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Digital Technology in Zambian Agriculture: A Scoping Report

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ABSTRACT

Digital technologies in agriculture have been identified as a game changer in agrifood systems (IFPRI, 2020). Policy makers, researchers and corporate interests make claims about how digital technologies in agriculture are significant in making farming more productive, efficient and sustainable. In Zambia, agriculture remains a critical sector to achieve the country's development goals. FAO states that digital technology is part of the solution to Zambia's challenges in the agricultural sector. Zambia has not yet developed a policy on digitalisation in agriculture and most of the digital interventions in agriculture are done by non-state actors, or supported by parts of the state, but in silos. The lack of national policy and a strategy leads to fragmented interventions with very little impact in terms of shaping the course of digitalisation. Advancement of digital technologies in agriculture can cause negative effects including displacement of labour in agriculture, a boom in cybercrimes and data protection concerns, reproduction of entrenched inequities in the global systems, and lead to new forms of value-chain control and value extraction. With the range of potential benefits and risks, more needs to be done to understand, and inform the development of adequate governance of digital technologies in Zambian agriculture.

ACKNOWLEDGEMENTS

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LIST OF ACRONYMS AND ABBREVIATIONS

8NDP	Eighth National Development Plan
Ag tech.	Agricultural Technology
AI	Artificial Intelligence
CCARDESA	Centre for Coordination of Agriculture and Rural Development for Southern Africa
CEEC	Citizens Economic Empowerment Commission
ICT	Information and Communication Technology
FISP	Farmer Input Support Programme
GRZ	Government of the Republic of Zambia
GPS	Global Positioning System
MNO	Mobile Network Operator
NAESS	National Agricultural Extension and Advisory Services Strategy
NAP	National Agricultural Policy
NAIP	National Agricultural Investment Plan
SHF	Small holder farmer
SMS	Structured Messaging Servicing.
SSA	Sub Saharan Africa
SZI	Smart Zambia Institute
MVFM	Maano Virtual Farmers Market
ZSA	Zambia Statistical Agency
ZICTA	Zambia Information and Communications Technology Authority

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TABLE OF CONTENTS

1. INTRODUCTION

Digital technologies in agriculture have been identified as a game changer in agrifood systems (IFPRI, 2020). Policy makers, researchers and corporate interests make claims about how digital technologies in agriculture are significant in making farming more productive, efficient and sustainable (Shimpf, Seufert and Van Dyck, 2023). Promoters of digital technologies are promising enhanced efficiency in the use of resources in food production, new innovative financial services, improved access to markets and information for farmers, the traceability of food, as well as the exploitation of big data technologies (FAO,2023). Donor agencies such as the Food and Agricultural Organization (FAO), GIZ and the World Food Programme (WFP) among others have become aware about the promising effects of digital technologies and are now incorporating digital technologies in their strategic frameworks to accelerate efficiency of the agri-food sector. Policy makers, governments as well as entrepreneurs are also exploring ways to leverage digital technology to transform Africa's food system (Simeon, 2018). As Africa's demand for food increases, FAO (2022) and Yara (2023) argue there is a need for farmers to grow their produce more efficiently and sustainably and for this to happen, they need digital solutions or innovations that would assist them to improve their yields. Different kinds of digital technologies such as precision farming machinery, drones and online food and agricultural input platforms are now being used in African agriculture. Digital technologies are already driving change in agri-food systems and leading to the emergence of a new version of agriculture in Europe and other parts of the world (FAO, 2023).

In Zambia, agriculture remains a critical sector to achieve the country's development goals. CGIAR (2019) and Heuk and Benjamin (2020) noted that for smallholder farmers and pastoralists in Zambia, inclusive digital technologies have the potential to produce significant livelihood improvements. CGIAR (2019) further argues that for women and youth, digital technologies could lead to greater engagement in the agricultural sector and also enhance employment opportunities along several agricultural value chains. However, agricultural productivity in the sector has continued to be low. For instance, during the 2021/2022 agricultural season, the yields per hectare for maize, rice, groundnuts, soyabens and sunflower were 1.80 metric tonnes, 1.33 metric tonnes, 0.66 metric tonnes, 1.12 metric tonnes, 0.37 metric tonnes respectively (Ministry of Agriculture and ZSA, 2022).

FAO (2022) states that digital technology is partly the solution to Zambia's challenges in the agricultural sector and offers opportunities to improve agricultural productivity, and can also enhance farmers' access to capital and resources. Simeon (2018) noted that digital technology can also enhance value chains through economies of scale by enabling small players to be integrated into the value chains. In addition, it is claimed, digital technology can improve the management of resources of natural resources through precision tools, assisting to boost food production sustainably. Digital technologies also hold the potential to make information on land, soils and other resources more widely available, enabling farmers to apply inputs such as fertilizer and water in a more precise way (Simeon, 2018).

Although digital technologies are usually seen as a silver bullet – as a significant tool for innovation and addressing global challenges in agriculture - critiques of digital technologies emphasize that the truth is far more complex.

Shimpf, Seufert and Van Dyck (2023) argue that "the promoters of new digital technologies sometimes use this narrative of being indispensable to propel corporate and political agendas and consolidate political and economic power". They emphasize that the promoters of digital technologies might use this transformation to further undermine food sovereignty and peasant agro-ecology (Shimpf, Seufert and Van Dyck, 2023).

