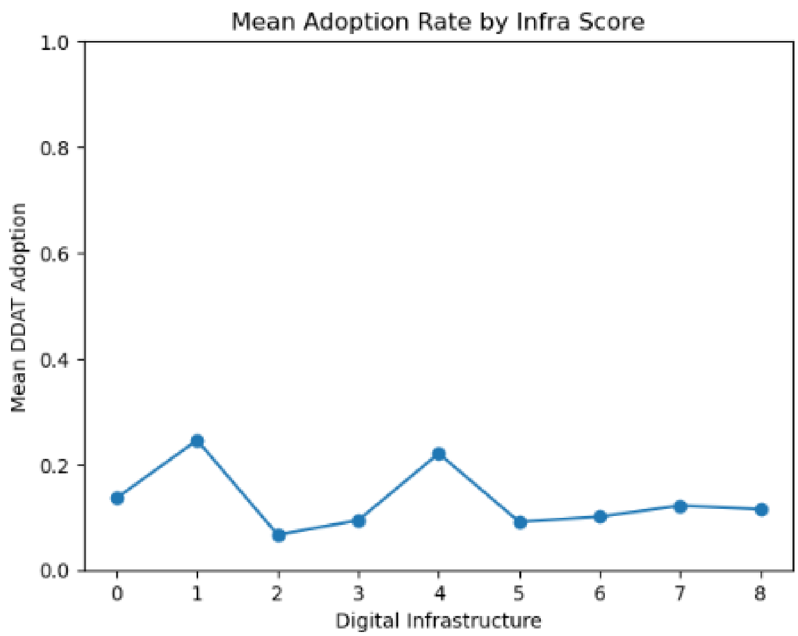
Appendix B


Digital Infrastructure Distribution
1e6
7
6
5
4
3
2
1
0
Count
0
2
4
6
8
Score (0–8)


DDAT Adoption Distribution
1e7
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Count
0
1
Adoption flag (0 = no, 1 = yes)


Stakeholder Collaboration Distribution
1e7
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Count
0
1
2
3
4
5
Index (0–4)


Comfort Level Distribution
1e7
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Count
0
1
Comfort flag (0 = yes, 1 = no)


Mean Adoption Rate by Infra Score
Mean DDAT Adoption
Digital Infrastructure
0.0
0.2
0.4
0.6
0.8
1.0
0
1
2
3
4
5
6
7
8

Appendix C

Table 4.6
Variance Inflation Factor

Variable:	**VIF**
Digital Infrastructure	1,004
Digital Literacy	2,109
Stakeholder Collaboration	1,001
DDAT Adoption	

Note: DDAT Adoption is the dependent variable of this study

Appendix D

Sustainable Development Goals (SDG) Statement

Name	Nelson Leesberg
ID	6396703
Supervisor	Sidi Amar
Date	20/06/2025

Through the research conducted for this master's thesis, I seek to contribute to one or more of the 17 SDG(s) set forth by the United Nations (https://www.undp.org/sustainable-development-goals). Specifically:

SDG Code(s): 4, 8, 9

Explanation (max. 300 words): Explanation: This research contributes to **SDG 8 (Decent Work and Economic Growth)** and **SDG 9 (Industry, Innovation, and Infrastructure)** by exploring how digital infrastructure supports the adoption of agricultural technologies, leading to increased productivity, higher incomes, and better job opportunities for smallholder farmers. Furthermore, it highlights the need for investment in digital infrastructure, such as internet access and mobile networks, to support innovation and sustainable agricultural development, aligning with both SDG 8 and SDG 9.

Appendix E

Official statement of original thesis

By signing this statement, I hereby acknowledge the submitted thesis (hereafter mentioned as "product"), titled: **The roadmap of digitalization in the agricultural sector in the Global South: A Nigerian case study mapping the stakeholders and the implementation requirements**

to be produced independently by me, without external help.

Wherever I paraphrase or cite literally, a reference to the original source (journal, book, report, internet, etc.) is given.

By signing this statement, I explicitly declare that I am aware of the fraud sanctions as stated in the Education and Examination Regulations (EERs) of the SBE.

Place: Maastricht

Date: 20/06/2025

First and last name: Nelson Leesberg

Study programme: Digital Business and Economics

Course/skill: Writing a Master Thesis

ID number: 6396703

Signature: Nelson Leesberg

Appendix F

Statement on the use of Generative AI (GenAI) in the master thesis

I hereby certify that I adhered to the SBE guidelines on the use of GenAI tools such as ChatGPT in the master thesis. In the box below, I document how and for what purposes I used GenAI.

During the preparation of this work, I used GenAI for the following purposes:

- Ideation helper: [List tool(s); provide explanation]
- Text summarizer: [List tool(s); provide explanation]
- Explanation provider: [List tool(s); provide explanation]
- Language assistant: [List tool(s); provide explanation]
- Other: [Help with coding errors in Jupyter notebook; ChatGPT]

After using any tool, I reviewed, quality-checked, and edited the content as needed and take full responsibility for the content of the thesis.

By signing this statement, I explicitly declare that I am aware of the fraud sanctions as stated in the Education and Examination Regulations (EERs) of the SBE.

Place: Maastricht

Date: 20/06/2025

First and last name: Nelson Leesberg

Study programme: Digital Business and Economics

Course/skill: Writing a Master Thesis

ID number: 6396703

Signature: Nelson Leesberg