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Digital Empowerment in Agriculture: Evaluating Digital Infrastructure, Services, Benefits, and Challenges for Smallholder Farmers in Chongwe, Zambia

Trans Nyimba Munalula
PhD in Business and Management
Graduate School of Business, University of Zambia
Lusaka, Zambia

Professor Mubanga Mpundu
Faculty of Economics and Management Sciences, University of the Western Cape
Cape Town, South Africa

Abstract

The adoption of digital solutions by smallholder farmers can enhance both input and output market participation, market information, and reduce the cost of selling farm produce thereby increasing productivity. The objectives of this study was to assess the digital empowerment of smallholder farmers in Chongwe, Zambia by evaluating the existing digital infrastructure, available services, perceived benefits, and challenges, with the aim of providing insights that can inform strategies to enhance the effective integration and utilization of digital solutions in agricultural practices. The study followed a mixed methods paradigm using a three-stage sampling procedure. In stage 1, Chongwe district was purposively sampled out of 6 districts in Lusaka province. In stage 2, Nkomesha Block was purposively samples out of 5 agriculture blocks of Chongwe district. In the last stage, 4 agriculture camps were randomly selected out of 6 camps in Nkomesha Block. Then Yamane's formula was used to randomly sample 92 smallholder farmers. For qualitative data, 5 key informants were purposively selected for in-depth interviews. The findings were that out of 92 respondents on digital infrastructure available for smallholder farmers in Chongwe, 89 had mobile phones although 59 only had ordinary phones while 30 had smart phones; 55 had internet connection; 2 were connected to national electricity grid, and 87 used solar powered electricity. Out of 92 respondents on digital services available for smallholder farmers, smallholder farmers in Chongwe receiving extension services through three main channels: 78 were through extension works, 69 through radio, and 43 through TV; and 90 used mobile money for financial transactions. Out of 92 respondents on the benefits of digital solutions to smallholder farmers, 91 benefited social

interactions, 90 benefited enhance extension linkages, 66 benefited access to agriculture information, and 89 benefited elimination of middlemen. Out of 92 respondents on the major digital challenges smallholder farmers face, 87 faced high cost of phones, 83 mistrust due to scammers, and 81 high cost of maintenance.

Key words: *Agriculture, Digital Empowerment, Infrastructure, Services, Benefits, Challenges, Smallholder Farmers*

Introduction

Almost 9% of the world population suffer from hunger and malnourishment (Roser and Ritchie, 2019). From a total of 2 billion people of the world population which suffer from food insecurity, 1.04 billion (52%) are in Asia, 678 million (34%) are in Africa, and 188 million (9%) are in Latin America (FAO et al., 2019, p. 20). In developing countries including sub-Saharan Africa, agriculture is the main economic activity and the main employer (Akinwale et al., 2023). Most of sub-Saharan Africa population live in poverty with 60% living on less than US$2 a day, and 40% living on less than US$1 a day (Mutsvangwa-Sammie and Manzungu, 2021). The agriculture sector in Africa is underdeveloped due to among other factors, low adoption and use of digital solutions (Abdulai et al., 2023b). The huge agriculture potential in Sub-Sahara African can be exploited by adoption of digital solutions which has been declared as a game changer for agricultural productivity (Agyekumhene et al., 2018; Atanga, 2020; Duncan et al., 2021; Etwire et al., 2017).

The adoption of digital solutions unlocks the digital services for smallholder farmers in Chongwe district, which include electronic agriculture extension (e-agriculture), electronic banking (e-banking) services such as mobile money, digital payment platforms, and e-market services. However, the adoption of digital solutions by smallholder farmers depends on the availability of digital infrastructure such as mobile phones, the internet connectivity, and the availability of electricity in rural areas where smallholder farmers dwell. The adoption of digital solutions can bring huge benefit to the smallholder farmers in Chongwe. Digital solutions can improve smallholder farming productivity (Quayson et al., 2020). There are several factors affecting the adoption of digital solutions by smallholder farmers such as insufficient electricity (Musa et al., 2013) and poor internet connectivity, and their low access to mobile phones (Kieti et al., 2022), high costs of both buying digital solution gadgets and maintaining them (Izuogu et al., 2023; Mansour, 2023), and the mistrust caused by scammers (Kieti et al., 2022).

Background

The development of agriculture in Sub-Sahara African countries has undergone significant technological transformation over the years, notably the rapid introduction and adoption of digital technology in agriculture (Miine et al., 2023). The adoption of new technologies improves agricultural production (Bontsa et al., 2023). As

smallholder farmers' digital solutions are increasingly promoted in Africa (Kim et al., 2020; Tsan et al., 2019), their adoption and usage must be well-understood to facilitate the scaling up (Abdulai et al., 2023a). Assessing the level of smallholder farmers' digitalization in Africa can drive progress toward solving their productivity challenges and exploit economic potentials (Kim et al., 2020; Tsan et al., 2019). Digital agriculture can help increase crop yield, improve agricultural sustainability and food security (Goedde et al., 2021) and reduce the cost of farming through reduction in cost of transaction (Issa et al., 2003).

Despite the potential benefits of digital solutions to smallholder farmers, the adoption of digital agriculture solutions is still low in Sub-Sahara Africa (SSA) including Zambian. Goedde et al. (2021), argue that only 30 % of smallholder farmers in SSA have adopted digital solutions. Digital solutions facilitate smallholder farming transformation (Kudama et al., 2021) hence the increase in their productivity. However, the adoption of digital solutions by smallholder farmers in Chongwe district depends on the availability of digital infrastructure such as mobile phones, internet connectivity, and the availability of electricity.

Statement of the Problem

There is a problem of reduced productivity by smallholder farmers in the Zambia due to several factors, including lack of digital technology, a situation which erodes their profitability. Despite Sub-Sahara Africa currently having very high penetration and adoption of digital solutions (Mapiye et al., 2021, p. 15), the penetration of mobile phones and the delivery of internet and mobile network connectivity especially in rural areas has lagged due to several challenges (Trendov et al., 2019) such as high cost of smartphones. This situation has negatively affected the smallholder farmers' productivity and profitability. The difficulty arising from this problem is that the national and household food security is at risk as smallholder farmers' yields continue to decline amidst many challenges including adverse weather conditions due to climate change. A report by Sylvester (2017) argued that existing research on Sub-Sahara Africa's agricultural digital technology is still patchy and on-going. While some studies tried to address smallholder farmers' digital solutions adoption behaviour (Abate, 2023; Abdulai et al., 2023b; Bontsa et al., 2023; Dong et al., 2022; Fadeyi et al., 2022; Hendrawan et al., 2023; Nyagango et al., 2023; Parlasca et al., 2022; Taheri et al., 2022; Verma and Sinha, 2018), most of these studies may not specifically address the Zambian smallholder farmers' digital empowerment. Therefore, a mixed methods study employing a three-stage sampling procedure was conducted to specifically evaluate the digital infrastructure, services, benefits, and challenges for smallholder farmers in Chongwe, Zambia to address the digital empowerment for smallholder farmers in Zambia.

Aim of the Study

The aim of this study was to assess the digital empowerment of smallholder farmers in Chongwe District by evaluating the existing digital infrastructure, available services, perceived benefits, and challenges, with the aim of providing insights that could inform strategies to enhance the effective integration and utilization of digital solutions in agricultural practices.

Specific Objectives

1. To determine the digital infrastructure available for smallholder farmers in Chongwe district.
2. To determine the digital services available for smallholder farmers in Chongwe district.
3. To determine the benefits of digital solutions to smallholder farmers in Chongwe district.
4. To determine the major digital challenges faced by smallholder farmers in Chongwe district.

Overarching Research Question

How does digital ecosystem impact the empowerment of smallholder farmers in Chongwe district, considering the interplay of digital infrastructure, available services, perceived benefits, and challenges, and what insights can be gained to enhance the digital empowerment of farmers in this agricultural context?

Research Questions

1. What digital infrastructure is available for smallholder farmers in Chongwe district?
2. What digital services are available for smallholder farmers in Chongwe district?
3. What digital solutions benefits do smallholder farmers have in Chongwe district?
4. What are the major digital challenges faced by smallholder farmers in Chongwe district?

Study Scope

This research study was confined within the Zambian agriculture industry and it was restricted to Chongwe districts in Zambia. Selected players such as smallholder farmers, District Agriculture Coordinator, Ministry of Science and Technology officer, Ministry of Information officer, Food and Agriculture Organization officer took part in the study. The study addressed only the issues of digital solutions among smallholder farmers in Chongwe district. The study could not be extended to other districts because of inadequate resources and time.

