DIGITALIZATION OF AGRICULTURE: ADOPTION OF DIGITAL AGRI-FOOD TECHNOLOGIES AMONG SMALLHOLDER FARMERS IN RURAL GHANA. A CASE STUDY OF BONO EAST REGION.

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Disclaimer:

This document was an aspect of the author's study programme while at the Institute of Social Studies (ISS). The opinions expressed therein are of the author and not those of the Institute.

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List of Acronyms

ABSA	Amalgamated Banks of South Africa
AFES	Agrarian Food and Environmental Studies
CRS	Catholic Relief Service
CTA	Technical Centre for Agricultural and Rural Cooperation
FAO	Food and Agriculture Organization
FBN	First Bank of Nigeria
FDG	Focus Group Discussion
GDP	Gross Domestic Product
GhAAP	Ghana Agriculture and Agribusiness Platform
GSS	Ghana Statistical Service
ICT	Information Communication Technology
IFC	International Financial Corporation
IOT	Internet of Things
IVR	Interactive Voice Response
MOFA	Ministry of Food and Agriculture
NGOs	Non-Governmental Organizations
SDG	Sustainable Development Goals
SMS	Short Message Service
USAID	United States Agency for International Development

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Abstract

Adoption of digital technologies among smallholder farmers is believed to be the "game changer" for agricultural transformation in sub-Sahara Africa, including Ghana, due to their abilities to provide farmers with insights that help them optimize their production, access appropriate services and products and explore new market linkages. However, the framing of the adoption of these digital technologies among smallholder farmers is often oversimplified into binary metrics (adoption and non-adoption). This kind of approach often reduces adoption to a technical process of increasing uptake, ignoring the complex realities of farmers' lives and the different capacities to engage these tools, as well as the group dimensions of adoption. This study examines how the adoption of digital technologies takes place and the impact on farming practices among smallholder farmers in Bono East region of Ghana. Employing both qualitative and quantitative methods in obtaining data, the study revealed that subscriptions among smallholder farmers are high in the study area, but that active engagement with these platforms is much less than high subscriptions would suggest at first glance. The study also identified factors that influence the adoption and use of these platforms including individual, institutional, and innovation. Lastly, the study revealed that the perceived impact of the adoption of digital technologies extends beyond mere improvements in farming practices, such as weather updates and agronomic advice (fertilizer application). It can exacerbate inequalities, dependency, and deskilling of farmers.

Relevance to Development Studies

Digitalization has become crucial in our world today, especially in the context of agriculture, as it reshapes traditional farming practices and redefines rural livelihoods. The research holds significant relevance to development studies by revealing new realities within the agricultural systems, particularly reshaping the focus of critical agrarian studies. This is important for understanding development in Ghana, where agriculture remains the key contributor to the country's economy and employs most of its working population. By understanding the factors that influence farmers' decisions to adopt digital technologies, the government and policymakers can design better programs and policies to suit communities' interests. This will help harness the potential benefits of digitalization of agriculture while addressing the challenges in adopting digital technologies.

Keywords: Adoption, digital technologies, platforms, smallholder farmers

Chapter 1: Introduction

"Development has entered a new era in which digitalization is profoundly transforming our economies and societies. Significant advances in digital technologies have driven dramatic changes, from the way we communicate and access information to how we conduct business and interact with the environment. Digitalization has opened new avenues for innovation, efficiency, and inclusion, bringing tangible benefits and new possibilities to individuals, organizations, and nations" (World Bank Report on Digital Progress and Trends, 2024).

This statement draws attention to the reality of life today, as it is no longer a choice to make but rather a necessity to go digital. Everything we do, from what we grow, eat, wear, and to how we communicate, is connected to digital technology. It is therefore imperative to understand how digitalization is manifesting in different countries, as the pace and impact of technological adoption differ across regions. The sector that has gained traction in technological transformation in recent years is the agriculture. This was evident during our AFES trip to France.

> We toured a dairy farm, observing the milking process independently after a warm welcome from caretaker. Surprisingly, we found out that a robot did the milking. We watched in amazement as the robot worked, and we couldn't help but exclaim, let's see what the robot can do! whenever the cow walked into the robotic milking machine, something amazing happened. The machine started working as soon as the cow entered. It carefully checked and recorded the details about the cow, like its health and the quality of its milk; while the cow stood quietly, the robot did its job, making sure everything was just right for the cow before the actual milking took place.

This, along with many other advancements, illustrates how digitalization is elevating agriculture to a whole new level. Digitalization of agriculture involves direct and indirect use digital tools and systems such as mobile phones, laptops, robot, drones, and soil sensors to improve practices and processes (The Technical Centre for Agricultural and Rural Cooperation (CTA),2019). Given the variation of digital technologies, Birner et al., (2021) grouped digital technologies into two, building on the notion of embodied and disembodied innovation in agricultural economics. Whereas the former investigates the use of precision technologies (robots, drones, soil sensors) to produce crops and animals, the latter involves the use of software applications to link agricultural service providers to farmers to provide them with agriculturally based services for production. The focus

of the paper will expand on the latter, as digitalization of agriculture in developing countries involve the use of the disembodied innovations particularly the mobile phone.

For Duncan, Abdulai, and Fraser (2021), the emergence of these digital technologies is transformative in nature, as they have abilities to sustainably produce enough food for the growing population of the world and, at the same time, address environmental and climate change issues. For some, it is considered as the "game changer" for agricultural transformation in sub- Sahara Africa (CTA, 2019). For instance, the digitalization of agriculture provides farmers with insights that help them optimize their production, access appropriate services and products, and explore new market linkages. For Tang et al. (2002), agricultural digitalization has risen as a solution to address food concerns and provide new opportunities in the sector. In the same vein, Abdulai (2021) posits that digitalization aims to improve agriculture by bridging knowledge gaps, increasing food security, promoting environmental sustainability, creating jobs, and strengthening rural livelihoods as (cited in Quarshie et al.,2023).

Beyond these benefits are contrary views of the actual impact of digital technologies adoption on smallholder farmers in Sub-Saharan Africa. Atanga (2020) argues that the adoption of digital technologies tends to undermine the autonomy and traditional knowledge of smallholder farmers. Furthermore, it contributes to agricultural deskilling in multiple ways, regardless of their specific nature. For instance, in the adoption of green revolution seeds, deskilling can happen when a farmer is not able to determine the initial impact due to slight modification of the technology (Brooks, 2021). For Srnicek, the digitalization of agriculture is considered a new form of capitalism, which is termed "platform capitalism," where data captured by digital technologies are used by a few international companies to do business as usual (Srnicek, 2017). In this vein, Fraser (2019) calls this "data colonialism" a situation whereby digital subjects are "dispossessed and alienated from the very data they generate." Hence, questions about who owns the data. for what purpose are they used for? Who benefits the most? Among others have attracted attention in the discourse of digitalization of agriculture.

According to Minne et al. (2023), agriculture in the global south has witnessed a widespread of digital technologies in the entire agri-food value chain in recent years. However, the use of these digital technologies is still far off. This is because, there are noticeable differences in adoption rates based on farms and farmers characteristics and across countries. The growing presence of digital technologies and their potential impact highlight the need to understand how these technologies are adopted and spread within the farming sector of countries (Shang et al., 2021). According to Glover, Sumberg, and Andersson (2016), the notion of adoption has historically been and

continues to be, fundamental to documenting technological advancements and their effects on agriculture in developing countries. However, the concept of adoption, is often presented as a simple transactional process which can be misleading (Shang et al. 2021).

For many, technology adoption is seen as fixed package of tools or methods that individuals either accept or reject in a straightforward, linear way (Rogers, 2003). This has resulted in most studies on the factors influencing digital technologies adoption, highlighting individual characteristics and institutional factors (Mhlanga and Ndhlovu,2023; Antwi-Agyei et al.,2021). This approach has certain limitations, as it rarely extends beyond examining user characteristics (Giua, Materia, and Camanzi, 2022). Nonetheless, some scholars argue that the adoption process is more complex and multifaceted, involving numerous stages, stakeholders, and varying degrees of integration (Weersink and Fulto, 2020; Shang et al., 2021). Thus, the complexity of the adoption process can significantly influence the perceived impact of these technologies on farming practices.

Despite this understanding, few studies on adoption of digital technologies by smallholder farmers in Africa have considered this multifaceted nature of adoption (Klerk et al.,2019). This study therefore seeks to contribute to the existing literature on digital technology adoption and its impact on smallholder farming practices. The research focuses on the multifaceted nature of the adoption process, with particular attention to the role of technological and institutional characteristics in the adoption process.

1.1Contextual background

Ghana's agriculture sector remains the key contributor to the economy, contributing more than one-fifth of the country's Gross Domestic Product (GDP) and employs about 36.1% of workers (Ghana Statistical Service (GSS), 2020). Despite its importance, the sector faces challenges such as lack of market access, poor road infrastructure, inadequate financing coupled with climatic variability (GSS, 2020). Recently, the sector has witnessed a decline in agricultural activities and its share in GDP. Reasons include the inadequate extension agents to carry out their duties effectively, leaves most farmers not served (Munthali,2018). For instance, Anang et al., (2020) revealed that the ratio of extension agent-to-farmer is 1:1500 and this make it difficult for farmers to receive information from these agents (as cited in Jones et al., 2023). To others, the limited adoption of technologies has contributed to the underdevelopment of the sector (Abdulai et al.,2023).

Thus, the revival process of the sector lies in the adoption of digital technologies since they can overcome long-standing transaction costs and information asymmetries (Schroeder et al., 2021). Deichmann et al. (2016) argue that it will depend on how farmers adopt and use various digital tools and services for their farming activities. Additionally, Mittal and Mehar (2016) posit that

mobile-based information distribution technologies have the potential to improve adoption of best practices, inputs, and modern technologies that can improve productivity (cited in Jones et al.,2023). A similar vision is shared by international organizations such as World Bank, and European Union, suggesting that to make the agricultural sector more competitive, there is a need to invest in technology and help farmers improve their skills by giving them access to knowledge and support (European Union,2013; World Bank 2023). Thus, to benefit from digitalization, Baumüller and Addom, (2020) posit that a supportive environment is needed to develop and adopt digital solutions that can improve African agriculture, hence a call on governments of countries to embrace such efforts.

In Ghana, the government has contributed to the country's digitization efforts through the introduction of the National Telecom Policy in 2005, which resulted in significant growth in the mobile telecommunication sector. This effort has led to more mobile networks, better coverage, and the creation of many mobile services that provide information to rural areas and farmers (Owusu et al.,2018). In 2018, the Ministry of Communication launched the Digital Agenda initiative to ensure that there is nationwide connectivity. These initiatives, among others, have resulted in the influx of many agritech companies in the country, including Farmerline, Esoko, Trotor Tractor, and Complete Farmer, among others (CTA,2019).

Digital services provided by these companies are claimed to transform the agricultural environment of Ghana through the provision of innovative solutions such as market opportunities, financial services and agricultural inputs aimed at increasing productivity, efficiency, and profitability. By using mobile phones and the internet, farmers can now receive weather forecasts, crop management advice, and market pricing for their commodities (CTA, 2019). Although the state has played a significant role in driving the digitalization process in Ghana, there are concerns about the actual impact of these initiatives on the adoption of digital solutions among smallholder farmers. Question remains about how effective are these efforts in influencing farmers' willingness and ability to embrace digital technologies in their agricultural practices?

1.2 Background of Digital Agriculture Platforms

Digital agriculture platforms are software-based systems that offer farmers and agribusinesses solutions to enhance decision-making, boost efficiency, and improve productivity. These platforms combine technologies such as data analytics, satellite imagery, artificial intelligence (AI), the Internet of Things (IoT), and cloud computing to provide insights and real-time data on farming activities (Brook, 2021). In Ghana, several platforms are known for offering agricultural-

based solutions to farmers. However, this paper focuses on two prominent platforms identified within the study area, including FarmerLine and Esoko.

FarmerLine was founded in 2013 with the goal of creating an environment where producers relate to buyers, agribusiness with food manufacturers, government, and NGOs. It claimed that the company has been able to link over 1000 local and global partners and is still growing (FarmerLine, 2024). This is possible through their partnership with financial institutions like First Bank of Nigeria (FBN) and Amalgamated Banks of South Africa (ABSA), local and international organizations such as the Ministry of Food and Agriculture (MOFA) and USAID respectively to develop scalable solutions like agronomic advice, inputs and extension services to farmers.

Esoko is a digital platform operating in different Africa countries, including Ghana where it began 2008.Initially aimed to supply smallholder farmers with market pricing via SMS, Esoko has expanded to offer digital tools for farmers, agribusiness and development organizations including agronomic advice, data gathering, biometric profiling, and analytics to support rural communities (Esoko, 2015; Esoko 2024a; Esoko,2024b). Recently, Esoko has introduced new services such as digital credit, insurance, payment, and transaction service through partnership with both local and international organizations such as Wienco Agriculture, Vodafone, Toto Agriculture, International Financial Corporation (IFC), and others.

1.3 Research problem

In recent years, Ghana has witnessed a growing interest in harnessing agriculture potentials and addressing myriad challenges such as limited access to markets, erratic weather patterns, insufficient extension services, and low productivity rates faced by smallholder farmers through the adoption of digital technologies (Abdulai et al., 2023). This interest sparks from the rapid penetration of mobile and cellular devices in the country. For example, the report by Datareportal on digital Ghana (cited in Miine et al., 2023) indicates that Ghana stood at 68.2% in 2022 with regards to internet penetration. Consequently, most of its population, including smallholder farmers, now have access to these digital technologies.