This paper investigates how digitalization is transforming agriculture (specifically farming) in Zambia. It provides a review of the state of agricultural digitalisation in Zambia, guided by the following research questions:

1. Who is driving the promotion of digital technologies in Zambia? Why? Using what mechanisms?
2. Who is using digital technologies? What kind of digital technologies are used? With what outcomes?
3. How widely have digital technologies been adopted in Zambia? And where?
4. How do political institutions at local and national levels in Zambia position themselves vis-à-vis digital technologies in agriculture?

The next section gives a brief overview of Zambia's agricultural sector as well as the methodology of this study. Section 2 discusses the nature of the digital eco-system in Zambia. Section 3 looks at the differentiated effects of digital technologies in Zambia's agro-food system and Section 4 discusses Zambia's policy and regulatory framework for digital technology use. Section 5 gives the conclusion and policy options.

1.1 Overview of Zambia and its agriculture sector

Over the past decade, Zambia's economic performance was relatively stable apart from 2020 which experienced poor/ negative economic performance. Yet poverty levels have remained stubbornly high. As shown in Table 1, according to the 2022 Poverty Assessment Report by the Zambia Statistical Agency (ZSA), at national level the incidence of poverty was estimated at 60% in 2022 compared to 54.5% in 2015.

Table 1: Incidence of poverty in Zambia in 2015 and 2022

Level	Incidence of poverty	Incidence of poverty
Year	2015	2022
National	60.0	54.5
Urban	23.4	32.9
Rural	76.6	78.8

Source: Highlights of the 2022 poverty assessment in Zambia. Zambia Statistical Agency, 2023

Poverty in Zambia remains more pronounced in rural areas than urban areas and there are also gender disparities in poverty (ZSA, 2022). At national level, in 2022, almost 59 out of every 100 male-headed households relative to 63 out of every 100 female-headed households were poor (4 more%age points poor). In rural areas, 77 out of every 100 male-headed households were poor while 83 of every 100 female-headed households were poor (more percentage points poor). Similarly, 37 out of every 100 female-headed household in urban areas were likely to be poor compared to 30 out of every 100 male-headed urban households (ZSA, 2023).

Agriculture is a significant sector in the country given the proportion of the population involved in it. Zambia has over 75 million hectares of land, of which 42 million is suitable for agricultural production (Ministry of Finance, 2022). However, only 14% of the arable land is utilized for production of crops, livestock, and fish. Agriculture supports the livelihoods of over 50% of the population, the majority of whom are in the rural areas (ZSA, 2022). Despite the high proportion of the population being supported by agriculture, poverty remains predominantly high among households engaged in farming. The poverty rate among households engaged in farming, fishing and forestry activities was recorded at 80.3% in 2015 and 78.2% in 2022 (ZSA, 2023). In this context, and given the high rate of poverty in rural areas and among households engaged in farming, digitalisation of agriculture might lead to the transformation of the agricultural sector through improved productivity and livelihoods.

According to the Zambian government's classification, agriculture in Zambia is divided into three categories; smallholder, medium and large-scale farming. The agriculture, fisheries, and forestry sector ("agriculture") in Zambia is composed of about 1.6 million small scale farmers and about 700 large scale farmers (International Labour Organisation, 2015). Small scale farmers represent the vast majority (about 90%) of Zambia's farmers and are mainly substance farmers with occasional marketable surplus Medium-scale farmers produce maize and a few other cash crops for the market while large scale farmers produce different crops for the local and export markets. The crops grown for the domestic market include maize, millet, cassava and sorghum while the export market is driven by maize, coffee, soybeans, sugar, cotton, groundnuts, rice and horticultural produce. Zambia covers 75 million hectares out of which 58% (42 million hectares) is classified as medium to high potential for agriculture production. However, only 15% of this land is currently under cultivation (International Trade Administration, 2022). Agriculture contributes 3.4% of the gross domestic product and employs 23.6% of the total employed population. Employment in the sector is characterized by a high level of informality, with over 89.3% employed informally (Ministry of Finance and National Planning, 2023; ZSA, 2022).

1.2 Methodology

This study was conducted through a desk review of papers, reports and news websites. A total of 23 papers, 33 reports and 25 news websites were reviewed. In some cases, organisations were contacted to get more information about the digital technologies that were available. I focused on literature that was related to digitalisation in agriculture, the policy environment, as well as how widespread the digital technologies are. The limited publications or literature on adoption and impact studies of digital technologies in the agricultural space in Zambia posed a limitation to this study, and it represents only an exploratory scoping phase of work.

2. THE NATURE OF THE DIGITAL ECOSYSTEM IN ZAMBIA

2.1 Types and scale of digital technologies promoted in Zambia

This section discusses the nature of the digital ecosystem in Zambia as it relates to agriculture. The types of existing digital technologies, the drivers of digital technologies as well as factors that contribute to the adoption or resistance of digital technologies in Zambia are discussed.

Countries go through various stages before reaching full maturity while developing the national digital agricultural system. A study by Boston Consultancy Group (2022) categorized Zambia to be at the end of the 'digital inflection point' or early in the 'moderate capacity stage', as shown in Table 2.