Justification of the Study

This study was justified by several reasons most of which was drawn from literature. There was little evidence of a study that was conducted to show the digital empowerment of smallholder farmers in Chongwe. While some studies tried to address smallholder farmers' digital solutions in Sub-Sahara Africa (Abate, 2023; Abdulai et al., 2023b; Bontsa et al., 2023; Dong et al., 2022; Fadeyi et al., 2022; Hendrawan et al., 2023; Nyagango et al., 2023; Parlasca et al., 2022; Taheri et al., 2022; Verma and Sinha, 2018), most of these studies were not specifically conducted in Zambia and most of them were desk research studies (Degila et al., 2023; Farayola et al., 2020; Izuogu et al., 2023; Kudama et al., 2021; Mapiye et al, 2021; Mushi et al., 2022; Quayson et al., 2020; Sekabira et al., 2023; Smidt and Jokonya, 2022). Therefore, a study that would specifically address the digital solution adoption for smallholder farmers in Zambia by carrying out a mixed methods survey was necessary in order to address the challenges of smallholder farmers' low productivity.

Significance of the study

The results of the study would help the agricultural input providers, extension officers, government service providers and Non-Governmental Organizations to identify practical solutions to low productivity of smallholder farmers. The results of this study would also help government to come up with appropriate policy directions that would positively impact the agriculture sector. This research would add to the body of knowledge because little research in digital technology for smallholder farmers have been conducted in Zambia. Secondly, most of the research in smallholder farmers and digital technology was desk research that didn't provide primary data.

Literature Review

Introduction

This chapter discussed the digital infrastructure, the digital services, the benefits of digital solutions to smallholder farmers, and factors affecting the adoption of digital solutions among smallholder farmers.

Theoretical and Conceptual Framework

This study is guided by the Systems Theory, the Value Chain Theory, the Technology Adoption Model (TAM) theory, and the Diffusion of Innovation Theory (DOI).

The Systems Theory

The Systems theory aims to explain the active relationships and interdependence between components of the system and the organization-environment relationships

and it focuses on three levels of observations, and these are the environment, the social organization as a system, and human participants within the organization (Lai and Lin, 2017). Since smallholder farmers belong to cooperative societies aimed at accessing both input and output markets, the systems theories can be applied to the cooperative organizations and their environment because their technological environment include the use of digital tools.

The Diffusion of Innovation Theory (DOI)

The Diffusion of Innovation Theory is a theory of technology adoption which was developed using observability, relative advantage, compatibility, and complexity (Rogers, 2006). Ismail (2012) incorporated consumer decisions in the theory of technology adoption using the DOI and showed the connection between a consumer's perceptions of utility and the adoption intentions in utilization of the Apple iPhone. He concluded that if US construction companies could predict the utilization of a new ICT, they could better predict success, total cost of implementation and ownership and complete a more accurate cost-benefit analysis.

The Concept of Value Chain

A value chain are series of activities that are undertaken to bring a product from the initial input-supply stage, through the various phases of processing, to its final market destination, including its disposal after use (UNIDO, 2009). The value chain is a sequence of linked events and processes for conversion of raw materials and resources into products for the market (ADBG, 2013; Smidt and Jokonya, 2022). In order to increase the smallholder farmers' productivity, all the value chain members and the enablers should be activated. The value chain members include the input market partners, the farmer, and the output markets. The enablers are the business environment which include digital solutions.

The Technology Adoption Model (TAM)

The Technology Acceptance Model (TAM) is one of the most leading research models in studies of the determinants of information systems, and information technology (IS/IT) acceptance where perceived usefulness and perceived ease of use are hypothesized and empirically supported as major determinants of user acceptance of a given IS/IT (Chau, 1996). The TAM also focuses on the factors influencing individuals' acceptance and adoption of technology (Sorce and Issa, 2021). Sorce and Issa further agrees with Chau that TAM considers perceived usefulness and perceived ease of use as key determinants of technology adoption, providing a structured framework to understand how and why individuals, in this case, smallholder farmers, might embrace or resist digital solutions in agriculture. The TAM has been adapted in several instances to explain the adoption of technology in the agriculture industry in general and on smallholder farmers in particular (Bontsa et al., 2023; Dong et al., 2022; Fadeyi et al., 2022; Hendrawan et al., 2023; Nyagango et al., 2023; Taheri et al., 2022;

Verma and Sinha, 2018). The TAM can help explore the perceived benefits, challenges, and the overall adoption process within the context of digital solution empowerment for smallholder farmers in Chongwe District. The Value chain concept and the Technology Adoption Model clearly grounds the basis for this research study.

Conceptual Framework

The TAM can help explore the perceived benefits, challenges, and the overall adoption process within the context of digital solution empowerment for smallholder farmers in Chongwe District.

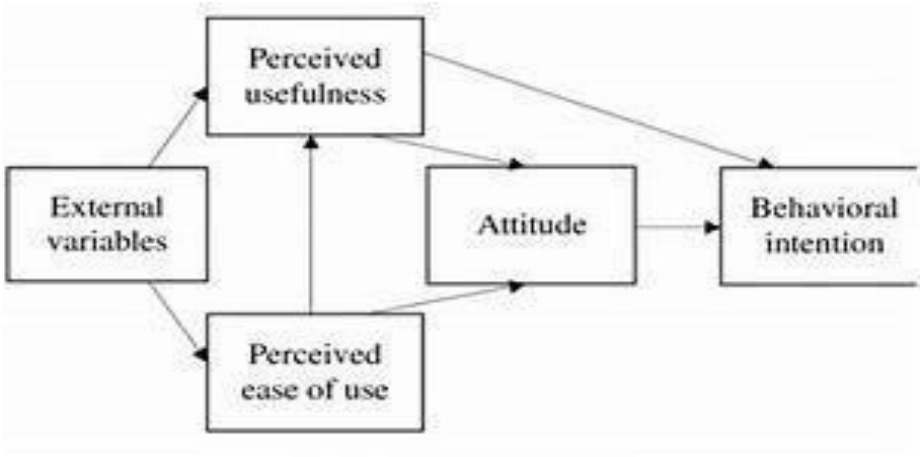

Figure 1: The technology acceptance model (TAM) (Davis et al., 1989, p. 320)

The TAM concept influences the willingness of smallholder farmers to adopt digital solutions (Behavioral intention). The willingness to adopt is directly influenced by the farmers' attitudes towards digital technology and also the benefits of digital solutions (perceived usefulness). The digital solutions benefits are influenced by availability of electricity for mobile phone charging, availability of network and internet connectivity, and ease access to phones (external variables). These external variables influence the perceived challenges of digital solutions such as low digital literacy levels that hinder adoption and use of smart phones (perceived ease of use). The external directly influence both the farmers' attitudes toward the digital solutions and also the benefits they may obtain when they adopt and use digital solutions.

Digital Solutions

Digital Services for Agriculture can be defined as a solution that uses digital equipment and services such as mobile phones, computers, satellites, and sensors to solve agriculture problems (Kieti et al. 2021). Digital solutions comprise of mobile applications (apps) and tools that increase access to timely market price data, financial services, weather predictions, pest outbreaks, and other services (Thompson and Gyatso, 2020, p. 25). Digital solutions play a huge role in agricultural development by

making information available at a cost-effective rate, providing access to global best practices and enhancing productivity (Vishwatej et al., 2022).

The Digital Infrastructure

This section discussed mobile phone usage by smallholder farmers, the internet connection and the availability of electricity in rural Sub-Sahara Africa (SSA).

Mobile Phone Usage by Smallholder Farmers in Rural Sub-Sahara Africa (SSA)

During the last decade, mobile phone technologies and usage were rapidly adopted in several developing nations such as Zambia (Aker and Mbiti, 2010; Wesolowski et al., 2012). The mobile phones in developing countries have reduced the costs of communication, improved access to information, and have enabled other technological innovations such as mobile money (Kikulwe et al., 2014). Many studies have shown significant benefits of mobile phones on smallholder farmer households such as improved access to information, lower inputs and marketing costs, hence increased production and profits (Abraham, 2007; Muto and Yamano, 2009), while the indirect benefit is that mobile phones enable other technological innovations such as mobile money transfers, which is very relevant for rural smallholder farming households that are usually underserved by the commercial banks (Kikulwe et al., 2014). Mobile phone in Sub-Saharan Africa is still driving digital transformation and socio-economic advancements (Global System for Mobile Communications [GSMA], 2023).

The internet Connection in Rural SSA

The internet connection is much lower in the majority of SSA countries with cases such as Ethiopia with only 4% of its population accessing the internet (Tsan et al., 2019), while most smallholder farmers have much lower internet connection (Mapiye et al., 2021).

Despite more SSA population accessing internet, smallholder farmers in rural areas have remained disconnected and isolated hence both a huge gender gap and the rural-urban gap which stands at 60% in mobile internet use exist in SSA (Wyrzykowski, 2020). About 40% fewer women are likely to use mobile internet than men in SSA (International Telecommunication Union [ITU], 2020).

The Availability of Electricity for Charging in Rural SSA

In 2009, the rate of access to electricity in Latin America, the Middle East and Developing Asia were 7%, 11% and 19%, respectively (Onyeji et al., 2012). Africa is energy poor, with 80% of Africans with no access to electricity and two-thirds without clean cooking energy (International Energy Agency [IEA], 2023).

The majority of the population in SSA countries have no access to electricity, with smallholder farmers in rural areas being worst hit (Nkwetta et al., 2010). According to the International Energy Agency (International Energy Agency [IEA], 2017), 1.1 billion people in the developing world don't have access to electricity of which 80% are located in rural areas of Sub-Saharan Africa (SSA).