The mobile phone technology has emerged as an effective instrument for driving digitalization in Ghana's agricultural sector. Since agritech startups such as Esoko, and Farmerline deliver agricultural solutions like weather forecasts, crop management tips, financial services, and market prices to farmers via the mobile phone (Abdulai et al.,2023). Solutions offered by these companies are claimed to allow farmers to make informed decisions, tackle challenges facing the industry, and improve their farming practices, which can result in increased agricultural productivity (Tsan et al., 2019; Miine et al., 2023).

However, Goedde et al. (2021) contend that despite the widespread of agritech companies and the potential benefits of digital solutions for transforming the agricultural sector, these technologies often fail to scale effectively and do not significantly enhance farmers' livelihoods. Evidence shows that smallholder farmers have low adoption rates of digital agricultural solutions offered by these companies, and among those who adopt, active user engagement is less than 30% (Goedde et al., 202). In 2019, Africa had 26 million registered users on over 400 agritech applications with 40 percent (11 million) users actively engaged (Elliot, 2023). This has resulted in most studies focusing on individual and institutional factors overlooking technological factors (Baumüller and Addom, 2020; Walter et al., 2011).

The assumed accuracy and user-friendliness of digital technologies is rarely questioned in the digital agriculture literature, highlighting a critical gap that needs investigation. Also, the concept of adoption is often conceived in a simplistic way, resulting in most of the literature on adoption equating subscription with actual usage, assuming that farmers continue to use technology once they subscribe. There is a clear need to take a more holistic, dynamic look at the adoption and usage of digital technologies (Glover et al., 2019). This study seeks to understand how digital technologies adoption and usage is taking place among smallholder farmers and the effect on their farming practices.

1.4 Research Objectives

1.4.1 Main objective

The main objective of the research is to assess the adoption and usage of digital technologies and their effects on smallholder farming practices in the Bono East region of Ghana.

1.4.2 Sub-Objectives

1. To examine the adoption and usage of digital technologies among smallholder farmers

2. Assess factors that influence the adoption and usage of digital technologies by smallholder farmers

3. To assess the perceived effects of adoption of digital technologies on smallholder farming practices

1.4.3 Research Question

How are smallholder farmers adopting and using digital technologies in Bono East region of Ghana?

1.5 Relevance and Justification of The Study

Digitalization of agriculture in Ghana, particularly in Bono East region, is crucial due to the potential to address various challenges faced by farmers in the region. Although the region is known to be the food basket of the country, farming in recent years is inherently risky as farmers are faced with challenges in access to credit, market, land, and erratic weather conditions, undermining their productive capacity (Minne, et al.,2023). Therefore, it is crucial to understand how farmers are using their mobile technology to harness the potential benefits of digital solutions provided by agritech companies, as these solutions are claimed to enhance productivity, mitigate climate change, improve market access and promote inclusive growth (Tang et al., 2002: Tsan et al.,2019).

The agricultural diversity in the region makes it suitable for the implementation of agricultural policies and deploying digital solutions from agritech companies such as Esoko and Framerline. Therefore, it is important to understand how these programmes are influencing the adoption of digital technologies in the region. Hence, an extensive and insightful study on this area will help us understand how adoption of these digital technologies is taking place and how it is affecting smallholder farming practices.

This study will be relevant to different categories of actors including farmers, policymakers, agritech firms. The empirical evidence will enlighten smallholder farmers on the transformative impact of digital technologies on agricultural productivity and livelihoods. Moreover, by identifying drivers and barriers to digital technology use in rural Ghana, policymakers can formulate evidence-based policies, allocate resources effectively, and create conducive regulatory frameworks to overcome constraints and advance digitalization efforts. In essence, policymakers will formulate polices that will address challenges in the agricultural sector, contributing to economic growth, food security and sustainable development. Additionally, agritech companies can leverage these findings to understand market demands, user preferences and adoption limitations. This knowledge will enable them to develop innovative solutions and improve product offerings tailored to rural smallholder farmers' needs, thus contributing to agricultural development wellbeing. This will contribute to existing literature on agriculture digitalization.

Chapter 2: Literature Review and Theoretical Framework

2.0 Introduction

In this section, key literature and theories were investigated to explain the intricacies of the topic. Key literature on digitalization of agriculture in Africa (actors, potential benefits, and drivers), the

concept of Adoption (definition, factors). Also, theories such as innovation of diffusion by Rogers, and the political economy of digital technologies were employed in study.

2.1 Digitalization of Agriculture in Africa

In recent years, digitalization has emerged as a focal point in discussions across various sectors, including agriculture, due to its transformative potential and wide-ranging implications. The integration of digital technologies into agricultural practices, often referred to by different terms such as digital agriculture, smart farming, and agriculture 4.0, has gained significant traction globally (Klerkx et al., 2019).

The shift towards digitalization has sparked global debate, highlighting its role in shaping future of agriculture, with varied digital tools, actors, adoption factors, and the impact worldwide. Although critical social science research appears to exhibit an empirical bias towards regions in the Global North (North America and Europe) and developed nations in the Global South (Australia and New Zealand), there is a growing call for critical examination of the widespread implementation of digital technologies in agriculture sector within developing and emerging countries in Africa (Klerkx et al., 2019). This is because digital agricultural technologies are not universally applicable, requiring a thorough examination, contextualization, adaptation, and reinforcement through a locally tailored and contextually sensitive support framework (Glover et al., 2019).

In Africa, the pressing need for food and nutrition security requires more than double the current agricultural production levels by 2030.This challenge is particularly acute in Sub-Sahara Africa (SSA), which already grapples with the highest level of food insecurity compared to other regions (Kudama et al., 2021). The emergence of digital agriculture presents a promising solution to address the region's significant challenges. According to Baumuller and Addom (2020), digitalization is instigating change and propelling advancement across various sectors, notably agriculture. This is because it reduces barriers, fosters cooperation, and promotes inclusive opportunities, thereby aligning with the United Nations Sustainable Development Goals (SDG).

Hence, digitalization is perceived in Africa as a pivotal factor in bolstering climate resilience among farmers, as it has the capacity to enhance productivity and profitability throughout the value chain. Also, it facilitates access to financial resources and addresses social inclusion disparities, particularly among women and youth (Tsan et al.,2019). For instance, there are about 390 digital service providers in Africa, and about 33 million smallholder farmers have access to these digital applications in 2019 and it is expected to increase by 2030 (Tsan et al., 2019). Nonetheless, Klerkx et al., (2019) argue that, despite numerous promises and case studies showing the advancement of

digital technologies in agriculture, significant uncertainties persist regarding their practical utilization by farmers. Similarly, Baumüller and Addom (2020) posit that despite advancements agricultural transformation has been relatively sluggish in adequately benefiting the smallholders who contribute 80% of Africa's agricultural output.

Therefore, to revolutionize African agriculture, there is a need to implement the concept comprehensively. This entails clear definition and strategic deployment with broader agricultural and rural development initiatives. In essence, digitalization should be viewed as a tool for agricultural development, prioritizing problem solving over technocentric approaches. Additionally, digitalization necessitates an enabling environment conducive to the emergence and effective adoption of appropriate digital solutions aimed at transforming the African agrifood system (Baumüller and Addom ,2020).

2.2 Concept of Adoption of (Digital) Technology

The concept of adoption originates from the diffusion of innovation theory, introduced by Everett Rogers in 1962.This concept holds significant importance in the assessment of technological advancements in the agricultural sector of countries, especially in Africa. It serves as a key determinant in evaluating the effectiveness of investments made in agricultural research and the development of technology (Glover, Sumberg, and Andersson,2016). However, the limitations of the adoption process and conventional methods for measuring it have long been recognized (Glover et al., 2019; Glover, Sumberg, and Andersson, 2016; Shang et al., 2021). Nevertheless, assessing the adoption rate of newly introduced technologies continues to play a crucial role in evaluating agricultural research and informing decisions on future investment (Glover et al., 2019).

Understanding how farmers embrace and incorporate new agricultural technologies into their practice is crucial. Hence, the need to understand the concept of "adoption" in a much broader sense. For Ruzzante, Labarta and Bilton, (2021) the combination of innovative decision and diffusion of innovation theory can better explain why some farmers tend to adopt a technology and others do not. With this understanding of how adoption of digital technologies happens, it raises questions of what purpose are digital technologies being used for? how accurate and precise are information provided by digital technologies? It is against this backdrop that some scholars have cautioned that there is a need to redefine the concept of adoption about technological change (Mukhamedova et al., 2022; Glover, Sumberg, and Andersson, 2016).

For Glover, Sumberg, and Andersson (2016), the concept of "adoption" is often flawed, leading to inaccurate and misleading conclusions. The concept is too linear in both space and time, too binary, overly focused on individual decisions, and ignores significant aspects of technological

progress. Hence, technological progress should include how these innovations are shaped, adapted, and sometimes challenged by various stakeholders within agricultural system. Similarly, Weersink and Fulto (2020) proposed a multi-stage approach to adoption, emphasizing the importance of economic, social and attitudinal factors at each step. Moreover, adoption studies that prioritize farmer and agricultural characteristics over technology effectiveness has been criticized by Munguia and Llewellyn (2020) as they proposed replacing binary metrics of adoption with interactive parameters that consider farmer preference and technology attributes. Therefore, a more critical perspective on the concept of adoption is crucial in the digitalization process of agriculture.

2.3 Factors Influencing the Adoption and Usage of Digital Technologies

The factors accounting for the adoption of digital technologies have received much attention in scholarly discussions concerning agricultural development in Africa. This is because the adoption and use of digital technologies among farmers differ across countries.

For Mhlanga and Ndhlovu (2023) weak or non-adoption of digital technology is caused by inadequate infrastructure, socio-economic disparities, and limited understanding at the user end. The authors argue that inadequate infrastructure, poor connectivity, socio-economic disparities and limited digital skills impede digital transformation among smallholder farmers. Sumberg 2005 (cited in Daum et al., 2021). Categorized factors into endogenous (innovation fit with potential users) and exogenous (external factors necessary for adoption). Walter et al. (2011) identified three main dimensions driving digital agricultural solution adoption:" who" (farmers' and farm characteristics), "where" (spatial and institutional factors), and the "why" (motivations).

For Daum et al., (2021) the endogenous factors include user-related and innovation-related problems, with adoption depending on whether the innovation is more efficient than conventional solutions. Similarly, low levels of education, limited government support, cultural and social practice, and reluctance to accept change have slowed down the rate of adoption among smallholder farmers (Antwi-Agyei et al.,2021). Addison et al. (2024) argue that the adoption of digital technologies in agriculture is influenced by individual factors like education, internet access, and attitude towards innovation as well as community-level factors such as telecommunication infrastructure and digital service providers.

Nonetheless, some argue that nature of the app, whether it is user-friendly to potential users, can also influence its adoption. Visser, Sippel, and Thiemann (2021) revealed that certain technologies can feature inaccuracies, which can hinder their adoption or effective usage after its adoption. Hence, not only is it an issue for farmers but an issue for innovators as well. For instance, a farmer

can own a mobile phone, the ability to use the app for agricultural-related solutions is determined by the user-friendliness of the app and the farmer's literacy level. Shang et al. (2021) argue that technological attributes such as compatibility, usability, reliability, and cost-effectiveness influence the adoption of digital technologies. For instance, farmers are more likely to adopt technologies that are easy to use, integrate well with their traditional practices, and provide reliable benefits. Similarly, Daum et al. (2021) argued that the cost of the innovation compared to other factors of production (capital and labour) could influence adoption among farmers. Hence the complex and context-dependent nature of technology is crucial in the adoption and adaption processes (Glover, Sumberg and Anderson,2016).

Factors related to brokers, Community-based farmers groups and cooperatives, Non-Governmental Organizations (NGOs), and digital service providers are often ignored in the literature. Proponents believe that these categories of groups play a significant role in influencing the adoption process (Abdulai et al., 2023; Addison et al., 2024).

Addison et al. (2020) posit that the availability of mobile money agents and cybercafes can enhance the accessibility and affordability of services. Moreover, farmers engagement in cooperatives and farmer-based groups are necessary in building capacity and transferring technology. For instance, group membership builds trust in new knowledge, promote information exchange as well spillover benefits through communal use of agriculture technologies. A study in Zambia on the adoption of improved maize varieties by Manda et al. (2020) revealed that cooperative members were most likely to adopt digital technology since these cooperatives facilitate marketing, input distribution, and information provision, particularly in addressing market failure. For Abduali et al. (2023), farmers' engagement with digitalization in the northern region is mainly driven by the existence of NGOs. For instance, NGOs often offer free or discounted digital solutions to these farmers hence it influenced the number of adopters, however farmers tend to discontinue such services once fees are introduced.

2.4 Diffusion of Innovation Theory

The study employed the diffusion of innovation theory as a reference point in explaining how the adoption of digital technologies takes place, and which factors influence such adoption. Although the theory provides a framework for understanding how new ideas, technologies or practices spread within the social system over a given period (Rogers, 2003). It was important to engage with literature from scholars to better explain this theory (Shang et al., 2021; Glover et al., 2019). Diffusion is a process by which an innovation is communicated through certain channels among members of a social network (Roger, 2003). For Rogers, everyone within the social system

independently undergoes their own innovation-decision process, hence, the identification of the five-staged innovation-decision process including knowledge, persuasion, decision, implementation and confirmation (Rogers, 2003).

The assumption that individuals experience the adoption process differently prompts a critical question: how independent are these decisions in reality? This perspective encourages a closer examination of the various external influences shaping individual choices. Glover et al. (2019) contends that individuals within the social system may experience the adoption process differently, encounters (farmers associations, extension officers, and training programs) can significantly influence their decision. This is because the way these interactions are structured and orchestrated can either enable or limit individual agency, creating opportunities for certain actors while restricting them for others.