Table 2: Digital agriculture performance and potential

Basic investment stage	Digital inflection point	Moderate digital capacity	Robust scaling up
Regions at this stage require significant basic investments in agricultural systems to prepare the way for digital agriculture to have meaningful impact	Regions at this stage have some limited digital infrastructure, but are at an inflection point for digital agriculture, driven by the public or private sector.	Regions at this stage have moderate digital infrastructure and innovation capacity, with public or private sector-led pathways for scaling and impact.	Countries at this stage have more robust digital infrastructure and innovation capacity to scale comprehensive digital agriculture solutions (led by the public sector, or both).
Examples: Burkina Faso, Malawi, Mozambique and Mali	Example: Ethiopia, Tanzania, Uganda,	Example: Nigeria and some Indian States	Examples: Ghana, Indonesia, Kenya, Rwanda

Source: Boston Consultancy Group, 2021.

Zambia's ranking implies that the country's digital ecosystem is not yet mature, but at a relatively early stage. In line with this ranking, McCampbell and Migisha (2022) argue that there is still a need for broadening capacity, and digital agricultural initiatives lack impact and scale at this point in time. Furthermore, the country still lacks well articulated and agriculture-specific strategies on how to integrate digital technologies into agriculture.

According to Zambia's Digital Agriculture Study Report, which is a supplement to the Situational Analysis Report/Assessment of Digitalization in Agricultural Systems of SADC Region, Zambia was ranked 10th out of 16 countries in the region for the benchmark assessment that was conducted in 16 SADC member states (CCARDESA and World Bank, 2022). The purpose of the benchmark was to provide a context to the findings and identify where SADC countries are progressing or where they may be lagging behind or not developing in terms of the digital ecosystem. The benchmark assessment included six pillars as shown in the table below.

Table 3: Pillars of the benchmark assessment

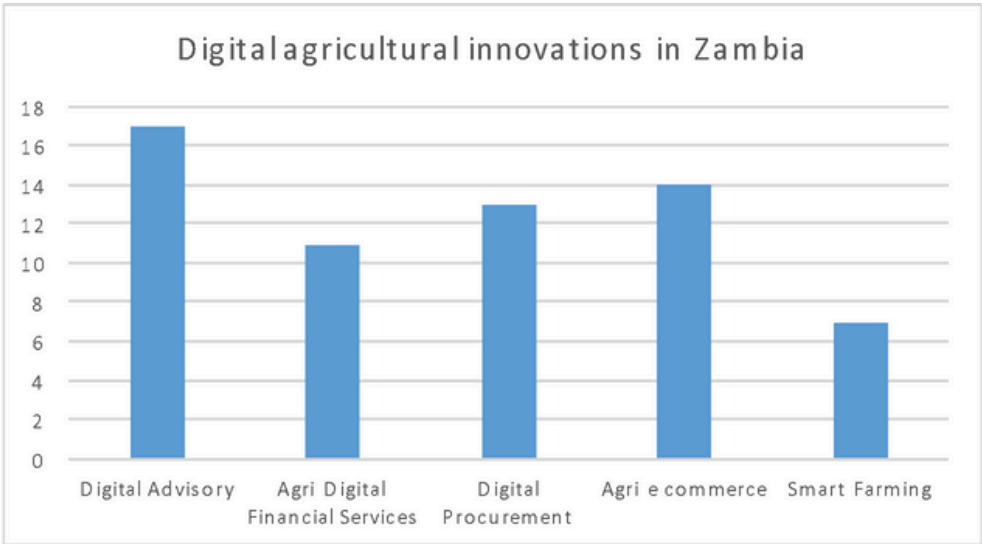
Digital government	Digital business	ICT infrastructure	Innovation driven entrepreneurs hip	Digital skills	Policy and regulatory framework s
The presence and use of digital services and platforms to enable public service delivery.	The development of a robust market place for digital trade, digital financial services, and digital content.	The availability of affordable, accessible, resilient, and reliable infrastructure.	The presence ofan eco-system that supports home grown firms to generate world class products and services that help to widen and deepen digital economic transformation	The development of a digitally skilled workforce that is grounded on sound ethical practices and socio-cultural values.	The presence of policies and regulations that are dynamic, flexible and promote the digital economy.

Source: CCARDESA and World Bank, 2022

Zambia scored moderately in most of the areas of assessment but fell in the bottom half of SADC countries in digital government and innovation-driven entrepreneurship. This assessment showed that although Zambia is making a breakthrough to the digital economy to a certain degree, it was not clear from the findings if there is vigorous or favourable environment (CCARDESA and World Bank, 2022). The assessment classified Zambia under a group of countries that are undergoing digital transition and therefore stand a chance of learning from other neighbouring countries in the region (McCampbell and Migisha, 2022).

The most common digital innovations in Zambia are digital advisory services that focus on addressing the continued knowledge gap among various actors, especially farmers (World Bank, 2022). The assessment conducted by CCARDESA found a total of 26 innovations (as shown in Figure 1) including digital advisory services, agri-financial services, digital procurement, e-commerce and smart farming. Similarly, Porciello et al (2021) found that the provision of digital extension and advisory services was the most common.