Zambia's national electricity access rate in rural areas is only 4% implying that the majority of the smallholder farmers in Zambia have no access to electricity (Zigah and Creti, 2023).

The Digital Services Available for Smallholder Farmers in Zambia

This section discussed e-agriculture extension, e-banking (mobile money), smallholder farmer's use digital payment platforms, and e-market services.

E-Agricultural Extension Services

Agricultural extension is the backbone rural development in SSA as it is responsible for transmission of agricultural information to smallholder farmers to improve their farming productivity and well-being (Deichmann et al., 2016). The government extension services are an important source of information and advisory services for farmers (Mapiye et al., 2019) despite the top-down approach and many limitations such as lack of support resources and high farmer-to-extension ratio, that has led to its failure to effectively support the smallholder farmers (FAO, 2017).

In the past few decades, the adoption and utilization of digital solutions technologies have been used for agriculture extension services and these digital extension services are widely distributed across the SSA region (Mapiye et al, 2021). Approximately 43 out of 49 SSA countries use digital solutions in agriculture but more than 50 percent of the innovations are headquartered in Kenya (Tsan et al., 2019).

The adoption of digital solutions technology in extension services has helped to reduce poverty among the smallholder farmers in SSA (FAO, 2017; World Bank, 2017; Zyl et al., 2014) because it promotes and quicken interactions between farmers and extension workers, who are government employees working with smallholder farmers to improve their livelihoods and productivity and to share farmer-to-farmer skills and innovations (Mapiye et al., 2021).

Smallholder Farmer's use of Mobile Money

Digital solutions technology promotes the development of e-banking on mobile phones, also known as mobile money in Sub Sahara Africa (Mapiye et al., 2021). Mobile money is a service that allows monetary value to be stored on a mobile phone and sent to other users via text messages (Suri and Jack, 2016).

In Kenya, most smallholder farmers use mobile money to access finance for purchasing farming inputs such as seeds, farm machinery, fertilizer and pesticides (Kirui et al., 2010). In a study done by Suri and Jack (2016) in Kenya, the use of mobile money services reduced extreme poverty in female-headed households by 22% and positively impacted household income of smallholder farmers respectively.

In Zambia, the introduction of mobile money reduced the number of people that don't bank their money and has reduced the rate of employment (Ngoma, 2019, p. 32).

Smallholder Farmers' Access to Mobile Application (Apps)

Scientists and organizations have developed mobile applications to share various crops and livestock information (Mushi et al., 2022). Centre for Coordination of Agricultural Research and Development for Southern Africa [CCARDESA] (2022) identified 18 innovations operational in Zambia were identified out of which 9 were for Zambia only and the remaining 8 were regional innovations. The majority smallholder farmers in Zambia don't use Mobile Application (Apps) because they don't own smartphones on which these Apps can be installed.

The Benefits of Digital Solutions to Smallholder Farmers

Digital solutions facilitate smallholder farming transformation because they facilitate market information and agriculture value chain linkages, improve farm productivity and income, improve access to financial services, improve social well-being and risk minimization, and increase women's empowerment and inclusion (Kudama, et al., 2021). Digital solutions have the capacity to increase productivity and resilience while reducing the vulnerability of smallholder farmers (Quayson et al., 2020). Access to and use of digital solutions could benefit smallholder farmers and farming communities by facilitating access to nutrition and agricultural information, increasing access to financial services, increasing access to insurance to better manage risk, and providing new business opportunities for smallholder farmers (Sekabira et al., 2023). Digital solutions increase weather resilience by providing weather forecasts via SMS messages and mobile applications (Sekabira et al., 2023).

In Nigeria, digital solutions eliminated some roles of middlemen, allowed farmers to expand their markets, enhanced extension and research linkages, and improved the productivity and livelihood of smallholder farmers (Izuogu et al., 2023).

Factors Affecting the Adoption of Digital Solutions Among Smallholder Farmers

There are several factors affecting the adoption of digital solutions by smallholder farmers and some of these are access to extension services (Abdulai, et al., 2023a), poor infrastructure (Izuogu et al., 2023; Smidt & Jokonya, 2022), insufficient electricity

(Anand et al., 2020; Musa et al., 2013; Smidt and Jokonya, 2022), poor internet connectivity, and low access to mobile phones (Kieti et al., 2022; Anand et al., 2020; Abdulai, et al., 2023b), high costs of purchase and maintenance (Izuogu et al., 2023; Kudama, et al., 2021; Mansour, 2023), low education levels (Kieti et al., 2022; Mansour, 2023; Sekabira et al., 2023; Smidt and Jokonya, 2022) and the mistrust caused by scammers (Kieti et al., 2022).

From the literature review conducted, it was evident that most studies about digital technology for smallholder farmers were conducted in West Africa and in East Africa and these studies were mostly desk research papers.

A gap therefore exists in literature and qualitative research justifies a mixed methods research with the objective to assess the digital empowerment of smallholder farmers in Chongwe District by evaluating the existing digital infrastructure, available services, perceived benefits, and challenges, with the aim of providing insights that can inform strategies to enhance the effective integration and utilization of digital solutions in agricultural practices.

Methodology

Introduction

This chapter looked at the research paradigm, research design, sampling methods and sample size, data collection methods, data analysis, validity and reliability, and ethical consideration.

Study Design

The mixed methods research design, using Triangulation Design approach (Creswellet al., 2003) was conducted using interview guides for smallholder farmers and in-depth interviews and key respondents.

Study Site

The study site was Nkomesha agricultural block of Chongwe district in Zambia. Chongwe district is one of the districts of Lusaka province and the other districts are Lusaka, Chilanga, Shibuyunji, Kafue, Rufunsa and Luangwa.

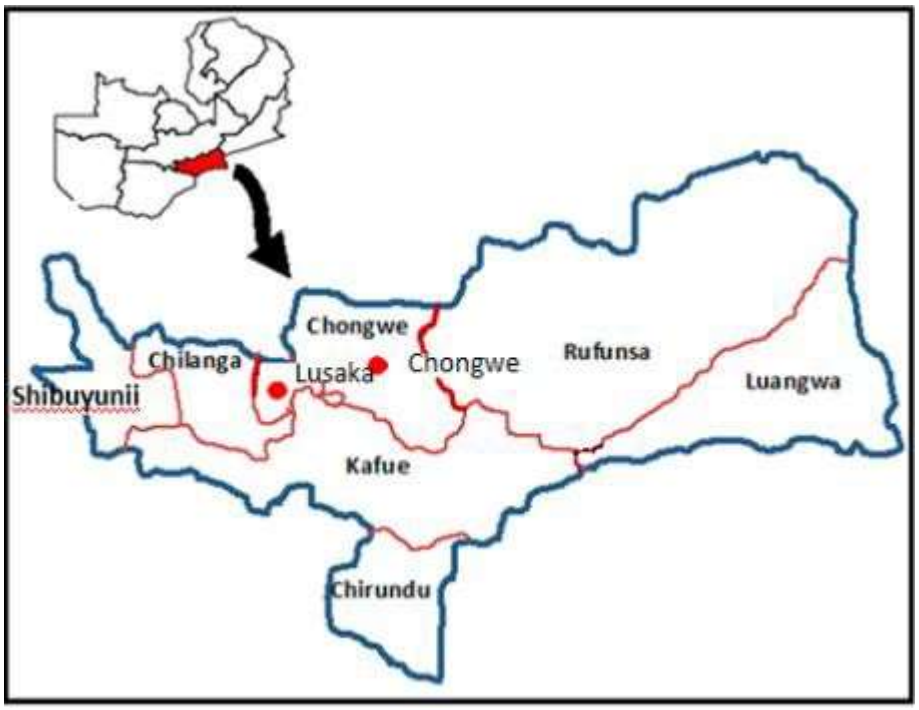

Figure 2: Map of Zambia Showing Chongwe District (Inonge Milupi et al., 2020, p. 23)

Population

The study population was all smallholder farmers in Nkomesha block of Chongwe district in Zambia. In addition, 5 key informants were included in the study. The key informants were the District Agricultural Coordinator, the Camp Extension Officers, the Ministry of Science and Technology officer, the Ministry of Communication officer, and the Food and Agriculture Organization officer. These key informants were important in the study because they had insights due to their experience working with smallholder farmers and their use of digital technology.

Sample Size Determination and Sampling

For the quantitative research component, the study used a multi-stage sampling procedure to select participants for the study. The first stage involved the purposive selection of Chongwe district out six (6) districts of Lusaka province. Chongwe district was selected due to the presence of agricultural technology firms, non-governmental organizations, and government extension offices operating in the district and due to mobile and internet connectivity. In the second stage, Nkomesha block will be selected out the five (5) agricultural blocks in Chongwe districts because it has the most productive smallholder farmers in Chongwe district. Nkomesha block was identified with the help of agricultural extension officers who were employed as field officers. Then 4 agricultural camps (Lwiimba, Kampekete, Lukoshi, and Mwalumina) were randomly selected out of 6 camps in Nkomesha block. In these 4 camps households whose main economic activity was farming were identified and randomly selected.