Knowledge: this is the awareness creation of an innovation through interactions, such as learning and gathering of information from different sources. In contrast, Glover et al. (2019) argues the first stage, the proposition, introduces technology as an idea with expert guidelines for optimal use, serving as a distinct, initial awareness step in the adoption process. The quality and quantity of encounters are essential in shaping the extent of understanding and autonomy that intended beneficiaries, or potential users experience when engaging with a proposition and acting in response to it (Glover et al., 2019). Importantly, issues of information asymmetries could hinder the adoption process, since not all farmers have equal access to the needed information to make such decisions.

The persuasion stage is where an individual gathers more information about innovation and develops either a positive or negative attitude towards the innovation, which can be influenced by peers and opinion leaders (Rogers, 2003). While assessing the perceived benefits of an innovation is crucial, complex factors such as Attitude, Subjective norms, and Perceived behavioral control can influence such attitude (Shang et al. 2021). Attitude explains how a technology matches with existing ones. Subjective norms explain the perception of leaders about the technology. Perceived behavioral control entails the farmer's ability to use, influenced by their complexity of the technology, financial resources, and available support in social network (Shang et al.,2021). For Glover et al. (2019) individual's perspectives shape how each decision-maker views the proposition, with initial reluctance often evolving into action over time. As they gain experience, their perception shift, leading to a gradual behavioral change.

The decision stage is where a farmer decides to adopt or reject the innovation based on factors such as perceived relative advantage, compatibility, complexity, trialability, and observability

(Rogers, 2003). Perceived relative advantage explains how solutions are rated compared to conventional solutions. Compatibility shows how the innovation aligns with the adopter's existing values and practices, which can either make it easy or hard to integrate. Complexity pertains to how easy it is to use the innovation. Trialability denotes whether an innovation is tested on a small-scale level before full adoption. Lastly, observability relates to how results of the innovation is visible to others (Shang et al., 2021).

The implementation stage involves the actual use of the innovation. At this stage, the individual may encounter practical challenges that result in adaptation or modification of the innovation to fit specific needs (Rogers,2003). The user's agency is crucial since the user decides how to use it and for what purpose. Roger's theory highlights that the process of adoption is not simply reception but active engagement with it. Although the farm operates with the aim of profit maximization, farmers must take into consideration other available resources and adhere to environmental concerns. Adoption of innovation impacts production activities, which are shaped by the input market and contribute to the output market (Shang et al.,2021). Despite the importance of the user agency, broader infrastructure and support systems are necessary for actual implementation.

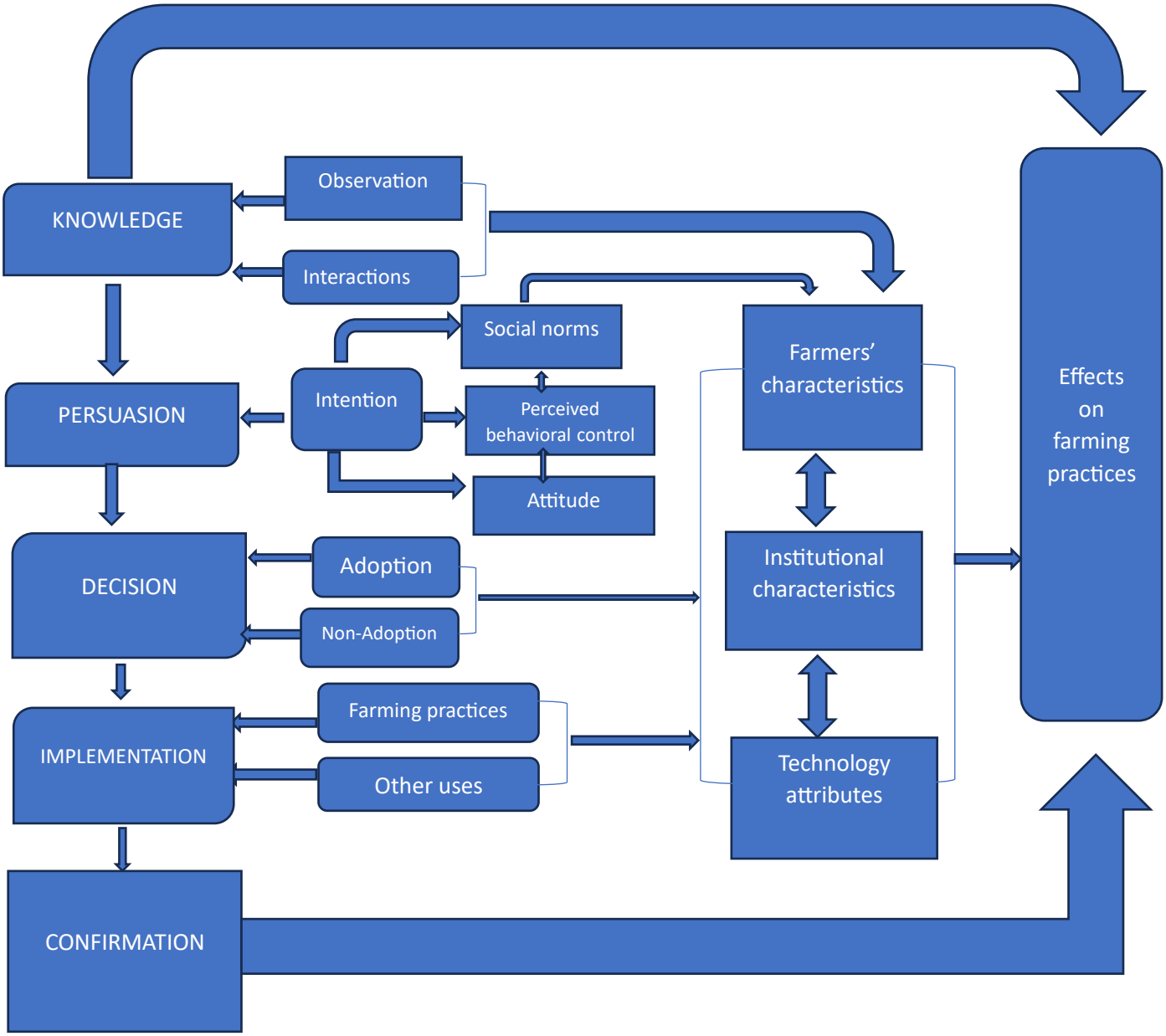
The confirmation: a phase whereby individuals seek reinforcement of the decision to adopt or reject the innovation based on experience (Rogers, 2003). Farmers in this context assess the technology based on its performance and investment costs to decide on using it in the future. Shang et al. (2021) reveal that this stage allows for both dis-adoption (abandoning technology) and mal-adoption (improper use). Additionally, the feedback from farmers is important for technology providers, as they can improve certain aspects of the technology based on user experience.

Despite the importance of this theory, it has limitations that require critical examination. The assumption that individuals move systematically through each stage might not always be the case since individuals may revisit earlier stages based on new information or experiences, which shows the complexity of decision-making, making the adoption process more cyclical and iterative (Glover et al., 2019). The model insufficiently considers contextual factors such as culture, socioeconomic status, and institutional dynamics that significantly influence how individuals navigate these decision processes (Shang et al., 2021). This oversight raises issues regarding power relations and social hierarchies that may affect access to information and resources, potentially skewing adoption rates among different population segments.

Moreover, the emphasis on individual decision-making may also overshadow the role of collective agency and social networks, as innovations often spread through social interactions (Glover et al.,

2019). Furthermore, the applicability of the theory may be limited in non-western settings since it was developed in western world. Given these limitations, this study adopted and modified the conceptual framework (Figure2.4.1) by Shang et al. (2021) inspired by Rogers's theory. It captures the diverse factors and sources of the agency, thus creating a process-oriented view of the adoption of technology. Glover, Sumberg and Anderson (2016, p.4) put this well as they indicate that "technology should be viewed as an activity that individuals engage in, create, or modify, rather than simply something they receive and adopt"

Figure 2.4.1 Conceptual Framework



Source: Adapted and modified from Shang et al. 2021 (adopted from Rogers)

This conceptual framework shows the possible link between the adoption of digital technologies among smallholder farmers and the effects of their adoption and use on their farming practice. This framework was inspired by Shang et al. (2021) as it is useful for studies investigating the role of institutional factors, technological attributes, and social networks in the influence of farmers' adoption decisions at a regional level. However, this framework is limited as it did not capture the effects of adoption and use on production activities of farmers, and the modified framework intends to investigate that.

2.6 Impact of Digital Technological Adoption and usage

As global agriculture faces concerns such as climate change, food security, and resource constraints, integrating digital solutions presents a critical opportunity. The adoption of digital technologies in the agricultural sector is ushering it into a new phase of innovation and efficiency. Therefore, understanding the actual impact of these digital technologies is critical for shaping the future of agriculture and maintaining the sector's long-term viability. The integration of digital technologies into agriculture, whether through access to information, transactional services, advisory services, or comprehensive solutions across the entire value chain, creates a significant impact across social, economic, cultural and environmental dimensions (FAO,2019).

Nsabimana and Amuakwa-Mensah (2018) (cited in FAO, 2019) posit that the usage of mobile apps with price information reduces market distortions and boosts productivity and income. For instance, in the cocoa and coffee industry, increasing mobile technologies reduces price distortion by 0.22% points on average. Similarly, Zhao et al. (2022) posit that digital financing alleviates credit constraints for farmers, this is because digital finance provides farmers with sustainable agricultural production and market information, thus minimizing information search costs. A report by Panel (2019) indicates that digitalization provides farmers with greater access to services, financing, and market connections. This can boost productivity and support data-driven policies through the reduction in geographic, social, and economic isolation. Thus, farmers can be integrated into the value chain. For instance, accurate weather information and improved forecasts delivered via digital platforms help farmers to make better decisions about when to plough, sow, and harvest (Panel,2019).

Evidence is seen in Kenya's" Cropmon project, which offered advisory services to smallholder farmers growing maize, wheat, coffee, grass, and sugarcane via SMS. This included updates on production conditions, weather forecasts, and temperature based on satellite data and soil analysis. It is argued that the location of the farm is often registered in a database, ensuring localized specified information" as indicated by Van der Burgt 2018 (cited in Panel, 2019). Despite the

importance of farm locational data to provide localized weather forecasts, it is equally necessary to question whether farmers consent to the terms and conditions of these companies during the data collection process.

The Panel report (2019) postulates that adopting digital technologies can improve agricultural extension, timely service delivery, and agronomic practices adoption, leading to higher yield and income, as evident among small-scale sugarcane farmers in Kenya. In contrast, Carbonell (2016) argues that the reorganization of the agriculture sector because of digitalization has increasingly diminished farmers' autonomy and control over their production processes, reducing them to what she calls "glorified sharecroppers or, at best contract laborers". Atanga's (2019) study in Ghana revealed that the adoption of digital technology tends to diminish farmers' ability to leverage their traditional knowledge, as digital information often obscures their own expertise in farming activities. Furthermore, the reliance on digital technologies can result in farmers losing their own autonomy in their production activities.

2.8 Political Economy

Political economy investigates "the social relations and dynamics of production and reproduction, property and power in agrarian formations and their processes of change, both historical and contemporary" (Bernstein 2010, p.1).This lens examines the underlying political and power relation driving the adoption of digital agricultural technologies, allowing for scholars and policymakers to explore the motivation behind digital agriculture and to address issues such as ownership, technological development, and data/cybersecurity (Rotz et al., 2019).This will provide us with nuanced understanding of how digital agricultural technologies both reflect and reshape existing power structures, offering insights into the opportunities and challenges they present for farmers, corporations, policymakers, and society at large.

2.8.1 Power Dynamics and Data Ownership

The diffusion innovation theory traditionally overlooks important aspects such as data ownership and power dynamics. As digital technologies become increasingly integrated into agriculture, control and access to data have become essential in shaping power relations among stakeholders. This gap highlights the need to revise the theory to address the implications of data-driven power structures in modern agricultural practices through the lens of political economy.

According to Rotz et al., (2019) central to digital agricultural transformation lies in the gathering and utilization of data for decision making. Agricultural data originates from various sources, exists in the diverse forms, and is managed by different entities, resulting in varying levels of empowerments among stakeholder and users. The complexities surrounding data ownerships and

control are not merely byproduct of technological progress but also serve to impede interoperability while strengthen vendor hegemony. Although, farmers may accept digital agricultural software terms and conditions, their authority over data consent rights remains limited. While digital agricultural companies purport that farmers retain ownership of their data, the absence of clear definition of terms and conditions may perpetuate a persistent lack of informed consent as indicated by Custer (cited in Rotz et al., 2019)

Bronson and Knezevic (2016) argue that there are various difficulties regarding the big data in food and agriculture, which go beyond simple data ownership and equity issues. It implies that, while crowdsourcing Big Data platforms may use farmers' knowledge, they frequently fail to engage farmers in creating the context of data collection. This omission tends to increase power inequalities and reducing farmers' agency in using their own knowledge. The power dynamics of Big Data in agriculture creates a "big data divide" where corporations' benefit from data collection while individuals lack access and control. Businesses like Deere and General Motors for instance restrict farmers' access to tractor software, highlighting structural inequalities (Carbonell, 2016). Furthermore, Climate Corp prevents farmers from modifying data-related products, widening the data divide as farmers disclose farms data to technological benefits, while entities like Monsanto, little transparency on how they store and use this data.

Similarly, Wiseman et al. (2019) discovered that commercial arrangements governing digital agriculture lack clarity and transparency concerning privacy, data ownership, trust, and liability, leading to farmers' hesitancy to participate in sharing farm data. The core of farmers' apprehension lies in the absence of trust between themselves as data contributors and the third parties responsible for collecting, aggregating, and disseminating their data. Addressing power dynamics and data ownership in digital agriculture is necessary to cultivate trust, ensure transparency and fair distribution of benefits between farmers and stakeholders

Chapter 3: Methodology

3.0 Introduction

The study was conducted in Bono East region of Ghana, specifically Tuobodom district. This study adopts both mixed method and case study approaches. According to Yin (2018), case study research involves an empirical inquiry method aimed at examining contemporary phenomena within a real-life context and asking questions such as the "how" and "why". This aligns with my topic since digitalization of agriculture is a contemporary phenomenon, and the research seek to understand how smallholder farmers are adopting and using digital technologies for farming. The

study adopted a mixed method (qualitative and quantitative) because according to Panke (2018), integrating both methods offers a comprehensive analysis of the case, allowing for deeper understanding. Moreover, it posits that the combination of methods has the potential to offset each other's limitations, thus proving advantageous. Hence my choice for a mixed method approach.