Figure 1: Digital agricultural innovations in Zambia



Source: McCampbell and Migisha, 2022

Some of the digital innovations in Zambia are discussed in detail below.

E-PICSA application

This application was developed by GIZ in collaboration with farmers and extension officers. It is being implemented under the project called Digital Climate Services for Smallholder Farmers in Zambia and Malawi. In Zambia, it is being implemented in Eastern province and partners in this project include Community Markets for Conservation (COMACO) and the Ministry of Agriculture. The application is meant to empower smallholder farmers to make better decisions for their individual farms and households, to improve production and productivity.

The project duration is 07/2022-02/2025 (GIZ, 2023). The project is targeting 100 agricultural extension workers, of which 35% are women, and should use digital extension solutions to assist smallholder farmers. A total of 10,000 smallholder farmers are being targeted, of whom 50% are women and the anticipated outcome is that they should be able to adapt their agricultural activities to climate change and variability. An additional 500 women smallholder farmers are also targeted in order to help them improve their decision-making power (GIZ, 2023).

In terms of digital innovations, the E-PICSA is a free application which was designed for both farmers and agriculture extension workers. Secondly, it comes with an automated system for National Meteorological Services (NMS) which provides quality-checked, locally-specific, historical rainfall and temperature data, and location-specific season and short-term forecasts. This is made possible by making best use of existing station data and state-of-the-art satellite and reanalysis data (GIZ, 2023).

Sunagri Drones

The Chinese government through its Ministry of Commerce has been funding the development of Agricultural Technology Demonstration Centers (ATDCs) in Africa. The ATDCs are funded by the Chinese government in the early stages and then operated by Chinese companies through a business model as a platform for training and technology transfer in developing countries (Nalwimba, Qi and Mudimu, 2018). One such company in Zambia is Sunagri investments. Sunagri is involved in the promotion of smart agriculture by providing modern technology such as drones. For example, in the past few years, Zambia has been struggling with pest attacks (by fall army worms) and this continues to affect maize yields – the staple food. Smallholder farmers have been adversely affected. Due to the outbreak of fall army worms, Sunagri brought 3 drones from China (Silimina, 2019; Opali, 2021).

An interview with an expert from Ministry of Agriculture revealed that drones are mainly used by commercial farmers. He indicated that some commercial farmers in Chisamba and Mkushi districts use drones especially for soybeans and wheat fields - and some farmers hire the drones out to other farmers for US$ 30 per hectare. Despite this, most smallholder farmers cannot access this technology as it only makes economic sense for a drone to be hired for spraying at least a minimum of 50 hectares, and smallholders' farms are too small, and spread far apart from each other. As well as limited reach for smallholders, drones need to be replaced every after three to four years as the technology becomes obsolete, making it even more difficult for farmers with limited finances to acquire this digital technology (Ministry of Agriculture Key informant, 2023). A drone is not affordable by most farmers as it costs about USD 19,000 currently.

Lima Links

Lima Links was established in 2016 to connect farmers to broad agricultural markets through technology. Its core business is to develop ICT tools in order to drive agribusiness growth, and one of the digital platforms it has developed is an ICT platform that targets smallholder farmers and is accessible on the most basic phone. Through this, farmers are able to access live buying prices for a wide range of crops or commodities including field crops and fresh vegetables from various market actors (Lima Links, 2021). Farmers are able to check agricultural equipment, agricultural products, as well as get messages on critical disease alert, events and opportunities that may be relevant to them (Lima Links, 2019; Malambo, Tembo, Chapoto et al., 2023).

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Zambia Integrated Agriculture Information Management System

A key government digital platform that is led through the SMART Zambia Institute is the Zambia Integrated Agriculture Management Information System (ZIAMIS). This is a platform that provides extension messages through SMS and acts as an e-subsidy platform with an e-voucher scheme to distribute state support (Ministry of Agriculture, 2021). ZIAMIS is the platform the state uses to implement the Farmer Input Support Programme (FISP), a subsidy programme which the government initiated in 2002 to support smallholder farmers with maize seed and inorganic fertilizer. ZIAMIS is also used to manage weather index insurance as all farmers under this FISP need to insure their crops through various insurance companies that the government engages. The FISP targets a total of 1,024, 434 smallholder farmers. The ZIAMIS is also a digital platform that is used for farmer registration in the country and over 3.6 million farmers are currently registered on the system (Ministry of Agriculture, 2022).