Finally, Yamane's formula for calculating sample size for a finite population as recommended by Sarmah and Hazarika (2012) was used. To select respondent households, the researcher worked with government extension workers to identify lead farmers, from which farmer registers (sampling frames) were retrieved. Farmers were surveyed at their homes since the study was conducted when farming activities were still going on. The eligibility criteria were that the unit of data collection was only farmers who were 18 years and above. These farmers must have lived in the community during the last farming season in 2022. The total sample size 92 smallholder farmers were randomly selected and interviewed in Nkomesha agricultural block out 693 smallholder farmers that were in farmer registers. Extension officers were recruited as enumerators and were trained to carry out the administration of the interview schedule.

Method used to calculate sample size for smallholder farmers;

Yamane's formula for calculating sample size for a finite population as recommended by (Sarmah and Hazarika, 2012).

Yamane's formula is as follows; n = N/1 + N (e2) where;

n is the sample size,

N is the population = 1,100 (respondents that met the set criteria), and

Assuming 95% confidence level and e is the level of precision = (+/-)10% = 0.1

Using the above formula, the sample size was calculated to be 92.

Thereafter, 92 smallholder farmers were randomly selected and interviewed in Nkomesha agricultural block.

For the qualitative research component, purposive sampling was used to selected key informants for in-depth interviews. The researcher selected 5 key informants using purposive sampling technique (Acharya et al., 2013, p. 4). The key informants included the District Agricultural Coordinators, the Camp Extension Officers, the Ministry of Science and Technology officer, the Ministry of Communication officer, and the Food and Agriculture Organization officer. These key informants were important in the study because they had insights due to their experience working with smallholder farmers and their use of digital technology.

Data Collection

Data was collected using both primary and secondary methods. Secondary data was acquired using desk research from peer reviewed journal articles and a literature review paper was published (Munalula and Qutieshat, 2024). Other secondary sources of data were research reports, government and non-governmental organization reports, and text books. Primary data was collected using both qualitative

and quantitative techniques. Descriptive data was collected by administering a semi structured questionnaire to 92 smallholder farmers in the target households. Five key informants were interviewed using an interview guide and qualitative data was collected. The researcher collaborated with 2 Soli speaking local extension officers who worked as research assistants to help with data collection. The assistants received a half day training on how to administer the data collection tools as well as data quality and ethics. The research assistants also participated in a half day pre-testing of the questionnaire session. The questionnaires were validated based on the feedback from pre-testing before data was collected.

Data Management, Processing, and Data Analysis

Survey data collected using questionnaires from the Chongwe district was cleaned by the researcher by verifying for completeness and consistency every day. Respondents whose questionnaires had inconsistent information were revisited to clear the uncertainties. Quantitative data from questionnaires were then entered into the software Statistical Package for Social Sciences (SPSS version 26) and analyzed using descriptive statistics. Qualitative data from in-depth interviews of the District Agricultural Coordinators, the Camp Extension Officers, officers from the Ministry of Science and Technology officer, Ministry of Communication and FAO, was categorized by the thematic content analysis, then comparisons were developed between the coded reports of the software tool NVivo9 and the emerging themes were identified. Microsoft Excel package from Microsoft Office Professional Plus 2017 was used to generate the visual data output formats including pie charts and histograms as presented in Chapter 5 of this paper. The research work employed simple statistical bunch such as tabulation and percentage in presentation of the data.

Validity and Reliability

The researcher implemented a Quality Assurance Plan during all data collection and analysis procedures were as follows:

- Verifying primary and secondary data for correctness and accuracy.
- Liaising with stakeholders to seek clarification on some of the smallholder farmer survey findings.
- Adhering to the ethical guidelines that were consistent with international research practices.
- Ensuring that all the study objectives were met.

Ethical Consideration

The researcher got ethical approval from the University of Zambia's ethical clearance body, University of Zambia Biomedical Research Ethics Committee (UNZABREC) to carry out the study. Permission to conduct the study was also obtained from the offices of the District Agricultural Coordination in Chongwe district to interview the smallholder farmers. The purpose of the study was explained to participants and informed consent

was sought. Participants were also informed that they were free to withdraw from the interview at any point without any consequences. The researcher also ensured that only participants who were 18 years and above were interviewed and that they consented to participating in the study. A participatory information sheet was read to each participant explaining their rights and responsibilities to ensure that they had adequate information to make a decision in taking part or otherwise. The participants that agreed to take part in the study were requested to sign an informed consent. Furthermore, participants were assured that the information they would provide would be strictly for academic purposes. Arrangements for interviews with key informants were made prior to the actual day after consent was sought from the concerned participants. After the interview, the researcher thanked the participants who participated in the study.

Research Findings and Data Presentation

Introduction

This chapter presents both quantitative and qualitative data and research findings from in Chongwe district of Zambia.

Data Presentation and Interpretation

The data was organized according to the response rate and the results obtained from the field of study. The data collected through interview guides and in-depth interviews was analysed, presented and interpreted under the following subheading starting with the demographic areas:

Demographic Characteristics of Respondents

Cooperative Membership of Respondents

Table 1shows the respondents' cooperative membership in Chongwe district. The data shows that 92 (100 percent) of respondents were members of cooperatives.

Table 1: Cooperative Membership of Respondents

Name of cooperative		
N	Valid	92
	Missing	0

Gender Segregation of Respondents

Figure 1 shows gender segregation of the respondents. The study revealed that out of 92 respondents, 49 53.3 percent) and 43 (46.7 percent) were female.

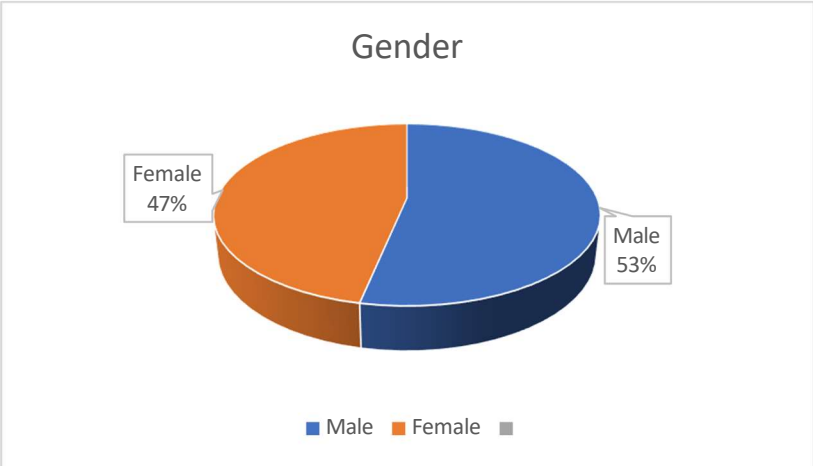

Figure 3: Gender of respondents (Total Sample=92; data obtained using interview guide)

Marital Status of Respondents

Figure 2 shows the marital status of the respondents. The data shows that out of 92 respondents, 76 (72.8 percent) were married, 8 (8.7 percent single or unmarried), 7 (7.6 percent) were divorced, and 10 (10.9 percent) were widowed.

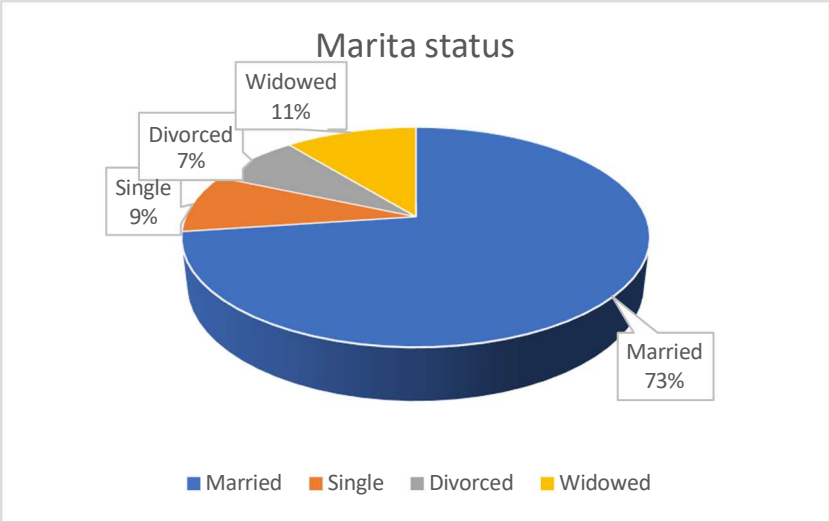

Figure 4: Marital status of respondents (Total Sample=92; data obtained using interview guide)

Education Level of Respondents

Figure 3 shows the level of education attainment of the respondents. The data shows that from 92 respondents, 2 (2.2 percent) did not enter school, 37 (40.2 percent) attained primary education, 50 (54.3 percent) attained secondary education level, and only 3 (3.3 percent) attained tertiary education.