3.1 Sampling Strategy

A purposive sampling technique was used to select the study area, this is based on the presence of agritech companies such as Esoko and FarmerLine and the fact that it is among the districts in the region that grow most of food crops. Subsequently, convenience sampling was employed to select 27 participants from the community who were readily available and willing to participate in the research. From the district analytical report (2010) approximately six out of ten households (60.3%) in the district are engaged in agriculture, with most households (58.4%) participating in crop farming. Due to the agrarian nature of the study area, this method was appropriate because most of the population was engaged in farming. The Focus Group discussion (FGD) was conducted on a collaborative owned and cultivated farm recommended by a local farmer. This setting was ideal for the discussion, as most farmers were already present, making it convenient to gather participants in a comfortable and familiar setting. Moreover, purposive sampling was utilized to select three (3) key informants from agritech companies and the Ministry of Food and Agriculture (MoFA). These key informants will be chosen based on their extensive knowledge and expertise pertaining to the subject matter.

3.2 Sources of Data/Evidence

The study employed interviews, focus group discussions, and observations as sources of primary data whereas the secondary data will be gathered through the agritech companies, as well as the Ministry of Food and Agriculture websites. Interviews were conducted with smallholder farmers to gain insight into how they are adopting and using these technologies and to assess the impact on their farming practices. Data was gathered from agritech companies on the kind of services provided, how they are provided and the benefits these services bring to their users. Additionally, information on the role of government in promoting the digitalization of agriculture in the region was gathered from MoFA officers. According to Yin (2018), employing different sources of evidence such as document review, archival records, interviews, direct observation, participant observation, and use of artifacts helps in triangulation, which can strengthen the credibility and the dependability of conclusions. In addition, it can also provide a comprehensive insight into the case. Thus, my choice of multiple sources of evidence is informed by these advantages.

The study used a semi-structured interview guide as an instrument for data collection. Data were collected from twenty (22) food crop farmers in the district through one-on-one interview. This is because a semi-structured interview guide merges the advantages of both structured and unstructured interviews, as it allows the interviewer to probe further for clarity and detail of the subject under study (Rubin and Rubin, 2011). This makes it an essential tool in qualitative research, allowing researchers to obtain comprehensive and nuanced insights into the study topic. An in-depth interview was also conducted with the three (3) key informants (MoFA officer, two officers from Esoko, and Farmerline) to gain extensive insight regarding the topic. Furthermore, the study conducted a FDG with five (5) participants, including both men (3) and women (2). Since the research topic does not aim to explore power dynamics among farmers, it is suitable to have a heterogeneous group. This diversity enriched the discussion by incorporating a variety of perspectives and experiences, thereby enhancing the overall quality of insight gathered. Although both interviews and FGDs have their own strengths and weaknesses, it was essential to use both methods in the research because they complement each other. While interviews focus on deep, personal insights, FGDs offer broader range of perspectives, revealing how different individual respond to shared topics in a group setting.

3.3 Data Analysis

The qualitative data from interviews and FGD was conducted in Twi and recorded with digital audio recorders and supplemented with field notes. The data was transcribed into English and thematic analysis was applied to the data to identify themes, associations, and relationships. After thoroughly reviewing the transcribed data to understand the content, open coding was employed to identify emerging concepts, including the adoption process, factors influencing the adoption, and the impact it has on farming practices. Also, an inductive process was adopted, drawing from existing literature on adoption and impact and the researchers' experience to provide explanation and presented as direct quotations. The secondary data from the journals, company websites, and apps were inferred during the discussion of findings. The quantitative data was analyzed using an Excel spreadsheet. Descriptive statistics were applied to the demographic variables, which were cross tabulated with selected outcome variables such as number of subscriptions, ease of use, and understandability of data and insight to ascertain their relationship. The results were presented using bar charts and tables.

3.4 Ethical Consideration and Positionality on the Research

According to O'Leary (2021, p.75), the core of research integrity lies in ethics. With power comes responsibility, and as a researcher, you bear an explicit and fundamental obligation towards your participants. Therefore, the ability to navigate these responsibilities on legal, moral, and ethical

levels is a prerequisite for a good researcher. Hence, I obtained ethical clearance from the school authority to undertake this research. I also sought permission from the community as well as the participants to undertake the study. O'Leary (2021, p.75) emphasized on the importance of safeguarding the dignity and well-being of respondents, both physically and mentally. Therefore, I ensured the confidentiality and anonymity of the data collected throughout the research process.

Positionality is yet another aspect that needs to be considered in the research process. O'Leary (2021, p. 61) argues that if the aim of research is to generate knowledge that others can trust and depend on, then its production should be credible. Therefore, it is crucial to acknowledge one's positionality and how it can affect the collection and interpretation of data. Considering my position as a researcher conducting a study in a district where I previously worked, my close relationship with farmers gave me easy access to participants to conduct the interviews. My familiarity, along with my experience working with the Ministry of Food and Agriculture (MoFA), provided me with a deeper understanding of the intersection of agriculture, technology, and policy as well as the challenges farmers face in adopting digital technologies.

3.5 Scope and Limitation of study

The study was conducted in Tuobodom district in Bono East region of Ghana. The study explored the adoption and usage of digital technologies among smallholder farmers. The study encountered several challenges during the entire process. Firstly, there was a tribal conflict ongoing in the study area which made it difficult to access certain areas in the district. Although the conflict had subsided during the time of my arrival, due to safety concerns, I was s restricted from going to certain parts of the district, hence narrowing the scope of interaction with participants.

In addition, gaining access to the agritech companies was not easy, especially with Farmerline. Manifold efforts through emails, phone calls and a visit to their office proved futile. Officials of Farmerline were hesitant to share information. Although I could not engage with an official at the head office, I had an informal interaction with the Farmerline field agent, who helped me in contacting the smallholder farmers as well as answering certain questions about the company's services. The struggle I went through in contacting Farmerline made me approach Esoko differently, which gave me the opportunity to conduct an interview with their official. However, this interview came with terms and conditions of allowing them to have access to findings after the research. Lastly, accessing certain policy documents from MoFA and the agritech companies was an issue since officers were hesitant to provide documents. Hence, I relied on the available ones from their websites for the study.

Chapter 4: Results and Discussion

4.0 Introduction

This chapter will discuss four main topics: the sociodemographic characteristics of farmers interviewed, the adoption and usage of digital technologies, factors that influence the adoption and usage of digital technologies and effects of adoption on the farming practices of smallholder farmers.

4.1 Socio-demographic characteristics of respondents

The socio-demographic characteristics such as sex, age, marital status, educational level, and land ownership of respondents in the study area were gathered, as they are likely to be relevant in explaining adoption or effect adoption in the data. According to Ayisi et al., (2022) that socio-demographic characteristics such as marital status, sex, educational level, and age play a significant role in the adoption of agricultural technologies.

Table 4.1.1 Demographic characteristics of Respondents

	Frequency	**Percentage (%)**
Sex		
Female	6	22%
Male	21	78%
Total	**27**	**100%**
Age		
30-39	7	26%
40-49	11	41%
50+	9	33%
Total	**27**	**100%**
Marital status		
Divorced	7	26%
Married	17	63%
Single	1	4%
Widowed	2	7%
Total	**27**	**100%**

Educational Level		
Basic	16	59%
None	6	22%
Secondary	4	15%
Tertiary	1	4%
Total	**27**	**100%**
Land size (acres)		
1-5	11	41%
6-10	9	33%
11-15	3	11%
15+	4	15%
Total	**27**	**100%**

Source: Fieldwork, 2024

Table 4.1.1 shows there are more males (78%) engaged in farming activities than their female (22%) counterparts. As for Tuobodom district report (2010), there are about 51.6% (males) than females (46.7.8%), although, recognizing that the difference in this study's sample is larger than in the Tuobodom study. With regards to age, many of the respondents were aged between 30- 39 and 40-49 years, representing 67%, while the remaining few (33%) were 50+ years. This suggests that the majority were part of the economically active population, consistent with Tuobodom district report, which states that 73.5% (15-50) is in the labour force, while 26.5% (below 15 and 60+) make up the dependent group.

Regarding marital status, most of the respondents were married, representing 63%, whereas the remaining respondents were either divorced (26%) or widowed (7%). This aligns with the findings from the Techiman North (Tuobodom) Analytical report (2010) showing that about 44% of its population aged 12 and older are married, 41.1% have married, 4.5% are widowed, 5.7% are divorced and 4.8% are in consensual unions. With regards to educational levels, the majority (78%) of respondents had some level of formal education, while the remaining (22%) did not have any form of formal education. These findings suggest that with the level of education, most respondents were able to operate a digital tool. This concedes with the data from the Techiman North analytical report (2010), which showed that out of the population, 73.3% are literate and 26% are non–literate.

Khalil et al. (2017, p.1) posit that there is no universal definition of smallholder farming, as definitions vary based on historical, institutional, and environmental contexts; therefore, a set of

criteria including production factors, management style, and economic size should be used in its definition. Thapa (2009) (cited in Khalil et al., 2017) indicated that a maximum land size of 2 hectares of cropland is mostly used to measure smallholder farmers. Based on this criterion, 41% of farmers owned land ranging between 1-5 acres which is equivalent to 2 ha as (1ha= 2.471 acres). Although the remaining farmers (59%) may have more than 2 hectares, they were still classified as smallholders based on the other criteria, such as management style and economic size of the farm outlined by Khalil et al. (2017). Generally, the demographics of the study closely reflect the district's population, confirming that the sample is representative.

4.2 Adoption and usage of digital platforms among smallholder farmers

Over the past decades, cell phones have revolutionized the developing world. It is argued that mobile phone adoption in developing countries creates opportunities and challenges, particularly in crucial sectors like agriculture (World Bank, 2011).

4.2.1 Digital Platforms in Ghana: Esoko and Farmerline

Bell et al., 2013 (cited in Etwire et al., 2017) the number of digital agricultural companies in Ghana had increased rapidly, largely due to the advancements in the telecommunication industry because of the increased use of mobile phones in Ghana. In this transition, digital platforms like Esoko and Farmerline have become important players, offering services meant to empower farmers, boost agricultural output and improve market access across different regions in the country. The extent and influence of these services have changed over time, reflecting the shifting needs of the agriculture sector as well as the increasing digital literacy of rural inhabitants.

Esoko expanded its offering to Bono East region in 2019 to provide a wide range of digital services including biometric profiling, agronomic guidance, financial services such as digital credit, insurance, and mobile money (Esoko 2020). These services are made possible through their different mediums such as Interactive Voice Response (IVR) which allows for automated phone calls to reach many people, playing back prerecorded questions and prompts. Thus, recipients can respond to these inquiries either by pressing keys or verbal response facilitating a two-way communication. In addition, SMS and Voice SMS for distributing prerecorded messages in any language as text and audio, respectively which are considered as one-way communication mediums. Also, Call-assisted interviews were conducted by Esoko official from their call center. These interviews are conducted through a digitized survey, or questionnaires known as Computer-Assisted Telephone Interviewing (CATI), where the response from these interviews is recorded, tracked, and submitted to organizations through a web reporting dashboard. These approaches

facilitate scalable data collection and real-time information dissemination (Esoko, 2022). During my interaction with Esoko officer he noted that.

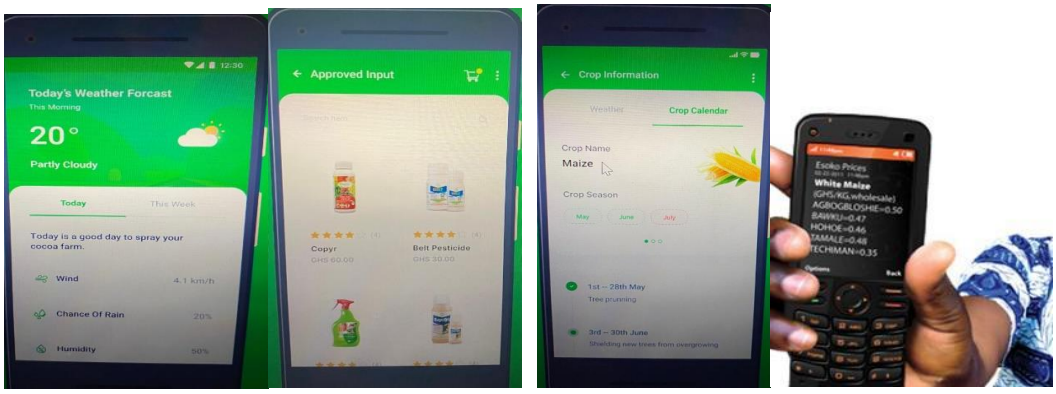
> Esoko have recently established a WhatsApp platform primarily for farmers who utilize smartphones, where they share videos and messages about their services. The frequency of service delivery varies across different mediums. IVR, SMS and Voice SMS are provided on a weekly basis, while call-assisted interview are conducted monthly. In contrast, WhatsApp platform messages are sent regularly as needed. Obtaining services from the platform requires a monthly subscription fee of $1 for farmers (Fieldwork, 2024).