Field Area Measure App

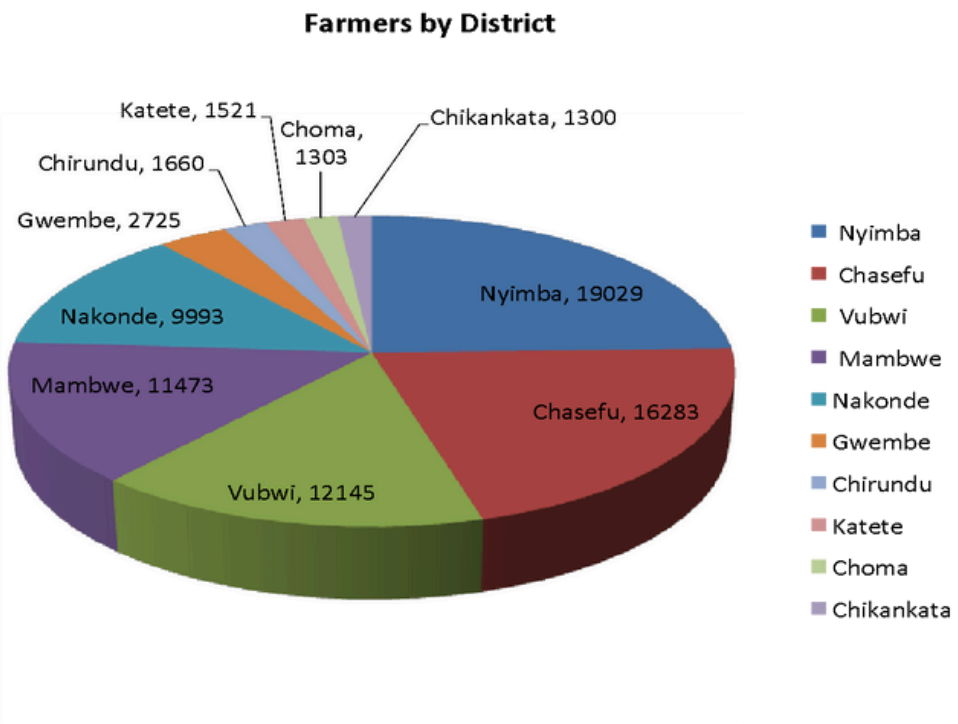
The Agricultural Knowledge and Training Center Zambia-Germany (AKTC Zambia- Germany) developed the Field Area Measure App in 2019 which measures field areas and distance. Farmers are taught how to take measurements of field areas, distances and how to get coordinates of a specific point through the use of the Field Areas Measure Up. The application can be accessed from both Android and IOS (Apple) stores, and the GPS technology comes with the mobile device (AKTC, 2021). With this application, using a smart phone, farmers can take measurements of their fields as opposed to doing it manually which can be tiring and time consuming. Through this application, farmers can work out the correct quantities of agro-inputs such as fertiliser and agro-chemicals to apply in order to improve appropriate use of inputs (AKTC, 2021).

Maano Virtual Farmers' Market

In 2021, the United Nations, through the World Food Programme (WFP) Zambia, supported the development of the market information application called the Maano Virtual Farmers' Market (MVFM). This application was a result of collaborative efforts involving the WFP and private sector players such as Zambia National Commercial Bank (ZANACO), and various public institutions (Ministry of Agriculture, 2021). The WFP contracted Digital Paygo, a local financial service provider to develop the platform (Digital Paygo, 2022). The MVFM is a digital agriculture trading platform designed to assist smallholders to navigate value chains, by providing with market access, insurance, and e-learning, among other services.

Through this e-platform, farmers are able to access market information, discover prices and sell their produce at premium prices through automated payment systems that are connected to mobile money providers and commercial banks. According to a key informant at Digital Paygo, a smallholder farmer with basic numeracy and literacy skills, with access to any phone (not just a smartphone), can find a buyer from amongst those trading on the Maano platform, and sell the produce at a remunerative price (Digital Paygo, 2022). By July 2021, over 1,000 smallholder farmers and commodity buyers were already making use of the application in Eastern, Southern and Central provinces of Zambia. The WFP then introduced a further 5,101 (2,245 women and 2,856 men) smallholder farmers to the MVFM application (WFP, 2021). Smallholder farmers and buyers of commodities are able to access the application through a Unstructured Supplementary Service Data (USSD) code from local mobile network service providers – meaning that they do not need a smartphone, or to buy data. In 2023, a total number of 99,016 farmers (45,164 females and 53,852 males) from various districts across the country were registered on the Maano VFM (Digital Paygo, 2023).

Figure 2: Top 10 districts with farmers registered on the Maano Virtual Farmers' Market



Source: Digital Paygo, 2023

Although 99,016 farmers registered on the Maano app, there is no evidence of how many farmers are actually using the services. Interviews with WFP and Digital Paygo indicated that there are plans to do an assessment of how many farmers use the VFM. Challenges were reported by Ministry of Agriculture officers from various districts who indicated that the poor network coverage in rural areas made it difficult for farmers to access the available services on the VFM. The available services on the Maano include e-learning, bulk messaging services, insurance services (crop, medical and funeral insurance), advertisement services, bulk disbursement of funds, purchase and sale of agro produce, and transportation services (WFP 2021; Digital Paygo, 2023). Currently, the produce includes legumes, grains and livestock.

Digital weather forecasting

The Ministry of Agriculture has been facilitating the provision of satellite-based weather index insurance to over one million smallholder farmers on the FISP, countrywide, since 2017. The smallholder farmers have seen tailor-made products with the introduction of weather index insurance specifically targeting the small- to medium-scale farmers. The Ministry engages various insurance companies to provide weather index insurance on the FISP (Ministry of Agriculture, 2021).

Weather index insurance is based on satellite data to estimate aggregate rainfall over farmers' fields and also uses weather stations in some cases. Automatic Weather Stations (AWS) data is available in some cases, while manual weather stations data takes longer and is less reliable. Data is monitored regularly and compared to product triggers and other parameters. Typical events covered are dry spells, droughts, and excess rainfall. According to Mayfair Insurance (2018) company, weather index insurance is cost effective, speeds up claim settling, relies on satellite data, automated loss assessment (as there is no need to visit the farm).