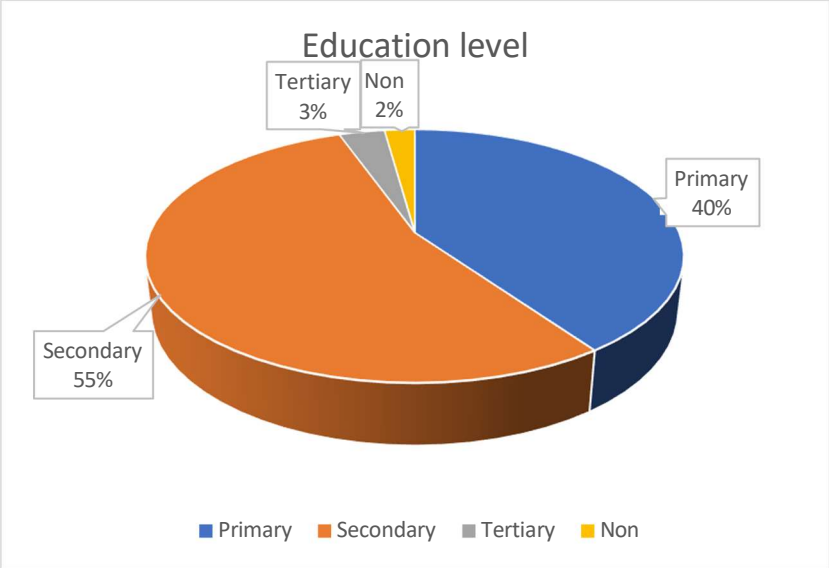

Figure 5: Education level of respondents (Total Sample=92; data obtained using interview guide)

The Digital Infrastructure Available for Smallholder Farmers

Type of a Mobile Phone Smallholder Farmers use

Figure 4 shows the type of a mobile phone used by the respondents. The data shows that out of 92 respondents, 3 (3.3 percent) had no mobile phones. However, 59 (64.1 percent) had ordinary phones while 30 (32.6 percent) had smart phones. This is consistent with literature from the Sub-Sahara Africa that shows rapid adoption of mobile phones in several developing nations (Aker and Mbiti, 2010; Kikulwe, et al., 2014; Wesolowski, et al., 2012).

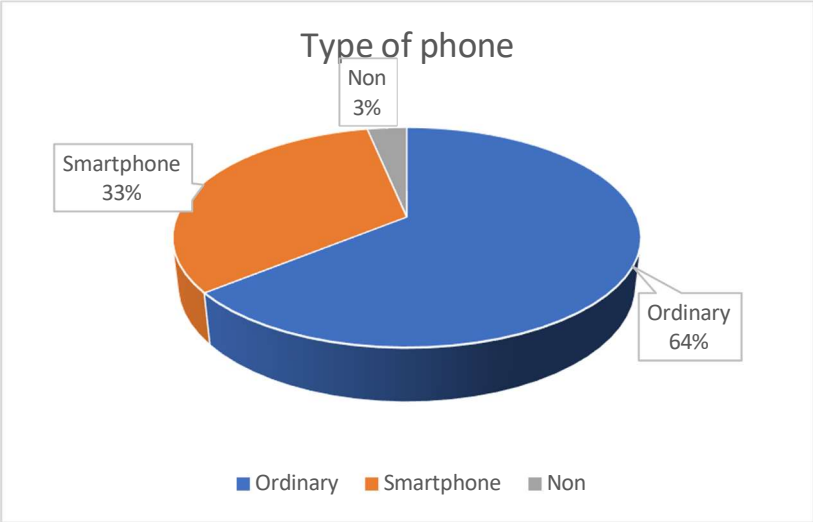

Figure 6: Types of mobile phone (Total Sample=92; data obtained using interview guide)

The Internet Connectivity in Smallholder Farming Areas

Figure 5 shows the internet connectivity of the respondents. The data shows that out of 92 respondents, 55 (59.8 percent) had internet connection, 36 (39.1 percent) did not have internet connection, and 1 (1.1 percent) didn't know whether there was internet connection in the area. This is contrary with literature from the sub-Sahara that shows that the internet connection is much lower in the majority of SSA countries (Mapiye et al., 2021; Tsan et al., 2019).

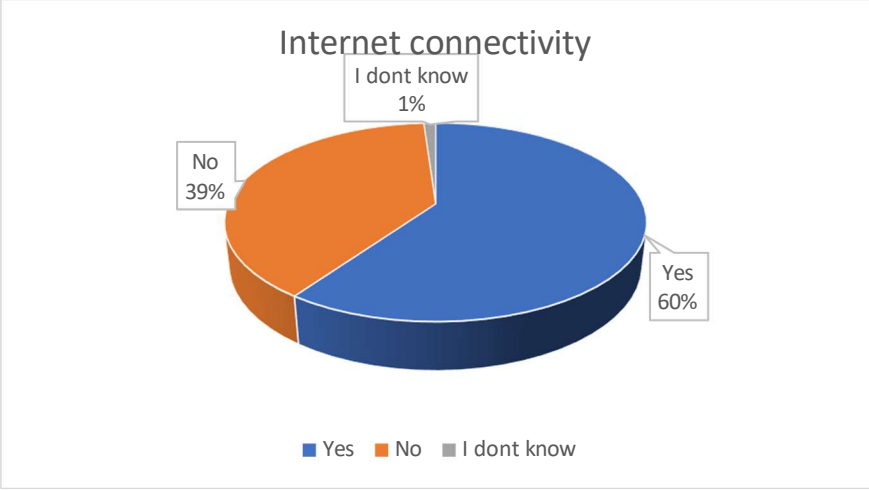

Figure 5: Internet connectivity (Total Sample=92; data obtained using interview guide)

The Availability of Electricity in Smallholder Farming Areas

Figure 6 shows the availability of electricity for the respondents. The data shows that out of 92 respondents, only 2 (2.2 percent) were connected to national electricity grid. This is contrary with literature from the Sub-Sahara Africa which shows that most smallholder farmers' rural areas had a shortage of electricity for disseminating agricultural information (Musa et al., 2013; Okpara, 2011). The smallholder farmers in

Chongwe afford solar powered electricity because of their high productivity compared to the rest of the country. Two in-depth respondents who are experts in agriculture and working with smallholder farmers have confirmed that Chongwe farmers are better in terms of productivity and adoption of digital technology and this due to many projects that are running in Chongwe.

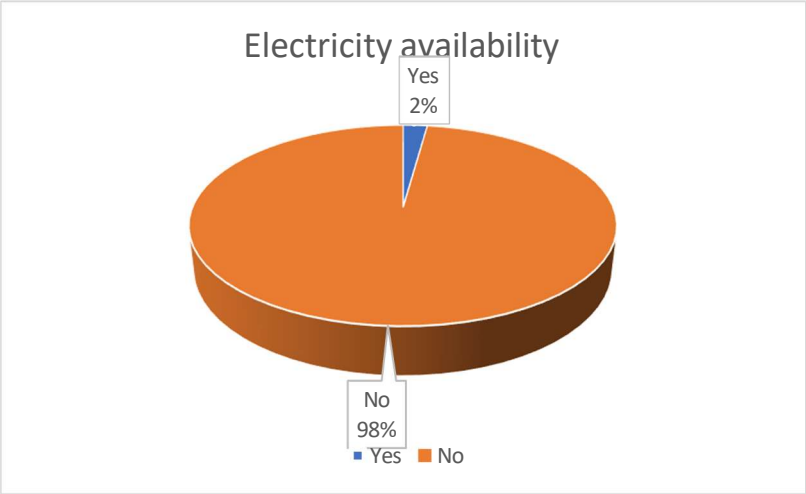

Figure 6: Availability of electricity (Total Sample=92; data obtained using interview guide)

The Phone Charging System for Smallholder Farmers

Figure 7 shows the methods of charging phones for the respondents. The data shows that out of 92 respondents, 87 (95 percent) used solar powered electricity of which 75 (81.5 percent) had access to own solar powered electricity, while 12 (13 percent) accessed the solar power systems from their neighbours.

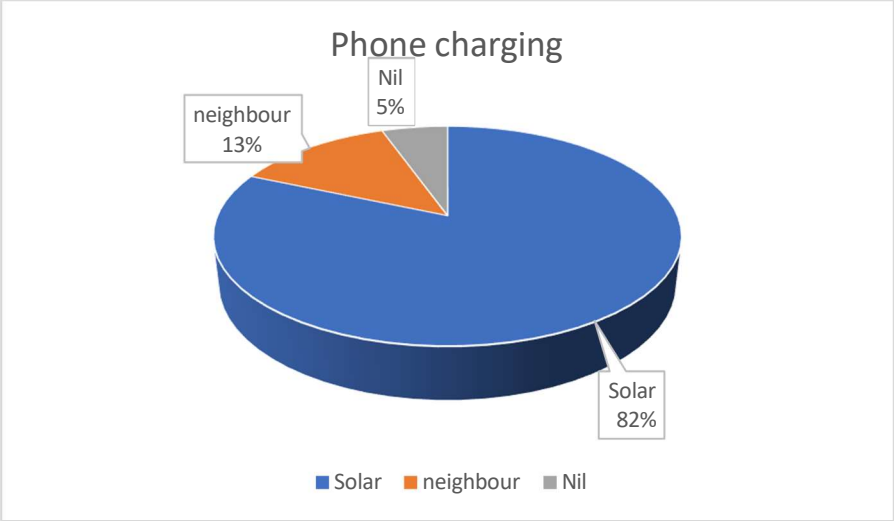

Figure 7: Method used for charging phones (Total Sample=92; data obtained using interview guide)

The Digital Services are Available for Smallholder Farmers

How Smallholder Farmers Receive Extension Services

Figure 8 shows how respondents receive extension services. The data shows that out of 92 respondents who received agriculture extension, 78 (84.8 percent) from agricultural extension workers, 69 (75 percent) through radio, and 43 (46.7 percent) through TV. This is consistent with literature from the sub-Sahara that shows that digital solutions are new ways of providing extension services (Deichmann et al., 2016).