Farmerline initially started as a platform that offers farmers quality inputs and training to increase productivity in the Ashanti region. However, in 2021, Farmerline expanded its services to Bono East region through the Mergdata platform, which is a central hub where data of smallholder farmers, agribusinesses, and other stakeholders within the supply chain are consolidated. Through the hub, Farmeline can integrate, analyze, and access a wide range of agricultural dataset in making decisions about crop production. Decisions such as market access and weather forecasts by partnering with agro-input dealers and commodity brokers and Meteorological agency respectively. This allows for flexible payment options for both input dealers and farmers. Such services are provided in both local languages and offline (Farmerline,2024). During an interaction with a Farmerline officer, who also served as an agro-dealer in Bono East region noted that:

> "I collaborate with Farmerline to supply agricultural inputs to farmers. The Mergdata platform facilitates this process by allowing me to offer inputs on credit, with the flexibility of receiving payment after harvest or accessing farmers' produce post-harvest" (Fieldwork, 2024).

For the farmer's side this service enables them to purchase inputs on credit. Furthermore, according to the agro-dealer, Farmer line provides farmers with weather forecast updates and agronomic advice through SMS, voice calls, and Interactive Voice Response (IVR) systems typically delivered on a weekly basis (Fieldwork, 2024).

Picture 4.4.1 Platforms interfaces



Source: Platforms websites

4.2.2 Access and Ownership of digital device

For adoption of digital technologies of course having a cell phone is important. The study revealed that most smallholder farmers (96%) had access to mobile phone devices while a few (4%) did not have access to mobile phones. Deductively, since majority of farmers owned mobile phones, this could be a potential step to adopt and use a digital platform. This affirms findings by Trendov et al. (2019) that the foundation for the digital transformation process of rural areas, agriculture and food sector lies in the access of a digital technology. On the other hand, the remaining few who did not own a mobile phone also had the opportunity to subscribe to available platforms via a different person's phone. This finding supports the argument of Abdulai et al. (2023) that with the increase in cell phone coverage and the broad availability of affordable smartphones, mobile-based solutions offered by agriculture technology (agritech) companies have the potential to reach millions of smallholder farmers, even those in the remote areas. Thus, farmers without mobile phones also stood the chance of assessing services provided by these agritech companies via a third party such as partners, family members, and children.

To this effect, a female respondent had this to say.

> I don't have a mobile phone right now because mine is faulty, but currently, my SIM card is in my husband's phone, which supports two SIM cards; hence, it allows me to continue receiving updates from FarmerLine (Fieldwork, 2024).

This situation highlights two critical issues that should be considered in the adoption process: first, underlying inequalities in access to technology, where some individuals lack resources, such as mobile phones or data, necessary to engage directly with digital platforms. Secondly, adoption should be seen as a household decision, not just an individual one. This is because, in most rural areas, families share resources like phones thus making collective decisions (Owusu et al., 2018). Although joint decisions can be taken regarding which platform to subscribe, the person (male)

who has access to the mobile phone can have greater influence in such a decision. Also, original information sent by the platform might be misinterpreted, reduced, or even altered when shared with joined users; in some cases, farmers might experience delays in receiving information, which can distort the intended purpose of the service provided.

To understand whether ownership of mobile phone devices guaranteed adoption and usage of digital platforms, respondents were probed further to understand whether they have subscribed to any digital agricultural platform. Out of the total respondents, 23 (85%) of farmers stated categorically that they had subscribed to digital agriculture platform, while the remaining 4 (15%) farmers had not subscribed to any digital platform. A similar study by Minne et al., (2023) found that over 50% of farmers in Bono East region of Ghana have adopted digital solutions, mainly for market and extension services. This trend indicates a growing accessibility of digital technologies in rural areas, suggesting that smallholder farmers are increasingly recognizing the importance of these tools for improving agriculture.

Also, their decision to subscribe may have been largely influenced by the nature of their encounters, as many acknowledged that they were motivated by the influence of fellow farmers during their meetings. The remaining 15% who had not subscribed to any platform, nevertheless, did have knowledge of the existing platforms in the district. It is also important to note that there were instances of un-subscriptions among farmers reasons for such decisions are unclear as farmers were not ready to talk.[1] This shows the extent to which knowledge of digitalization of agriculture has reached rural areas. However, mere awareness of a technology does not guarantee its adoption; instead, it requires a step-by-step process for successful integration (Rogers, 2003). Some farmers disclosed that they have not subscribed to these platforms due to lack of observable benefits among current users, and they will consider subscribing only if they see positive outcomes.

4.2.3 Characteristics of adopters and non-adopters

Glover et al., (2019) acknowledge that individual attitudes toward a technology can shift overtime, hence, initial reluctance to engage with the proposition may later transform into a decision to adopt. Although these non-subscribers demonstrate traits of early majority according to Rogers's theory such as waiting for proof of the innovation reliability and practicality from innovators and early adopters. Their 15% share does not meet the threshold for this category. This may be due to the platforms' relatively short duration in the region in the case of Farmerline (around 3 years),

[1] There was an instance where a subscriber of Farmerline opted out of the platform. The reason for such decision is unclear because the farmer refused to speak. The refusal to open up can be ascribed to the fact that the farmer thinks that the researcher was associated with the platform.

making it difficult for farmers to observe clear benefits, as noted by an officer during our interaction. Consequently, they could be classified as part of a more hesitant group like late adopters. Concerning the issue of non-adoption, a male respondent said this:

> Although these platforms promote the gospel of digitalization of agriculture during radio discussions, I have been hesitant to subscribe, as I have not observed any benefits from my neighbours who have subscribed to their services (Field work, 2024).

It was essential to understand which platforms farmers subscribed to and what type of services they received from them. Based on information on the platform's websites and interaction with officers. The services provided by these platforms can be categorized into four (4) namely market services (prices and linkage), extension services (weather update, agronomic advice), input services (mechanization, inputs), and financial services (insurance, payments). Out of the total 23 interviewed, who agreed that they have subscribed to platform were either on Farmerline or Esoko. With most farmers on FarmerLine (57%) followed by Esoko (43%) see Figure 4.2.2. This variation in the number of subscriptions across the different platforms could be partly due to the nature of the operation of these platforms. During the period of the study, field agents of Esoko had moved to a different region as they were involved in piloting whereas Farmerline was still in the region. My conversation with Esoko officer emphasized the essential role of field agents in registering farmers on the platform. Although Esoko operates as a digital service, the necessity of physical presence was clear; during the discussion, it was mentioned that field agents are mostly deployed to different regions to facilitate the registration process. However, field agents in Bono East region were reassigned to a different region, which could explain the low number of subscribers. This was noted by Esoko officer during our interaction

> Although our services are available nationwide, we operate through a process known as "piloting". This approach involves focusing on one region at a time, moving to the next only after completing their work in the previous area (Fieldwork, 2024).

With Farmerline, field agents were present during the study period. A conversation with the local agro-dealer revealed that these agents have been operating in the region for approximately 3 years. The relatively short presence may impact their ability to establish connections and trust within the community and, hence, the number of subscribers that continue using the platform. Surprisingly, farmers did not subscribe to more than one platform in the study area. Whereas there might be other platforms in the district that provide different services, their inability to reach out to these farmers may be due to the lack of robust fieldwork capability, visiting farmers in rural areas to demonstrate products and gather data. An interaction with MoFA official noted that:

> I acknowledge the presence of platforms in this region, but I believe it will be difficult for them to gather information from farmers on the field as they have not officially registered with our institution (Fieldwork, 2024).

This statement implies that, in addition to Esoko and Farmerline, there are other platforms available in the region. Apparently, a digital platform can be registered as an agritech company within the country, but failure to obtain official registration with MoFA in the region can hinder its operation and acceptance. Regional registration with MoFA helps establish legitimacy and trust among local framers. Without registration, platform may struggle to gain credibility, access local agricultural networks, or leverage support from extension officers, and farmer groups, which are critical for building user base.

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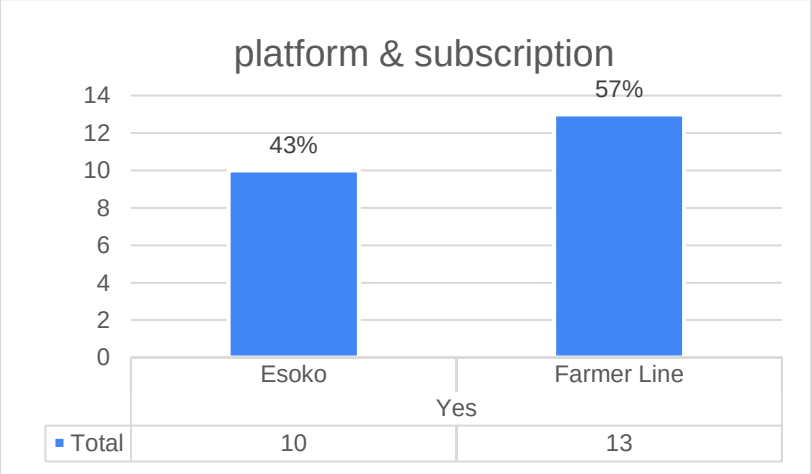
Figure 4.2.2 Subscription per platform



Note: The vertical axis shows number of interviewees subscribed per platform

Source: Fieldwork, 2024

4.2.4 Engagement with digital platforms

Although the subscription rate among interviewees were high, an interesting observation, however, is the growing adoption of digital technologies among older individuals, which suggests a shift in behavior, and which may highlight increasing digital inclusion across age groups. It was crucial to investigate whether there was actual engagement with platforms. The findings revealed that several factors influence users' engagement with platforms, although these factors may vary across the different platforms, as shown in Table 4.2.2. These factors include medium of service delivery,

frequency of services, cost of subscription, user-friendliness of platform as well as the accuracy of data and insight provided.

Table 4.2.2 Platforms' Services

PLATFORM	ESOKO	FARMERLINE
Cost of subscription	$1 monthly subscription fee	No subscription fee
Mediums of Service Delivery	SMS, and Voice SMS (one-way communication) call assisted interviews, IVR[2] and WhatsApp Page (two-way communication)	SMS, Voice SMS (One-way communication) IVR (two-way communication)
Kind of services	Market services (price and linkages), extension services (weather updates, and agronomic advice), financial services (insurance and payment)	Market services (price and linkages), extension services (weather updates, agronomic advice), Financial services (insurance and payment), input services (mechanization, inputs)
Frequency of service delivery	Market and extension services-weekly Financial services- monthly	Market and extension services (weather) -twice every month and weekly respectively Financial services- monthly Input services (once every two month)

Source: Platform websites and fieldwork,2024

Farmers from both platforms acknowledged that they are being reached out through different mediums which included the two-way communication known as Interactive Voice Response (IVR) which allows users to switch to their preferred language when they are being called by the platform. In addition, the one-way communication medium is known as Voice SMS which distributes

[2] IVR allows for automated phone calls to reach many people, playing back prerecorded questions and prompts. Thus, recipients can respond to these inquiries either by pressing keys or verbal response facilitating a two-way communication

prerecorded messages in different languages. Also, SMS alerts as well as the Call-assisted interviews conducted by field agents of Esoko. Out of these mediums, farmers asserted that the most frequently used one is voice SMS and least of them all was the Call-assisted interviews, which was done mostly when the platforms wanted to get information from farmers A situation which can be ascribed to the fact that the former involve less credit cost for the platform while the latter involved a lot of phone credit to enable an interview by the platform.

With regards to the frequency of service delivered, engagement with platforms either decreased or remain unchanged. Farmers disclosed that, in the first year of subscriptions, they received weekly updates. However, this decreased to monthly and now once every two months. It was discovered in the study that reasons for such situations differ across the platforms; while subscribers on the Esoko platform had to pay an amount of 1 dollar for renewal to receive weekly updates, subscribers on Farmerline did not have to pay for renewal. Thus, subscribers on Farmerline frequency of updates remained unchanged. To the issue of less engagement with platforms, an official from Esoko had this to say:

> We have a lot of subscribers on our platform, but in terms of active users, the number has reduced. The database shows that active users vary monthly, this is because there is need to renew your subscription monthly with an amount of $1 and if a farmer is not able to do that then automatically the user becomes inactive on our system (Fieldwork, 2024).

Consequently, the cost of using these platforms did not only change the frequency of service delivered, but also the kind of benefits subscribers enjoyed. Farmers shared their experiences regarding their subscriptions. Early adopters of Farmerline mentioned that they made an initial payment upon subscribing to the platform, and they benefited from credit top-up as well as tangible equipment. In contrast, farmers who subscribed a year later did not incur initial charges. However, they did enjoy additional benefits. The secretary of one of the farmers' associations had this to share:

> I can remember when we were being introduced to Farmerline for the first time (in 2021) during one of our meetings, we made an initial payment for subscription, even though, I cannot remember how much, it was worth it. I was given a rain gauge for free, and I was taught how to use it to determine the amount of water my crop had received after rainfall. This instrument was helpful until it got broken some time ago. As time went on, those who subscribed a year later were exempted from payment. However, they did not enjoy any benefit, and because of that, new members don't want to join because they believe they are not going to benefit (Fieldwork, 2024).

Such benefits offered by Farmerline served as incentives to encourage adoption of their platform among framers. With this, Farmerline aims to lower the barriers to entry for smallholder farmers who might be hesitant to fully adopt without experiencing the benefits of the services provided. Late adopters may miss out on such promotional benefits, as increased subscription rates make it harder for the platform to maintain early-stage incentives due to higher operational cost. However, this supports the finding of Levin and Cochrane (1996) that early adopters stand to benefit greatly from their proactive embrace of new technologies. The benefits farmers received in this context contradicted what Levin and Cochrane proposed in theory, which included frequently obtaining lower unit production costs, resulting in enhanced profitability and a competitive advantage in the market.