Improved satellite capturing is needed as some farmers and other stakeholders have doubted the reliability of the satellite data, questioning the validity of the insurance payouts to farmers. Some farmers suffered crop losses but these were not detected by the satellite. Farmers usually get information about their payouts through the phone where they receive a code to access their money. However, farmers in remote areas have problems to retrieve codes due to poor mobile network coverage. In some cases, certain farmers do not own phones, but only sim cards, with the result that they cannot access their insurance payouts on time or at all, according to a key informant in the Ministry of Agriculture.

The table below shows a summary of the existing digital agricultural platforms in Zambia.

Digital weather forecasting

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	Finance access	Input access	Data profiling	Production advisory	Post harvest	Value chain traceability	Market information and access	Resilience/ risk reduction	Others (including) bundled services
Lima Links		✓	✓		✓	✓			
Agri Predict			✓	✓	✓				
E Musika	✓		✓	✓		✓	✓		

	Finance access	Input access	Data profiling	Production advisory	Post harvest	Value chain traceability	Market information and access	Resilience/risk reduction	Others (including) bundled services
260 Brands					✓	✓	✓		
Community Harvest			✓		✓	✓			
Agri Pay	✓	✓	✓				✓	✓	
Digital Insurance	✓		✓	✓			✓	✓	
Mafisa	✓	✓		✓					
Maano App				✓		✓			
Union SS Farmers									✓
ZIAMIS		✓	✓	✓	✓	✓	✓		

	Finance access	Input access	Data profiling	Production advisory	Post harvest	Value chain traceability	Market information and access	Resilience/risk reduction	Others (including) bundled services
Kutwala					✓	✓	✓		
Kestrel Agro			✓		✓	✓			
IDE Platform	✓	✓	✓				✓	✓	
Farming as a business CFB Group	✓		✓	✓			✓	✓	
Farmer to market	✓	✓		✓					
Ag1 Global				✓		✓			
Kazang/MTN Money									✓
Lupiya		✓	✓	✓	✓	✓	✓		

	Finance access	Input access	Data profiling	Production advisory	Post harvest	Value chain traceability	Market information and access	Resilience/risk reduction	Others (including) bundled services
Better world innovation		✓		✓			✓		
Stock keeper			✓	✓		✓		✓	✓
ZAAB			✓	✓			✓		
Pelum		✓	✓					✓	
Valley logistics							✓	✓	

Source: McCampbell and Migisha, 2022

2.2 Drivers of digital technologies in Zambian agriculture

There are various drivers of digital technologies in Zambia which are discussed below.

2.2.1 Supply Side

The supply side mainly consists of Mobile Network Operators (MNOs), which provide a wide range of mobile network-based services for farming communities. For a country like Zambia, digital development is strongly influenced by the adoption and use of mobile phone technology. There is huge potential for digital technology in Zambia because 80% of smallholder farmers in Zambia have access to a mobile phone and accept mobile payments

(Zambia Agribusiness Society, 2021). In the past few years, Zambia has witnessed an expansion in mobile services including in rural and remote parts of the country, and there has been an increase in the usage of mobile services. Most farming households are increasingly using mobile money for making and receiving payments. Mobile money services are accessed through 3 service providers: Zamtel, MTN and Airtel. Farming communities use mobile money services to purchase inputs from agro-dealers, as well as to receive payments after selling their produce (Zambia Agribusiness Society, 2021). The increased network coverage by telecommunication companies has proved to be a huge driver of digital technologies.

From the supply side, Zambia also has a good number of innovation hubs and accelerators that are contributing to the digital ecosystem, as can be seen in Table 3. Some of the promising agri start-ups include E-Msika, Bongo Hive, Jacaranda Hub and Lima Links. The hubs are involved in various activities including incubation, training, mentorship and acceleration services, and extend their activities to other provinces through competitions and other programmes (USAID, 2022). Bongo is one of the pioneer start-ups and innovation hubs. Established in 2011, it is based in Lusaka and has made significant footprints on the country's technology space (Bongo Hive, 2023). In the agriculture, Bongo Hive's partners include GIZ, Good Nature Agro, and Conservation Farming Unit (CFU) among others. Its core mandate is implementing digital solutions in Zambia.

E-Msika is another innovation hub in Zambia, an agritech company that is involved in digitalizing processes and activities in the agriculture space. They offer various services which include an online platform for Marketing, e-Msika which allows farmers to find and buy agro inputs; they also give farmers video training on demand on how to do farming as a business using an e-learning portal. To get started, eMskika participated in various local events such as Data Hack for Finance and ZICTA's ICT Innovation Programme where they got a prize amounting to $10,000 (USAID, 2022).

Some of the donors involved in supporting digital innovations include the World Food Programme (WFP) and GIZ and FAO among others. For example, the WFP supported the development of the digital Maano Virtual Farmers Market and FAO supported the development of a digital agricultural market information system under the Sustainable Intensification of Smallholder Farming System in Zambia (SIFAZ) project. The donors are interested in supporting digital initiatives that promote efficiency in agricultural value chains. The donors have developed digital strategies that are meant to accelerate and scale innovative ideas with high potential impact in food and agriculture.