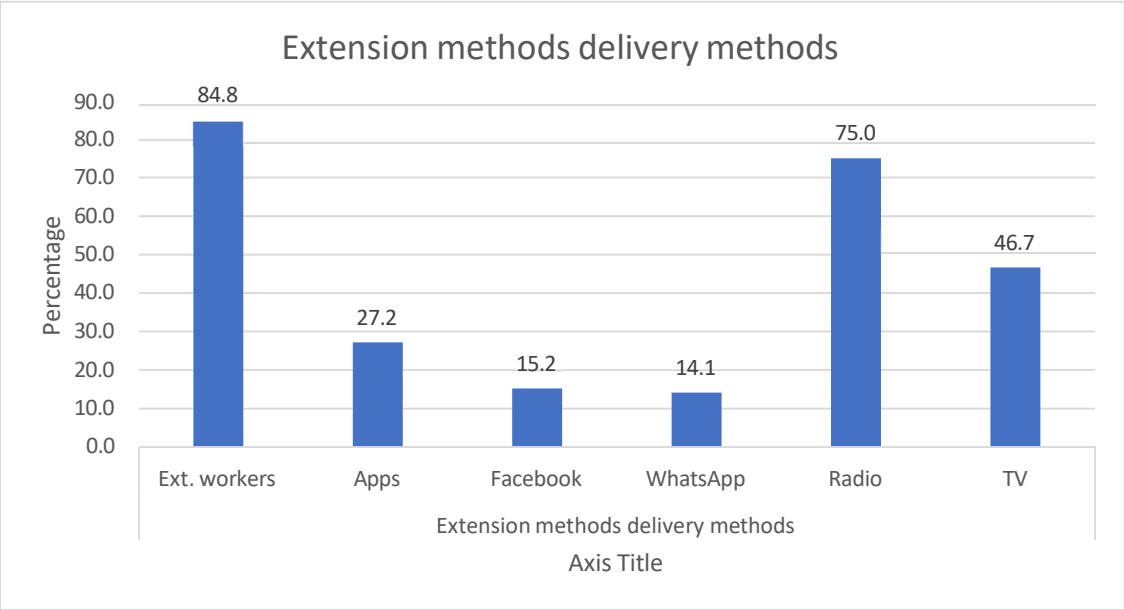

Figure 8: How smallholder farmers receive extension services (Total Sample=92; data obtained using interview guide)

The Digital Services Accessed by Smallholder Farmers

Figure 9 shows digital services accessed by respondents. The data shows that out of 92 respondents, 90 (97.8 percent) smallholder farmers in Chongwe used mobile money. This is consistent with literature from the sub-Sahara that shows that Smallholder farmers in SSA use mobile money services (Agamile, 2022; Quayson et al., 2020).

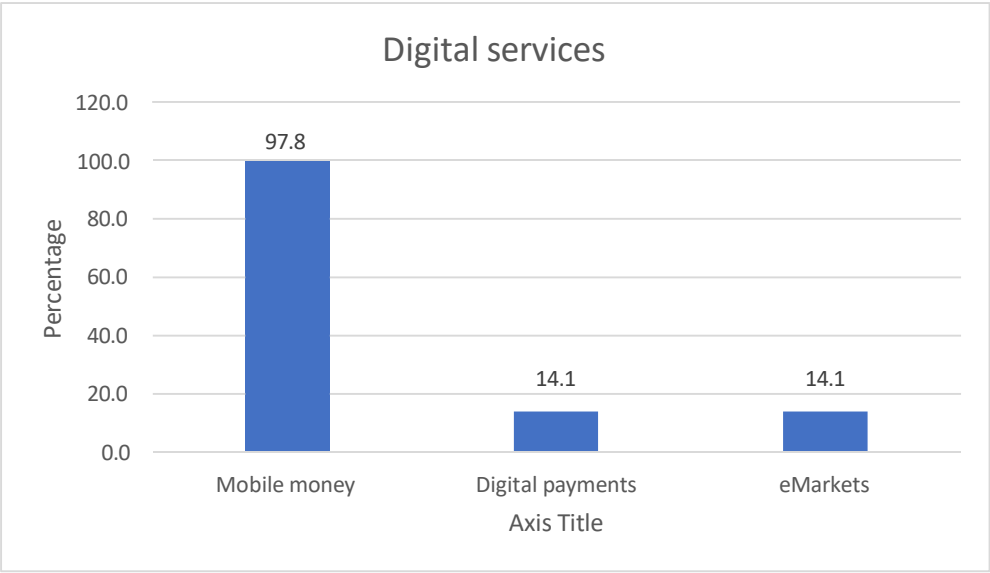

Figure 9: Digital services accessed by smallholder farmers (Total Sample=92; data obtained using interview guide)

Benefits of Digital Solutions to Smallholder Farmers

Figure 10 shows the benefits of digital solutions to respondents. The data shows smallholder farmers' digital solutions benefits. Out of 92 respondents, 91 (98.9 percent) benefited social interactions, 90 (97.8 percent) benefited enhance extension linkages, (96.7) 89 elimination of middlemen, 66 (71.7 percent) benefited access to agriculture information. This consistent with literature which shows that digital solutions facilitate market information and agriculture value chain linkages, improve access to financial services, improve social well-being and risk minimization (Kudama et al.,2021).

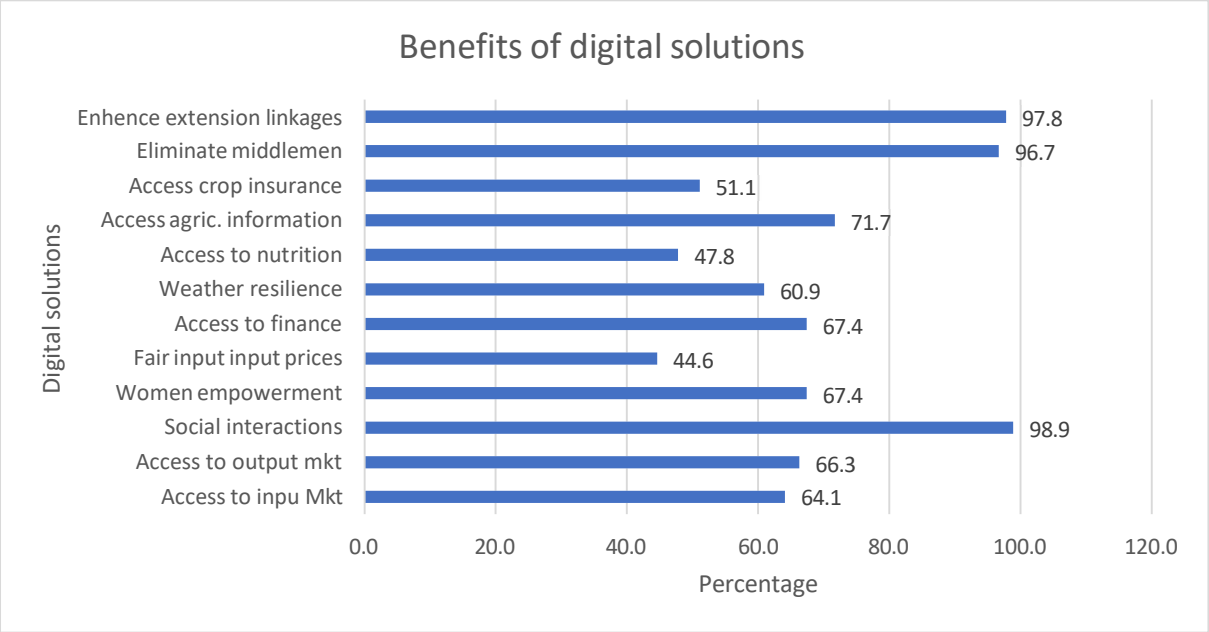

Figure 10: Benefits of digital solutions to smallholder farmers (Total Sample=92; data obtained using interview guide)

The Major Digital Challenges Smallholder Farmers Face

Figure 11 shows the challenges of digital solutions to smallholder farmers. Out of 92 respondents, 87 (94.6 percent) faced challenge of high cost of phones, 83 (90.2 percent) faced challenges of mistrust due to scammers, and 81 (88 percent) faced challenges of high cost of maintenance. This is in line with literature from the sub-Sahara that show challenges of digital solution and these are farmers' digital incompetence, low access to mobile phones (Abdulai, et al., 2023a), lack of technical skill, poor infrastructure, and high costs of purchase and maintenance as digital solution (Izuogu et al., 2023).