Nonetheless, the study's findings regarding average adopters may not fully support the Levin and Cochrane, (1996) assumption that limited resources, lack of institutional support, and limited knowledge may hinder their adoption. Not only were they hesitant to adopt; average adopters did not benefit as much as the early adopters. The laggards were not only resistant to change, as the theory posited, but these farmers were rather weighing the cost-benefit analysis of their adoption based on the experience of the early and average adopters. These findings do not downplay the essence of the theory; however, they open it up for revisiting to understand and inculcate more assumptions to better explain adoption. For Shang et al. (2021), the decision to engage or reject a technology is based on how farmers assess its performance and investment cost. Thus, allowing for both dis-adoption (abandoning technology) and mal-adoption (improper use).

Regarding user-friendliness of these platforms, farmers appreciated that services were offered in their local language. However, their main concern was their inability to directly interact with service providers. Farmers asserted that the interfaces of these platforms do not support two-way communication, this makes it difficult for them to ask questions and report issues to promote ongoing use. Farmers disclosed that the two-way communication as posited by these platforms does not reflect interactivity. The user interaction is generally restricted to language selection. This means that users can only engage in a meaningful interaction when changing their language preferences, with no option for further communication or feedback.

Although, Esoko had this feedback mechanism (call-interviewed assistant) where farmers could ask questions and receive clarification during these interviews, creating a more user-centered interactive experience. This feedback mechanism uses Computer-Assisted Telephone Interviewing (CATI), where trained agents conduct surveys with farmers via phone call. This medium collects real time responses from farmers on specific challenges, allowing for the development of

customized insights and solutions that address farmer's needs. Nonetheless, farmers shared that such interactions did not occur frequently and are mainly initiated by service providers, suggesting that farmers could not request at all.

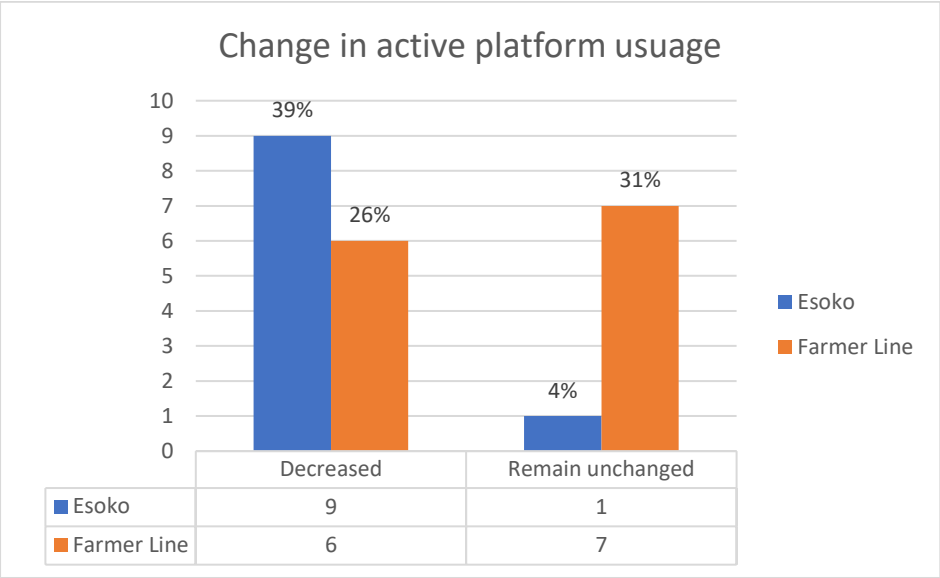
In terms of the accuracy and how data and insight was understood by these farmers influenced their engagement with these platforms. Farmers revealed that weather updates through voice messages were easy to understand as it was delivered in their languages. However, SMS updates were difficult to understand due to their inability to read. In some cases, they rely on their children for assistance, which is sometimes inconvenient, as the children may not always be available to explain the message. A male respondent said expressed his unsatisfaction during the focus group discussion:

> As an old, it bothers me that I cannot read the SMS messages sent to me by this platform since it is written in English. I constantly ask my children for help, but they are not always around when I need them. It leaves me feeling disconnected, as I cannot access the information on my own when I need it the most (Fieldwork,2024).

During my fieldwork, I observed something with regards to how farmers engage with platforms. Although I could not access all the delivery mediums, I had the opportunity to be part of the WhatsApp platform, where messages and links to videos regarding farming were sent. I noticed that group members received regular (daily bases), unlike those on other mediums. This points to information asymmetries existing in these areas, where farmers with smartphones receive more information than those without. As noted earlier by Esoko officers on the frequency at which they provide their service, it was important to establish how the frequency of services provided affects its usefulness to the farmer. Farmers noted the weather updates provided were not only accurate but timely, enabling them to make informed decisions. However, other services, such as agronomic advice and market prices, were not delivered when needed, limiting their usefulness.

Despite the different mediums through which farmers can engage with these platforms, it is evident from the discussions that farmers did not have much engagement with these platforms. This suggest why farmers who have subscribed, their active usage either remain unchanged or reduced as indicated in figure 4.2.2 This result confirms the study by Goedde et al., (2021) in 20 countries including Ghana that among smallholder farmers who subscribed to digital agricultural platforms , active user engagement is less than 30%.In contrast, a recent industry survey conducted in Germany on the adoption of digital technologies among farmers by Rohleder et al., (2020) came out with the following conclusion that "eight out of ten farmers use digital technology" (cited in Gabriel and Gandorfer, 2022).

Figure 4.2.3 Change in platform usage



Source: fieldwork, 2024

4.3: Factors that influence the adoption and usage of digital technologies

Having established that, most of the interviewed farmers in the district have subscribed to the digital agricultural platforms, albeit with rather minimal engagement with the platforms, it is necessary to better understand factors that influence adoption and the usage of these platforms. The factors that influence adoption and usage of these platforms grouped into three categories namely: individual, institutional and innovation characteristics (Walter et al., 2011: Daum et al., 2021).

4.3.1 Individual Characteristics

Individual factors like age, education, farm size, and sources of income had an influence on whether a farmer adopted or not. The study revealed that most of the farmers who subscribed had some level of formal education, while the few did not have any formal education. This concedes with the data from the Techiman North analytical report (2010), which showed that out of the population, 73.3% are literate and 26% are non–literate. This suggest that smallholder farmers had some level of literacy to be able to operate digital technologies. In contrast, Abdulai et al. (2023) revealed that smallholder farmers in northern Ghana were not able to operate digital technologies to support claims of widespread digital adoption. This contradiction does not underestimate the findings of Abdulai et al. (2023), but it reveals how different geographical locations and access to educational facilities can affect the literacy rate of smallholder farmers.

Moreover, the study suggests that the age of the respondents had an influence on the use of digital technologies. Most of the farmers who adopted digital platforms were aged between 40-49 and 50+ years, while the remaining few were between the ages of 30- 39 years. This result probably shows how there has been a shift on technological adoption in recent times. Smidt and Jokonya (2022) argue that farmers' perception of technological adoption has changed in the 21st century, arguing that studies in the United States within the period of 2007-2011 revealed that old and experienced farmers adopted a technology for profit while the younger farmers focused on environmental concerns however the story has changed as old and experienced farmers are now also concerned about the environment in recent years. Although reasons for adoption among age groups might not be the same in Ghana, the shift in behavior must be taken into consideration in the digitalization of agriculture.

Although the farm size of respondents did not have much influence on the adoption of digital technologies, it was crucial in understanding the income level of farmers (Anang, Nkrumah-Ennin and Nyaaba, 2020). Income levels play a significant role in assessing the capacity of farmers to renew their monthly subscriptions. The study revealed farmers with less than 10 acres of land had to supplement their income with non-farming activities such as taxi driving, food vending, and shopkeeping to generate additional income, helping them afford to subscribe to digital services. This relates with the findings of Zheng et al. (2018) (cited in Gabriel and Gandorfer, 2013) that farmers are more inclined to adopt digital technologies when their farms serve as the main source of income. However, on the other hand, income from non-farming activities can also provide additional financial resources to invest in these technologies

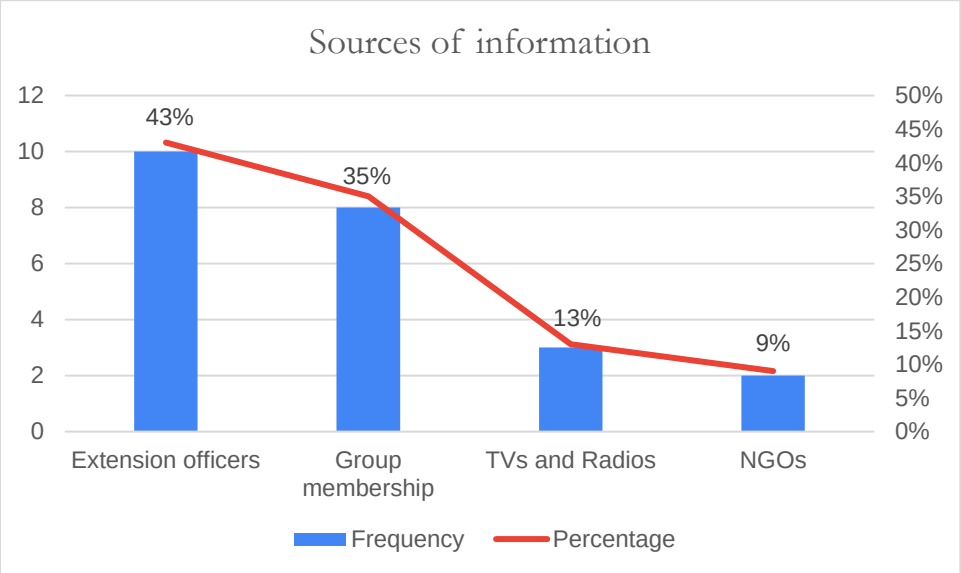
4.3.2 Institutional Characteristics

According to the Panel (2019) report, Africa's digitalization is possible through the collaboration between the government, the private sector (from start-ups to large companies), agricultural stakeholders, and farmers' organizations to create an inclusive digital environment, which ensures that smallholder farmers and rural communities are included in the digitalization process. This statement shows the important role of different institutions (formal and informal) in influencing the adoption of digital technologies. Although the state played a crucial role in the digitalization process through extension services, the role of farmer groups, radio and TVs, NGOs, and field agents from agritech companies cannot be underestimated in the dissemination of information (Abdulai et al., 2023; Addison et al.2024; Manda et al.2020). As argued by Glover et al. (2019) that the quality and quantity of encounters are essential in shaping the extent of understanding and

autonomy that intended beneficiaries or potential users experience when engaging with a proposition and acting in response to it.

The study revealed different mediums through which information reached farmers, including extension officers' visits, platform agents' visits, group meetings, and radio stations announcements see Figure 4.3.4. Most farmers received information primarily from extension officers and associations, while a smaller portion relied on NGOs, TV, and radio stations. Additionally, membership in farmers' groups significantly influenced the type of information accessed, particularly regarding digitalization. This resonates with the findings of Etwire et al. (2017) that interaction with agricultural extension agents, as well as farmer-to-farmer interaction, play a crucial role in influencing farmers' decisions to utilize mobile-based weather and market services. Similarly, Minne et al. (2023) discovered that group membership positively affected farmers' access to digital solutions such as financial and extension services. This could be ascribed to the fact that group membership tends to build trust in new knowledge, promote information exchange as well as generate spillover benefits through communal use of agriculture technologies as posited by (Addison et al.,2024).

Figure 4.3.4 Sources of Information



Source: Fieldwork, 2024

According to Horner and Alford (2019), the recent global political economy, the role of the state, and the interconnection of major private and public actors in the entire agricultural value chain need to be investigated further. This investigation could provide important insights into how

states, in conjunction with private actors are pushing the agenda of digitalization of agriculture. An officer from MoFA had this to say regarding their role in the digitalization process:

> As a government institution we play a significant role in digitalization. This is because we understand the importance of digitalization in this era, especially in agriculture. One of our limitations as an institution is the inability to provide adequate extension services to our farmers because of limited extension officers. As part of our efforts in the process of digitalization is the provision of a digital agricultural application for farmers known as GhAAP farmer.[3] This app allows farmers to request for inputs and other extension services. Despite this effort as an institution, we also collaborate with other agritech companies across the country, however in this region we work mostly with Esoko and Farmerline. These platforms help us extend our extension services to areas where we have not been able to reach (Fieldwork ,2024).

The presence of the GhAAP farmer indicates that platforms for smallholder farmers are not only privately owned but also owned by the state. Deducing from the statement, the platform mainly focuses on providing input and extension services. This limited scope likely explains why collaboration with the private platforms are necessary to fill the gap in services (market, financial) that the state platform does not cover. The state collaborates with private platforms by the provision of basic support through extension officers; these officers primarily serve as intermediaries, helping to introduce the platform to farmers and facilitate its use. This highlights what Fox (1993) calls the contradictory role of the modern state, capital accumulation and political legitimacy. In this context, the state plays a dual role as a facilitator and competitor. As a facilitator, the state promotes the growth of private agritech companies and invests in digital infrastructure. Conversely, by owning a platform, the state helps prevent private companies from dominating the market, making it fairer where farmers have options to choose.

What was unclear was the kind of regulatory system that was put in place with regards to data collection during profiling. Farmers were ignorant of where their farm data was taken to and who had access to their data. A farmer had this to share to this effect:

> I can remember when the officers came to register us, they took information about our phone numbers, the kind of crops we grow, how many acres of farmland, the location of our farms, and our annual income. Initially, we were hesitant, but they told us that they are not going to misuse our data, so we agreed to give out of information (Fieldwork,2024).