2.2.2 Demand Side

From the demand side of digital agricultural innovations, emerging commercial farmers are the champions, according to Malambo, Tembo and Chapoto (2023) and McCampbell and Migisha (2022). The reason given is that emerging farmers are 'business minded' and ambitious to expand their farming activities, and therefore are interested in adopting digital technologies to improve agricultural practices, enhance their resilience against weather and climate-related shocks, raise their productivity and build linkages to markets for their produce. Emerging farmers are willing and able to pay for digitally-enabled solutions, as long they perceive these to offer value for their money (McCampbell and Migisha 2022). On the other hand, smallholder farmers are less likely to adopt digital technologies.

2.3 Factors influencing adoption of digital technologies in Zambia

This study finds that there is insufficient evidence that the digital solutions offered by ag-tech start-ups are widely used. Despite several donor-driven initiatives on digital agricultural innovations in Zambia, there are limited studies on how and why farmers adopt these technologies (McCampbell and Magisha, 2022). This makes it difficult to establish the effects. Nevertheless, it can be noted that several factors affect adoption of digital technologies by farmers in Zambia. These are discussed below.

High levels of literacy and capacity challenges

High levels of illiteracy and capacity challenges impede digital technology adoption by farmers, according to Sarku et al (2020). Even where there is literacy, many smallholder farmers have no capacity to generate and process the data; and the ability to use the information effectively is weak. Digital technologies, it seems, are designed based on false assumptions about farmers' capacity to process information in this form. Most farmers are not able to use digital technologies since the available digital innovations are not only experienced, but perceived to be, too complicated (Sarku et al., 2020).

Mobile network and electricity coverage

In addition, rural areas in Zambia have poor network and electricity coverage. Malambo, Tembo and Chapoto (2023) noted that a large proportion of the population in rural areas has no access to mobile networks and this has been one of the key issues with regards to digital technology adoption in rural areas. Most of the rural areas in Zambia do not even have access to electricity and this has negatively impacted attempts aimed at enhancing the adoption of digital technologies.

Affordability of digital technologies

The ongoing debate about digitalisation in the agriculture sector also highlights the issue of affordability of digital technologies by smallholder farmers. Most farmers are not able to afford even the simplest digital technologies. Nkhandu and Phiri (2020) and Nalwimba, Qi and Mudimu (2017) noted that access to credit is a major challenge when it comes to purchasing inputs, equipment and other farming requirements as most farmers in Zambia do not have support from financial institutions. For instance, although the drone technology has potential to increase agricultural productivity, it is unaffordable for most smallholder farmers since it costs between US$ 2,000 and US$ 3,000 (Silimina, 2020; Opali; 2022). An employee at a commercial farm in Kalomo district in the Southern province of Zambia said that:

'A company visited our farm to carry out crop scouting with their drone.I It is a good and much more efficient method of insect and disease scouting as well as crop nutrition deficiencies or water stress identification. But is is costly and not feasible.'

(Interview with a worker at a commercial farm, Kalomo district, Zambia, 2023)

Most companies spearheading innovations in Zambia use subscription-based models or charge transaction fees while working with farmers or farmers' cooperatives. Some farmers are willing to pay for these digital services while some are not. In Zambia, smallholder farmers are less likely to adopt digital technologies compared to emergent farmers as emerging farmers are willing to pay for digital services that have potential to improve their agriculture business (McCampbell and Migisha 2022).

Language fractionalisation

Language fractionalisation has also been noted as one of the challenges to adoption of digital technologies in agriculture. Although Zambia has 7 official vernacular languages, the country has about 72 dialectics and this leads to challenges for digital service providers in creating products that cater for all the dialectics. Overall, this has an impact on digital adoption (Malambo, Tembo, Chapoto et al., 2023). The language variable, often under-stated in reviews of digital technology, limits adoption even where the technological conditions are in place.

Inadequate technical skills

Malambo, Tembo, Chapoto et al. (2023) also note that in Zambia, there are inadequate technical skills to embrace the new and emerging technologies such as artificial intelligence, block chain, big data analytics, cyber security and machine learning.

3. DIFFERENTIATED EFFECT OF DIGITAL TECHNOLOGIES IN ZAMBIA'S AGRO-FOOD SYSTEM

There are challenges with regards to the exact number of farmers using the available digital technologies across the various regions of Zambia. Despite limited information on adoption of digital technologies, a few studies have highlighted their effects on Zambia's agro-food system. There is some evidence that digital technologies in agriculture have potential to transform food systems to improve livelihoods for farmers (Mupeseni, 2022; USAID, 2022; FAO, 2023).

Firstly, there is some evidence that digital technologies are improving agricultural productivity. Through enhanced productivity, efficiency as well as sustainability, digital technologies in agriculture could help the country attain food security and improve livelihoods for farmers and other players in the food system, according to the FAO (2023). Digital technologies such as sensors, drones, and GPS systems are being used to help farmers monitor crop health, optimize irrigation and fertilizer use, and reduce waste. However, these technologies mainly benefit commercial farmers who have access and can afford these technologies (Kalito, 2018).