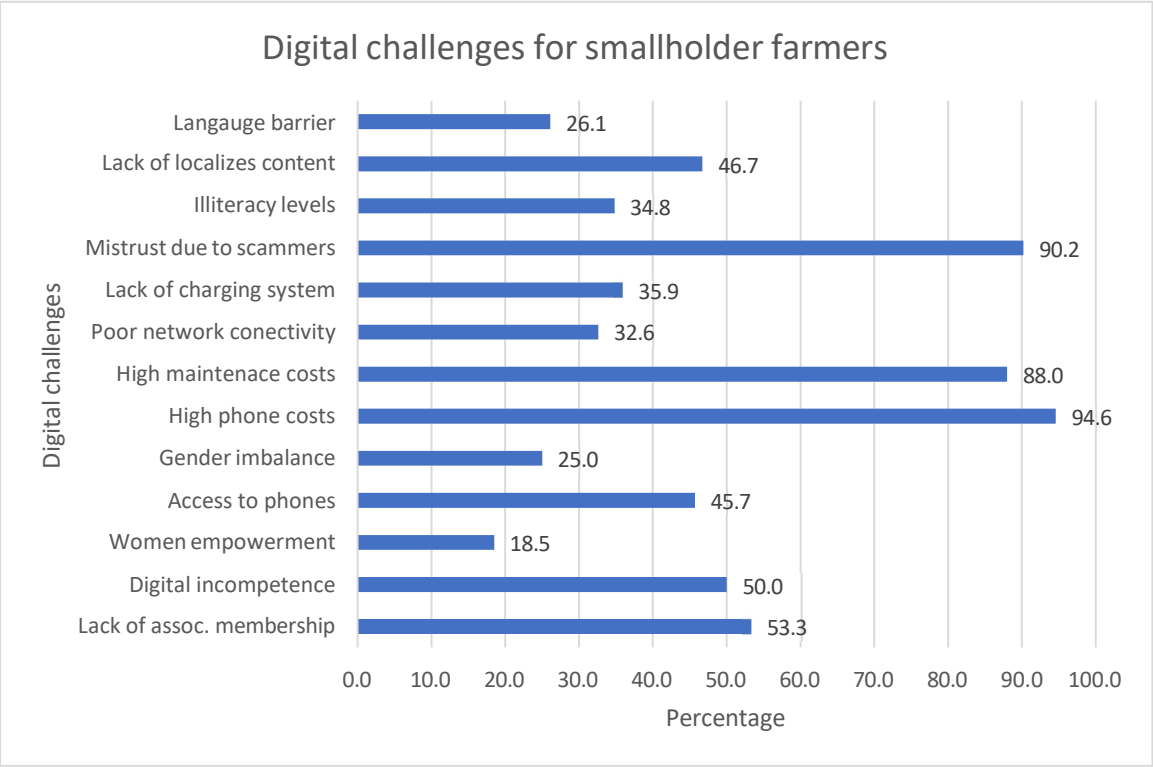

Figure 11: Major digital challenges smallholder farmers face (Total Sample=92; data obtained using interview guide)

Discussion and Interpretation of Results

Introduction

This chapter discusses and interprets results presented earlier in chapter four. The research findings and analysis were structured around the four research questions of the study which was conducted in Chongwe district.

The Digital Infrastructure Available for Smallholder Farmers

The digital infrastructure available for smallholder farmers in Chongwe district was studied under the following sub-headings: mobile phones smallholder farmers use, smallholder farmers' internet connectivity, and the mobile phone charging system. The study revealed the following:

With regards to the type of a mobile phone smallholder farmers use, the study revealed the type of mobile phones smallholder farmers in Chongwe district use. Most of the challenges respondents identified were also reflected in the literature review. Almost all the smallholder farmers in Chongwe district owned mobile phones (94 percent).

However, the majority of the had ordinary phones (64 percent) while 33 percent had smart phones. This is consistent with literature from the sub-Sahara that shows rapidly adoption of mobile phones in several developing nations such as Zambia (Aker and Mbiti, 2010; Kikulwe, et al., 2014; Wesolowski, et al., 2012). The use of smart phones by smallholder farmers is above the country average because of several projects Chongwe enjoys, which exposes them to digital world. During the in-depth interview, Ministry of Agriculture respondent said,

> "I have never worked with serious farmers like these of Chongwe in my fifteen years I worked in Western province…these Chongwe farmers are just something else, maybe it's because of their proximity to Lusaka (The capital city). Chongwe has a lot of projects which these farmers participate."

With regards to the smallholder farmers' internet connectivity in Chongwe district, the study showed that most of the smallholder farmers (60 percent) had internet connection, and only 39 percent didn't have internet connection. This is contrary with literature from the sub-Sahara that shows that the internet connection is much lower in the majority of SSA countries (Mapiye et al., 2021; Tsan et al., 2019). The high internet connectivity in rural Chongwe could be as a result of close proximity to the capital city, Lusaka.

With regards to the availability of electricity for smallholder farmers in Chongwe district, the study showed that most of the smallholder (98 percent) had access to solar powered electricity. This is contrary with literature from the sub-Sahara that shows that most smallholder farmers' rural areas had a shortage of electricity for disseminating agricultural information (Musa et al., 2013; Okpara, 2011). The contradiction with literature is due to the fact that smallholder farmers in Chongwe can afford solar powered electricity because of their high productivity compared to the rest of the country.

With regards to the mobile phone charging system for smallholder farmers in Chongwe district, the study showed that most of the smallholder (98 percent) had access to solar powered charging.

Digital Services Available for Smallholder Farmers

The digital services available for smallholder farmers in Chongwe district was studied.

With regards to smallholder farmers' channels of receiving extension services, the smallholder farmers in Chongwe received agriculture extension mainly from agricultural extension workers (84.8 percent), followed by radio (75 percent), and TV

(46.7 percent). This is consistent with literature from the sub-Sahara that shows that digital solutions are new ways of providing extension services (Deichmann et al., 2016).

With regards to digital services accessed by smallholder farmers in Chongwe, the most used digital services by smallholder farmers in Chongwe was mobile money (97.8 percent), and only few smallholder farmers access digital payments and e- markets (14.1 percent each). This is consistent with literature from the sub-Sahara that shows that Smallholder farmers in SSA use mobile money services (Agamile, 2022; Quayson et al., 2020).

Benefits of Digital Solutions to Smallholder Farmers

With regards to the benefits of digital solutions to smallholder farmers, there are several benefits of digital solutions to smallholder farmers the study found. The most important benefits are social interactions (98.9 percent), enhance extension linkages (97.8 percent), access to agriculture information (71.7 percent) and elimination of middlemen (96.7). These results are consistent with literature from the sub-Sahara that shows that digital solutions facilitate market information, improve farm productivity, improve social well-being and risk minimization (Kudamaet al., 2021).

Major Digital Challenges Smallholder Farmers Face

With regards to the challenges of digital solutions to smallholder farmers in Chongwe district, the study found three main digital challenges faced by smallholder farmers in descending order of importance and these are high cost of phones (94.6 percent), mistrust due to scammers (90.2 percent), and high cost of maintenance (88.0). This is in line with literature from the sub-Sahara that show smallholder farmers' challenges of digital solution as digital incompetence, low access to mobile phones (Abdulai, et al., 2023a), poor infrastructure, and high costs of purchase and maintenance (Izuogu et al., 2023).

Conclusions and Recommendations

Conclusion

With regard to digital infrastructure available for smallholder farmers in Chongwe district, the finding of the study are that 94 percent of smallholder famers in Chongwe district owned mobile phones, of which 64 percent were ordinary phones and 33 percent were smart phones. The use of smart phones by smallholder farmers in Chongwe district was above the country average. This was due to several projects that were being conducted in Chongwe district by different stakeholders and the exposed the smallholder farmers in that area to digital solutions.

The study found that 60 percent of smallholder farmers in Chongwe had internet connection, and is also above average for Sub-Sahara African countries whose internet connection is much lower with countries like Ethiopia having only 4% of its

population accessing the internet (Tsan et al., 2019). This high internet connectivity in rural Chongwe could be attributed to the close proximity of Chongwe to the capital city, Lusaka.

The study found that 98 percent of smallholder farmers in Chongwe district had access to solar powered electricity and this above Sub-Sahara average where most smallholder farmers' rural areas had a shortage of electricity (Musa et al., 2013; Okpara, 2011). The high electricity access by smallholder farmers in Chongwe comes from their high productivity coupled with exposure from several stakeholders running projects in the area.

The study also found that 98 percent of smallholder farmers in Chongwe district had access to mobile phone charging systems from solar powered electricity. Most smallholder farmers won solar systems while a few charging their mobile phones at their neighbors.