[3] https://play.google.com/store/apps/details?id=com.gaab.farmer

This aligns with the findings of Custer 2016 (cited in Rotz et al., 2019) that complexities surrounding data ownerships and control are not merely a byproduct of technological progress. Although, farmers may accept digital agricultural software terms and conditions, their authority over data consent rights remains limited. While digital agricultural companies purport that farmers retain ownership of their data, the absence of clear definition may perpetuate a persistent lack of informed consent. In the same vein, a study by Wiseman et al., (2019) discovered that commercial arrangements governing digital agriculture lack clarity and transparency concerning matters like privacy, data ownership, trust and liability. These deficiencies have led to farmers' hesitancy to participate in widespread sharing of farm data.

On the other side, MoFA officials gave a flip side to the story with regards to data ownership as they indicated that these agritech companies seek permission to profile these farmers. However, there remains uncertainty about who can have access to this information and how it is ultimately used.

> Before these companies collect data, they must seek for permission. To ensure data privacy, we ask them to specify the type of information they intend to gather before granting approval. During the process of data collection, we assign extension officers to accompany them, ensuring that farmers are willing to share their information. However, what is unclear is whether the data is solely used for intended purposes or other untended uses for their own gains (Fieldwork, 2024).

Undoubtedly the contradictory role of the state is evident in this statement. On the one hand, the state demands transparency on how the private platforms collect and use farmers' data; on the other hand, the state endorses these platforms through extension officers to collect farmers' data on the field. Yet, it's unclear how data collected by these platforms will be used, shared or protected.

4.3.3 Innovation Characteristics

Visser et al. (2021) argue that most agritech companies and researchers shift the blame on farmers for misadoption and 'operator faults' in the adoption of digital technologies. This focus reflects what they refer to as a de-contextualized view of technologies as abstract solutions, with adoption and use issues separated and attributed to the "human factor". Based on this statement, to assume that the adoption and use of digital agricultural platforms depends only on farmers and institutional characteristics will be biased on the part of researchers. One of the objectives of this study is to examine the user-friendliness, accuracy, and other attributes of digital technologies and how these factors influence its adoption and usage. Questions regarding the kind of services, the kind of

training involved, experiences navigating through the app, accuracy of the data and insights, the rate at which services are being provided, and mediums through which updates are given by the platform were investigated to ascertain their impact on the entire adoption process.

The provision of training is crucial in adopting any digital technology for smallholder farmers. This is because it gives the user a hands-on experience before actual usage. Hence respondents were asked whether these companies provided training services to them prior to their usage. Most farmers (91%) from both platforms stated categorically that they did not receive any training prior to using the platform whereas the remaining 8% received some sort of training, as indicated in Table 4.3.3

Table 4.3.3 Platforms Interface characteristics

Platforms	**Esoko**		**Farmerline**	
	Freq	**(%)**	**Freq**	**(%)**
Training received				
Yes			2	9%
No	10	43%	11	48%
Total	**10**	**43%**	**13**	**57%**
Ease of using the platform				
Easy	8	35%	12	52%
Difficult	1	4%	2	9%
Total	**9**	**39%**	**14**	**61%**
Understandability of data and insight				
Yes	10	43%	8	35%
No	3	13%	2	9%
Total	**13**	**56%**		**44%**

Source: fieldwork, 2024

My conversation with farmers revealed that these so-called apps do not offer any real interactivity. Instead, they simply present pre-programmed information without allowing meaningful user engagement. Of the 9% who responded that they had received training, most were group leaders who had the privilege of receiving a digital tool such as a rain gauge from FarmerLine and were provided with some form of training by the field agent to use it effectively.

Most farmers mentioned that they did not face any problem navigating through the app. This situation made more sense when farmers were probed further on the user-friendly nature of the

platforms, with the majority stating that it was easy to operate apps. The platform's ease to use stems from its restricted user interface, where farmers cannot initiate any conversation on the platforms. Information is delivered through voice SMS, requiring minimal digital literacy. In this case, farmers are seen passive recipients of information with very limited choice options in the case the two-way communications mediums and no interactive element at all in the case of one-way communication mediums rather than active participants in dialogue. A female respondent stated that:

> Even though I don't have a strong educational background, I can still use their services. All that I need is credit on my phone to answer their calls, making it simpler and easier (Fieldwork, 2024).

Another respondent added this.

> This platform is not as complex as other platforms. With Farmerline, I don't need strong digital skills to use it, because this platform does not permit user interaction (Fieldwork, 2024).

Nonetheless, respondents (87%) from both platforms who acknowledged it was easy to use also expressed concerns regarding the app, noting that it may be simple and convenient to receive calls or SMS messages, it is equally important to have the ability to communicate complaints back to service providers to them as well. Conversely, the 13% of farmers who experienced difficulties using the app, asserted that they are not able read updates sent through SMS because it is mostly sent in English. This aligns with the notion of technology as a weapon of social and economic dominance, where users have minimal agency and outcomes dictated by those who design and control the technology. The lack of interactivity highlights a design flaw rooted in a top-down approach, possibly reinforcing digital inequalities by making farmers dependent on the system, with limited capacity to influence its functionality (Glover et al., 2019).

When respondents were asked about the accuracy of data and insight provided by the platforms, most respondents (78%) agreed that weather prediction was generally accurate as compared to their own prediction as indicated. However, farmers stated information regarding market access is often not accurate.

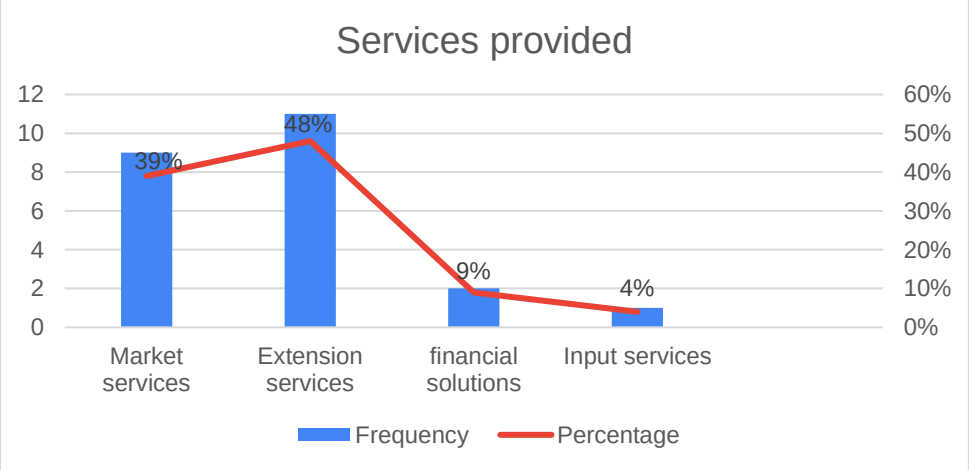
4.4 Perceived effects of adoption of digital technologies on smallholder farming practices

As mentioned earlier, Trendov et al. (2019) posit that digital technologies have the potential to revolutionize agriculture and increase production and profitability as they offer integrated solutions that connect farmers' resources, markets, and institutions. The adoption of digital technologies

through the provision of real-time weather updates, market information, financial assistance, and pest and disease data via mobile devices has the potential to reduce the costs of monitoring plant and animal health for optimal yield. However, the perceived impact of the adoption of digital technologies extends beyond mere improvements in farming practices, as it can exacerbate inequalities, dependency, or loss of autonomy of farmers.

With reference to the four categories of services stated earlier, farmers (87%) predominantly receive market and extension services and the remaining few (13%) receive input and financial services as shown in Figure 4.4.5. On the other hand, my discussions with officials from both platforms presented a different perspective, as the noted that all services listed on their websites are indeed provided to farmer. This variation may suggest two possible explanations; it could be that market and extension services were the only type of data available and consistently provided to farmers in the region, limiting their access to others forms of agricultural support. For instance, Farmerline's reliance on the centralized hub (Mergdata) to make decisions regarding farmers' needs rather than establishing direct feedback loops with users may obscure real-time input from farmers, resulting in a gap between the advertised services and ground-based issues. Alternatively, it is possible that farmers have consciously chosen to prioritize these two specific services from the available options, perhaps due to its perceived relevance to their farming practices.

Figure 4.4.5 Services provided by the platforms



Source: Fieldwork, 2024

Evidence seems to support the latter explanation, as farmers expressed concern about the kind of market services they receive from these platforms. Regarding the effect of market prices and linkage, it was revealed that most farmers did not receive accurate market information. Although

this situation may vary across the different platforms, it was not as common as the remaining services provided by these companies. The study demonstrated that Esoko delivers market information to their customers more frequently than Farmerline (see Table 4.2.2). The disparity in the kind of services provided also had an influence on why farmers would prefer a particular platform to another. This is because absent or weak market information was among the major issues facing smallholder farmers in the study area, as farmers expressed concerns about the lack of access to markets for their produce, and even when market opportunities arise, they are often forced to sell at significantly lower prices. A male respondent expressed his sadness:

> It is disheartening that after the day-to-day toil on the farm, finding a market for the harvest remains a challenge. For instance, last two years after harvesting my yams, the market condition was poor. I had no choice but to reach out to a middleman in my community to connect me with buyers. Unfortunately, the prices offered were extremely low, but it was my only option at that time since there was no information of any potential buyer. Without that sale, my produce would have spoiled (Fieldwork, 2024).

The above statement suggests that accessing market information is crucial to farmers in the study area. Farmers disclosed that, even though Esoko is known for providing market information about their crops, the information often fails to accurately reflect the actual situation on the ground. During the focus group discussion, a farmer said this regarding market information.

> In one of the cases, I received information regarding market prices for maize through Esoko, however, I found that the actual prices at the market were significantly different. I was really disturbed because I had budgeted based on the information I had received (Fieldwork, 2024).

This discrepancy highlighted a gap between the reported data and on-the -ground realities, which is sometimes challenging for farmers to rely on this information to make informed decisions. In addition, this shows the kind of inaccuracies that can come with digital technologies and the impact it can have on these farmers and the cycle of adoption

Another male farmer also added this*:*

> In my scenario, I was given market information about maize rather than market information about yam, which I was looking for. Hence, I did not benefit from such a service (Fieldwork, 2024).

Possible reasons for such an information gap could be a systemic deficiency within data management and communication systems used by the platforms. For example, if the process for data collection and dissemination is not adequately customized to address the varied needs of

farmers, it can result in an information gap. On the other hand, the platforms may inadvertently prioritize specific crops potentially due to its broader market request at a specific time or greater prevalence in the region. This issue may reflect the platform's assumption that farmers primarily sought maize market information, as maize had greater market appeal during that period. Although the region produces yam, maize, and other crops, the platform prioritized maize updates, presuming that its decision aligned with farmers' needs. This situation suggests how the absence of meaningful engagement prevents farmers from receiving tailored information that addresses their specific needs, leading to generalized data that often overlooks local issues. Thus, this highlights the limitation of the one-size-fits-all approach regarding generalized agricultural interventions and emphasizes the need to recognize the diversity of farmers' needs and context.

Respondents were asked how data and insights from these digital platforms influence their decision on what to grow and how to grow it. Most farmers acknowledged that it has influenced their decision as the rely solely on these platforms now with regards to what they must grow and how to grow it. On one hand, it is a good thing since the platform advice is based on their weather predictions; the downside, however, is that farmers' autonomy over their own farms has been indirectly affected. A male respondent had this to share during a focus group discussion:

> I can say that the effect of these platforms is two-sided, which is good and bad. While telling me what to grow based on the weather prediction is good, my knowledge and autonomy over what do for a living has been taken from me. I can no longer make any concrete decisions on my own now (Fieldwork, 2024).

Another respondent added this during the discussion:

> I can remember I was called through the voice SMS one time during my early year of subscription and was told not to grow my maize at that time because it was likely not to rain for a long time. I heeded to their advice, and it worked for me. However, the following year, I was expecting advice as whether to grow my maize or not, but it never came through. At that point, I was indecisive as to what to grow on my farm. This shows the negative effect of total dependence of these platforms for their advice (Fieldwork, 2024).

Farmers reported that receiving guidance on fertilizer application significantly improved their farming. This advice helped them use fertilizer more effectively, leading to higher yields. Farmers noted that, they used to apply fertilizer or manure based on their inherited knowledge from their parents. For example, farmers stated that they would just spread the fertilizer evenly across the field without considering specific crop needs, timing or soil condition, resulting some crops receiving excess and other little fertilizer which causes crops yields. However, farmers fertilizer

application has changed due to the advice they received from these platforms. During my interaction, a respondent shared this:

> "I used to apply a lot of fertilizer on my yam crops to increase yield. But this result in most of my getting rotten on the farm. But when I started receiving advice on the kind of fertilizer to buy and how to apply, it has helped me so much. Adding on, during one of our meetings, they taught us on how produce our own fertilizer devoid of certain chemicals. This has not only eased the struggle of getting the right fertilizer for your crops but also the how much I spend my income on fertilizers" (Fieldwork, 2024).

Deducing from these statements, farmers ability to make their own decisions have changed. This form of indecision is known as "deskilling the farmer" (Brooks 2021) a situation where farmers lose their autonomy and knowledge needed to make independent decisions about what to grow on the farm and how to grow it. Hence reducing farmers' role merely to following instructions from external sources, stripping away their ability to exercise their critical skills, adapt to local conditions or innovate. An interesting observation is how quickly the process of deskilling takes place among these farmers, often becoming evident after just a year of subscription. According to Stone (2007) an agricultural (farming) practice is an ongoing, evolving process of skill-building, where any disruption can lead to significant, potentially lasting impacts (Stone ,2007 cited in Brooks,2021; Atanga, 2019).

The rapid shift from traditional knowledge, where farmers test, observe, and adapt based on local conditions towards technological-driven instructions interrupts their capacity to gain hands-on experience. This situation could be because of the unpredictability of the weather due to climate change. Undoubtedly climate change introduces variability in seasonal weather patterns such as unexpected floods or drought. These patterns make traditional knowledge in the sphere of weather predictions as well as in terms of knowledge on the timing of agricultural activities (e.g. when to start seeding) less reliable (Guido et al.,2021). Farmers, facing this uncertainty may find themselves increasing reliant on digital platforms for weather update and agricultural advice.

Farmers recognize that the impact of adopting these platforms transcends beyond the individual level, as they have collectively benefited from group support. During the focus group discussion, participants noted that they have benefited from Farmerline as a group because they have been able to secure approximately 15 acres of land for the cultivating crops like carrots, onion, cabbage-crops they had not previously engaged in. While farmers purchased the farmland and contributed their own labour, the platform supplies inputs such as seeds and fertilizers. Farmers expressed their joy in the efforts of the platform towards the project, as they received more personalized and

detailed information, with specific support like soil testing, customized fertilizer guidance and on-site visits. This is a more intensive level of service compared to the general updates and tips usually offered to individual farmers. What is unclear is the motivation behind this support. Farmers indicated that the terms and conditions regarding harvest were not clearly outlined at the project's inception, with the platform framing their involvement as part of their corporate social responsibility (CSR) initiative. For O'Laughlin, (2008) such initiatives are termed as "the reconfiguration of capitalism as an ethical order which is reflected in corporate rhetoric". By this act, corporations aim to legitimize their operations and profit-driven motives under the mask of contributing to societal development, using ethical language to enhance their image and justify their actions.

Picture 4.4.2 Group members on the purchased farmland for the project

Source: Fieldwork, 2024

Chapter 5: Conclusions

Digital technologies are becoming an essential part of agriculture and attempts to ignore or resist such influence is unlikely to succeed. Nonetheless, the framing of adoption of these digital technologies among smallholder farmers is often oversimplified into binary metrics (adoption and non-adoption). This kind of approach often reduces adoption to a technical process of increasing uptake, ignoring the complex realities of farmers' lives and the different capacities to engage these tools, as well as the group dimensions of adoption.

This paper critically examined the adoption of digital technologies and the impact on farming practices among smallholder farmers in Bono East region of Ghana. Results show that subscriptions among smallholder farmers are high in the study area (85%), but active engagement with these platforms is much less than the high subscription rates would suggest at first glance.

The disparity between high subscription rates and low actual usage challenges the validity of claims regarding widespread adoption of digital technologies. While high subscriptions might initially indicate interest, they do not necessarily reflect long-term value or effectiveness, hence, without sustained engagement, subscription numbers alone are an unreliable measure of adoption. As true adoption requires an ongoing utility and meaningful engagement beyond mere sign-up (Glover, et al.,2019).

Furthermore, the factors that influence the adoption and use of these digital platforms include individual, institutional and innovation factors. The study revealed that the lack of engagement on these platforms is fundamentally tied to the absence of, or only minimally, interactive design of the mediums of delivery. The non-interactive mediums (Voice SMS, SMS) are termed as one-way communication because they do not allow for any interaction between platforms and farmers whereas the two-way communication mediums (IVR, Call-Assisted interviews, WhatsApp page) allow for minimal interaction between platforms and farmers. These mediums treat farmers as passive recipients, contrasting with optimistic claims of interactivity on digital platforms' websites, highlighting the gap between expectations and reality.

This finding exposes the limitations of existing literature, which often simplifies adoption as influenced by individual and institutional factors (Abdulai et al., 2023; Addison et al., 2024; Manda et al., 2020), neglecting the importance of specific technological attributes on usability and perceived value. Most research assumes that clear benefits will lead to adoption (Levins and Cochrane ,1996; Rogers,2003), this perspective overlooks how the delivery of services, such as frequency, accuracy, understandability, directly affect trust and sustained use, emphasizing the need for digital platforms to consider both functional and relational aspects of design (Visser et al., 2021;Shang et al.,2021; Glover et al., 2019).

The role of platform agents and extension officers was found to be crucial in the adoption and use of digital platforms. While digitalization is widely claimed by proponents to be transformative, suggesting that tech-based solutions can independently drive change in the agricultural sector, especially in rural areas (Duncan, Abdulai, and Fraser, 2021; Tang et al., 2002; CTA, 2019). The reliance on human interaction in the study area challenges this narrative as platform agents and extension officers builds trust and credibility between platforms and farmers. The critical role of human facilitators demonstrates that technology alone may not meet the needs of farmers, particularly in rural context. This contrast underlines that digitalization, while promising, must be viewed as a complementary tool rather than a standalone solution, requiring human support to ensure meaningful engagement and sustained impact.

The perceived impact of adoption of digital technologies extends beyond improvements of farming practices through weather updates and agronomic advice (fertilizer application). It can exacerbate inequalities, dependency, and deskilling of farmers and these impacts transcend beyond individual levels to group. Although farmers received services (market and extension) from these platforms, they often fail to reflect ground-based realities (market-based services) (Visser et al., 2021). Furthermore, the adoption digital technologies among farmers tends to curtail their agency to make their own decisions, as suggested by for instance Brooks (2021) in her theoretical article on "Configuring the digital farmer" as deskilling the farmer, a situation where farmers lose their autonomy and knowledge needed to make independent decisions about what to grow on the farm and how to grow it (Brooks 2021; Atanga, 2019). This process of deskilling among farmers is so rapid that it becomes evident after just a year of subscription, making it noteworthy. Whereas literature does not specify a clear timeframe for deskilling, it is often expected to be a gradual process (Brook, 2021; Atanga, 2019). The rapid deskilling may be explained by the effects of climate change, which erode traditional knowledge and increase uncertainty in decision-making (Guido et al.,2021). Future research could examine the relationship between climate change and digital technological adoption and how it impacts on smallholder farmers.

Generally, Glover, Sumberg, and Anderson (2016) argued that the "adoption problem" is just as important as tackling broader issues within the agricultural system. This insight highlights the importance of the dynamics of technology adoption in agriculture. To truly unlock the transformative potential of digitalization in this sector, it is not enough to focus solely on technological innovations. A more comprehensive understanding of the concept of adoption is needed, as the Rogers theory fails to fully account for the challenges of maintaining long-term active use of technologies. In the case of digital technologies, high subscriptions with low engagement reveal that adoption is not a linear process and cannot be measured by initial uptake. Without this, efforts to digitalize agriculture may fall short of their intended impact.

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Appendices

Questionnaire for Smallholder Farmers of Tuobodom District

This research is in fulfilling of the requirements for an award of a master's degree in development studies from Erasmus University. The main purpose of this study is to understand how adoption of digital technologies is taking place and its effects on smallholder farming practices. Respondents are assured that any information provided will be kept strictly confidential and anonymous.

Demographic Characteristics

1. Gender (a) Male [ ] (b) Female [ ] (c)others [ ]
2. Age (a) 18- 29 [ ] (b) 30-39 [ ] (c) 40-49 [ ] (d) 50 and above [ ]
3. Marital status (a) Single [ ] (b) Married [ ] (c)Divorced [ ] (d) Widowed [ ]
4. Educational level a) No formal education [ ] (b) Basic [ ] (c) Secondary [ ] (d) Tertiary [ ] (e) Others [ ]
5. Do you own a farm, or you manage someone's farm? (a) Owner [ ] (b) Manager [ ]
   If you own or manage, how many acres of land do you farm on? a) Less 10 [ ] (b) 10-20 [ ] (c) 20- 30 [ ] (d) 30 above [ ]
6. If you are a manager of someone's farm, does your owner have any formal education? a) Yes [ ] b) No [ ]
   If yes what level of education?.....
7. As an owner or manager, what kind of farming are you into? a) crop only [ ] b) animals only [ ] c) both
8. What kind of livestock do you rear? a) poultry [ ] (b) cattle [ ] c)sheep/goat [ ] d) others [ ]

9. What type of crops do you grow on your farm (a) Food crops [ ] (b) Cash crop [ ] (c) Others [ ]
10. How many years have you engage in farming? a) less than 5years [ ] b)5-10 years [ ] c)10-15 years [ ] d)15 above [ ]
11. Where do you get your main source of income from? a) farm activities [ ] (b) non- farm activities [ ] c) Both [ ]

    If, non-farm activities, please specify.....

Adoption and Usage of digital Technologies

12. Do you own a mobile phone? a) Yes [ ] b) No [ ]
13. If yes, which type of mobile phone do you use? a) smart-phone [ ] b) Non smart phone [ ]

    If no, whose phone do you use for communicating and getting information? a) Partner [ ] b) children [ ] c) relative [ ] d) friend [ ]

    What type of phone? a) smart [ ] b) non-smart [ ]
14. Have you heard of any mobile -based app that provide agricultural services? a) Yes [ ] b) No [ ]

    If Yes, indicate which one(s) a) Farmer Line [ ] b) Esoko [ ] c) Trotor Tractor [ ] d) others [ ] specify.....
15. How did you hear about it? a) TVs and radios [ ] b) Extension officers [ ] c) NGOs [ ] d) Association [ ] e) Other sources [ ]

16. Have you subscribed to any digital apps for farming? a) Yes [ ] b) No [ ]
17. Do you have to pay for it? a) Yes [ ] b) No [ ]

    If yes, how much? .....
18. If yes, which of the platforms have you subscribe to? a) Farmer Line [ ] b) Esoko [ ] c) Trotor Tractor [ ] d) others [ ] specify.....
19. Who introduced you to the platform? a) friend [ ] b) farmer [ ] c) platform agent [ ]

    Which one is most important for you and why?.....
20. If your answer to (Q18) is more than one, explain why you use different platforms?

21. How long have you subscribed to this platform? a) Less than a year [ ] b)1-3 years [ ] c) 3-5 years [ ] d) More than 5 years [ ] e) specify exact year.....
22. What kind of services are rendered to you by these apps? a) weather forecast b) market prices and access c) extension services d) others, specify.....
23. How often do you use this app? a) daily [ ] b) every week [ ] c) once every month [ ] d)once every year e) never
24. How has your usage change overtime? a) Decreased [ ] b) increased [ ] c) remain unchanged [ ]

Please explain your answer(Q24) .....

Accuracy and user-friendly of digital technologies

25. Did you receive any form of training before using the app? a) Yes [ ] b) No [ ]
    If yes, what kind of training, please specify.....
    If no, how was your experience navigating through the app a) very difficult [ ] b) difficult [ ] c)easy [ ] b) Very easy [ ]
26. What kind of service (s) do you subscribe to? a) weather forecast [ ] b) market prices and access [ ] c) extension services [ ] d) others, specify.....
    Is the subscription free or paid? If paid, how much? .....
27. How do you receive services from the apps? a) text message [ ] b) voicemail [ ] c) both [ ] d) none [ ]
28. How often do you receive these prompts? a) daily [ ] b) weekly [ ] c) monthly [ ] d. Others (specify).....
29. Do you data and insight provided by the app easy to understand? a) Yes [ ] b) No
30. How accurate are the services provided as compare to your traditional (conventional) knowledge? a) Very accurate [ ] b) accurate [ ] c) very different [ ] d) different [ ]
    Explain your answer in (Q29) by giving an example .....
31. How will you rate your experience with the features on the app? a) poor [ ] b) good [ ] c) very good [ ] d) excellent [ ]
32. Will you recommend this app to another farmer? a) yes [ ] b) No [ ]

Factors hindering adoption and effects on smallholder farming practices

33. What are some are challenges in adopting and using digital technologies?.....
34. What factors influenced your choice of adopting digital technology?.....
35. Has digital technology changed any thing regarding your farming practices? a) Yes [ ] b)No

36. How has digital technology affected your decision- making regarding type of crop to grow and how to grow it.....
37. How has digital technology changed the use of chemical inputs? a) reduced [ ] b)Increase [ ] c) no significant change [ ] d) uncertain
38. How has digital technology influenced your market access and how? .....

Interview guide for Ministry of Food and Agriculture

1. What do you understand by digital farming technology?
   a. What kind of digital technology do farmers use in this district?
   b. How do farmers get access to it?
2. Does your department provide any form of digital technology to farmers?
   a. What role does government play in terms of adopting digital technologies by farmers?
3. What problems do farmers face in adopting digital technologies?
   a. In what ways is government helping to address these problems?
4. What role does government play in terms of data access, ownership and use?
   How is government addressing the issue of data access, ownership and use?
   What data privacy and security measures have government put in place and how are these agritech companies abiding to it?

Interview guide for Digital platforms

1. What is the motivation behind providing this digital service?
   a. What kind of services do you provide? Which one of the services are directly to farmers and other users?
   b. What are the terms and conditions involved in subscribing to this digital service?
   c. How many farmers have subscribed to your services?
   d. how many subscribers actively engage with the services?
   e. How is the app operated?
   f. Do you provide any training prior to or during the use of the app?

2. What kind of data do you collect from these farmers?
   a. Who can have access, own or use the data?

b. What benefits do farmers obtain from the digital services provided by your company?

3. Who do you partner with both local and international and how do they support you in your activities?
   a. Do you get seed money from the state or donor?
   b. How do you pay for the cost in providing these services?
   c. What challenges do you face in providing the digital services?
   d. What measures have you put in place to address theses challenges?
4. How have target changed over the years?

Interview guide for farmers (focus group discussion)

1. Have you heard of digital farming technology and how do you understand it?
   a. what are some of the digital platforms in your district?
   b. Who introduced you to the digital farming technology?
   c. Did you receive training and support on the use of the digital platforms?
2. How is your experience using these digital platforms?
   a. How can you describe the accuracy of the advice/ information on the platforms?
   b. How have these platforms affected your farming practices?

      Input use

      Crops produced

      Chemical application

   c. Do the predictions and recommendations from the digital platforms align with your practices?
3. Do you face any challenges in adopting the digital platforms?
   a. How do these challenges affect the adoption and usage of these digital platforms?
   b. What do you think can be done to address these challenges?
   c. What new or innovative digital farming technology do you think if developed or made accessible would improve farming?