With regards to digital services available for smallholder farmers in Chongwe district, the research found that 84.8 percent of smallholder farmers in Chongwe received agriculture extension from agricultural extension workers, 75 percent through radio, and 46.7 percent through TV. The study further found that 27.2 percent of smallholder farmers adopted mobile Apps. Social media is ranked the least with 15.2 percent and WhatsApp at 14.1 percent but it's use is likely to grow as literature from the Sub-Sahara that shows that digital solutions are new ways of providing extension services (Deichmann et al., 2016). The study found that the most used digital services by smallholder farmers in Chongwe was e-banking through mobile platforms such as Airtel mobile money, MTNmomo, Zamtel mobile money, Atlas Mara Bank's Tenga mobile money, and Zanaco Express (97.8 percent) just like smallholder farmers in Sub-Sahara Africa who use mobile money services on platforms such as MPESA in Kenya, MTNMOMO in Uganda, Agrikore in Nigeria (Agamile, 2022; Quayson et al., 2020). The fact that smallholder farmers have adopted e-banking as one of digital services available for them, the implication is that the adoption rate for other digital services will continue to increase given the right digital ecosystem.

With regards to the benefits of digital solutions to smallholder farmers, the study shows social interactions (98.9 percent), enhance extension linkages (97.8 percent), and elimination of middlemen (96.7) the most important benefits of digital solutions to smallholder farmers. These results are consistent with literature shows that digital solutions facilitate market information and agriculture value chain linkages, improve farm productivity and income, improve access to financial services, improve social well-being and risk minimization (Kudama et al., 2021).

With regards to the major digital challenges faced by smallholder farmers in Chongwe district, the study found that there were three main digital challenges faced by smallholder farmers and these are high cost of phones (94.6 percent), mistrust due to scammers (90.2 percent), and high cost of maintenance (88.0). These results are consistent with digital solutions challenges in Sub-Sahara Africa (Abdulai, et al.,

2023b; Izuogu et al., 2023; Kudama et al., 2021). Unlike the SSA whose smallholder farmers are facing major challenge to the scaling and sustainability of mobile Apps owing to gender imbalance (Mapiye et al., 2021), the major digital challenges faced by smallholder farmers in Chongwe are not women empowerment (18.5 percent), and gender imbalance (25.0 percent). This shows that male smallholder farmers in Chongwe are gender inclusive. This could be attributed again to many projects that these farmers are involved with.

It can be concluded that a good digital ecosystem in Chongwe district is enhancing digital empowerment of smallholder farmers, considering the interplay of digital infrastructure, available digital services, perceived digital benefits, and challenges.

Recommendations

Based on the findings of this study, the following recommendations are made:

The main challenge of digital solution adoption for smallholder farmers is cost of the mobile phones. Therefore, it is recommended that government consider reducing tax on mobile phones to smallholder farmers.

Based on the findings of this study, it is recommended that this research be scaled up in Eastern, Southern and Central Zambia where there is high potential for smallholder production. This because the results for this study is better than SSA average and may not represent the general digital landscape for Zambia. This is due to uniqueness of Chongwe smallholder farmers and it geographical proximity to the capital city, Lusaka.

Further research will be required to target Scientists and organizations that develop mobile applications that are targeting smallholder farmers. This will help to understand challenges and the opportunities for these innovators.

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APPENDICES

Appendix 1: Information Sheet

Purpose of study	To assess the digital empowerment of smallholder farmers in Chongwe District by evaluating the existing digital infrastructure, available services, perceived benefits, and challenges, with the aim of providing insights that can inform strategies to enhance the effective integration and utilization of digital solutions in agricultural practices.
Length of study	6 months
Procedures	Consent for participation will be sought before interviews will be conducted.
Compensation	No compensation because there are no risks for participants
Risks/burdens	There is no risks involved for participants
Benefits/ ancillary care	The farming community will improve its production and profits when they adopt digital solutions in their farming business.

Appendix 2: Consent form

THE UNIVERSITY OF ZAMBIA

BIOMEDICAL RESEARCH ETHICS COMMITTEE

Determining Smallholder Farmers Preparedness for Digital Solutions in Chongwe District

INFORMED CONSENT TEMPLATE FOR INTENDING RESEARCHERS

Digital Empowerment in Agriculture: Evaluating Infrastructure, Services, Benefits, and Challenges for Smallholder Farmers in Chongwe District. I am conducting a research entitled, “Digital Empowerment in Agriculture: Evaluating Infrastructure, Services, Benefits, and Challenges for Smallholder Farmers in Chongwe District.” This is because I want to Assessing the digital empowerment of smallholder farmers in Chongwe District by evaluating the existing digital infrastructure, available services, perceived benefits, and challenges, with the aim of providing insights that can inform strategies to enhance the effective integration and utilization of digital solutions in agricultural practices in Chongwe, Zambia. If you would like, you can be in my study. If you decide you want to be in my study, you will assist to answer the questions which I will be asking you. These questions will enable me collect information on the research topic for further analysis. There are no risks involved in this study, it is also short and not complex. The benefits the study has is that it promotes digital technology adoption which will lead to high farming production and increased profits. Other people will not know if you are in my study. I will mix all information I will learn about with the information from other participants therefore no one can know which information is from you. When I share information about my research, I will not use your name any participant’s name so that no one can know who I will be talking about. My telephone number is 0966434370. You can call me if you have questions about the study or if you decide you don’t want to be in the study any more.

I will give you a copy of this form in case you want to ask questions later.

_____ _____

Signature of Study Participant Date

_____ _____

Signature of Researcher Date

Appendix 3: Data collection tools

Questionnaires

Demographic Questions (helps participants to warm up)

1. Name of smallholder farmer: ……..
2. Village/Chief/District: ……
3. Name of cooperative (If any) .....……
4. Gender of farmer: ……
5. Marital Status: ……
6. Number of Children: ……
7. Mobile Number (s): ……
7. Level of education: (a) Primary (b) Secondary (c) Tertiary (e) None

Section B

10. What type of a mobile phone do you use? (a) ordinary (b) smart phone (c) non
11. Is internet connection available in your area? (a) Yes (b) No (c) I don't know
12. Is there available electricity in your area? (a) Yes (b) No
13. If No, how do you change your phone?.....
14. How do you receive agricultural extension services? (Please tick (√) where appropriate)

Extension Delivery Methods	Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
Extension officers					
Through Mobile Applications.					
Through Facebook					
Through WhatsApp.					
Through Radio.					
Through Television					

15. What digital services do you access? (Please tick (√) where appropriate)

Digital Services used SHFs	Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
Mobile money					

digital payment platforms					
E-markets					

16. What are other digital services you access?.....

17. What are the benefits of digital solution to you? (Please tick (√) where appropriate)

Benefits of Digital Solution	**Strongly Agree**	**Agree**	**Unsure**	**Disagree**	**Strongly Disagree**
Access to input markets					
Access to output markets					
Social interaction					
Women empowerment					
Fair input prices					
Access to financial services					
Weather resilience					
Access to nutrition					
Access to agricultural information					
access to insurance					
eliminated some roles of middlemen					
enhanced extension linkages					

18. What are the major digital challenges you face? (Please tick (√) where appropriate)

Digital Challenges Smallholder Farmers	**Strongly Agree**	**Agree**	**Unsure**	**Disagree**	**Strongly Disagree**
lack of membership in associations					

poor access to extension services					
digital incompetence in placing phone calls,					
Low access to mobile phones					
Gender imbalance					
High costs of mobile phones					
High costs of maintenance					
Poor network connectivity					
Lack of Charging system					
mistrust caused by scammers					
low literacy levels					
localized content in local languages					
language barrier					

-End of Interview-

In-Depth Interview Guide

Demographic Questions (helps participants to warm up)

1. Name of Officer: ……
2. Position: …….
3. Gender: ……..
4. Mobile Number: ……
7. Highest level of education: (a) Diploma (b) Bachelors (c) Masters (d) PhD

8. How long have you worked in the Ministry of Agriculture?……

Qualitative methods In-depth Interview Question (To explore participants' general views towards Digital technology and reflect the interpersonal and personal meanings about digital technology for stallholder farmers).

11. How do you describe the importance of digital technology in your work with smallholder farmers in Chongwe?

Qualitative methods In-depth Interview Question (To explore the digital technology context usage of extension workers and to let them describe their recent usage experience of digital tools and reflect the interpersonal and personal meanings about digital technology).

12. What digital technology did you use during your recent interaction with smallholder farmers in Chongwe?

13. How do you describe the reception of your message by smallholder farmers when you used digital technology the relay the message?

14. What do you think should be done to improve reception of digitally channeled message to smallholder farmers?

15. What digital tools are your smallholder famers have access to?

Qualitative methods In-depth Interview Question (To discuss digital technology usage by small-scale farmers).

17. What are your beliefs about the digital technology adoption by smallholder farmers?

18. What are your feelings about the impact of digital technology on smallholder farmers yield and profits?

19. What are your digital technology expectations on smallholder farmers?

20. What could be your reasons for not adopting digital technology?

21. Describe your recent experience of digital technology failures on smallholder farmers?

-End of Interview-