Digital technologies also have an impact on labour in the agricultural sector, but with different outcomes for farmers and farm workers. In terms of effects on labour, Silimina (2020) and Opali (2021) reported that digital technologies such as drones are helping farmers with agricultural activities that are labour-intensive, reducing the need for hired labour. For instance, a farmer from Choma district in the Southern province of Zambia, one of the regions in the country most affected by army worms, affirmed that the drone helped to eradicate this pest. Mwemba noted in an interview at the 2019 Agritech Show that:

'Just imagine, last time we were spraying a 3 hectares farm in Choma district, we spent 20 minutes with this drone, but with a tractor, it takes three hours.'
(Silimina-China South Project, 2021)

It is widely argued that digital technologies are increasing access to information for farmers (Katilo, 2018). Farmers with access to digital technologies are able to make decisions based on data, thereby potentially reducing their risks during farming seasons especially that most of them depend on rain-fed agriculture. Farmers might be able to avoid mistakes based on the knowledge. Digital technologies could lead to enhanced connectivity between farmers and increased resilience across various agricultural value chains, as they enable better access to high-quality real-time data which is used to adapt to climate impacts. Digital technologies are being used for climate adaptation and technologies such as the use of satellite imagery to capture the extent of damage to crops and pay farmers (Below and Nalwimba, 2021. Furthermore, digital weather forecasts in the country are helping farmers access timely and accurate usable climate information and early warning and this helps the farmers to build resilience (Below and Nalwimba, 2021). Through these innovations, insurance risks are reduced through improved data monitoring.

Digital platforms and technologies are providing market access for some farmers by connecting them to markets as well as directly to consumers. For instance, the Maano Virtual Farmers Market is linking farmers to traders and off-takers. This has allowed farmers to sell their produce from the comfort of their homes, reducing the distance to be covered to the market, and associated costs. Through digital platforms, farmers are also able to access market information and, it is argued, get better prices for their produce, as they do not have to rely on middle-men to buy their produce (WFP, 2021; Digital Paygo, 2023). Digital technologies such as Lima Links and the MVFM offer technology solutions that bring markets into the hands of farmers (Lima Links, 2019; WFP, 2021). For instance, during the launch of the virtual farmer's market, the Permanent Secretary for the Ministry of Agriculture indicated that the it will help reduce exploitation of farmers by traders who offer low prices for farming produce, especially in rural areas (WFP, 2021). Again, many of these impacts are claimed, though there is limited data available as evidence to confirm them. In addition, the use of digital technology is claimed to enhance transparency and traceability (FAO 2023). Digital technologies are being used to track food products through the supply chain, from farm to fork. This can assist to improve food quality and safety.

The advancement of digital technologies in the agriculture sector also brings the prospect of negative effects. For instance, the advancement of digital technologies in has brought concerns over the future of labour in agriculture. Several activities that are currently done by farm workers have the potential to be automated in the future. Various policy makers and scholars have argued that digitalisation and automation will lead to major significant job displacements, especially in labour-intensive sectors such as agriculture (Vaghefi, 2022).

A worker at a commercial farm in Kalomo district had this to say:

> *The drone technology is good and efficient method for insect and disease scouting and we would use it if we had it, but this would mean laying off about three to five people in my department.'*
> **(Interview with a commercial farmer in Kaloma district, Zambia, 2023).**

The use of digital data leads to new forms of control and extraction, especially for large technology companies and multi-national agri-food companies. This leads to the entrenchment of neoliberal corporate-based power in agro-food systems (Prause, Hackfort and Lindgren, 2021). One significant question relates to the debate on conventional versus regenerative agriculture, how digital technologies bring changes to the way the agri-food system is organised.

Scientists note that existing digital innovations support conventional agriculture. That is, an agricultural system that uses pesticides and herbicides, chemical fertilisers, and hybrid-seeds; targets intensification and production increases; and is more suited to mono-crop production than mixed-farming systems (Simelton & McCampbell, 2021; Dietzler & Driessen, 2022).

Cybercrime is yet another challenge that comes with digital innovations in the agricultural sector. “Zambia has experienced a boom in the cybercrime industry in rural as well as urban areas and this has the potential to undermine trust in digital solutions” (Malambo et al., 2023). There are inadequate technical skills to address issues on cybersecurity. Although the Zambian government has put in place various laws governing security and cybercrimes such as the Cyber Security and Cybercrimes Act No. 2 of 2021, information related to the cybersecurity ecosystem in Zambia is still emerging and of great concern to government (GRZ, 2021). The key areas of concern have to do with the silo approach of implementing ICT systems causing security risks, the high cost of investing in information systems security, old systems which are still being used by the government, and inadequate disaster recovery sites (GRZ, 2021).

Despite notable achievement in the policy and legal frameworks, there are persistent challenges with regards to translating their objectives into tangible programmes and projects, and inadequate coordination among institutions with the responsibility of spearheading ICT policy and legal reforms. This has led to the duplication of roles, and lengthy review and repealing of legislation to harmonise with the speedy changes (Malambo et al., 2023).

Although digital technologies promise benefits in terms of the productivity, efficient resource use, and improved knowledge and coordination it brings to the agriculture sector or global food systems, some critical agrarian scholars have doubts about the revolutionary claims of digital agriculture. They argue that digitalisation of agriculture will lead to reproduction of entrenched inequities in the global systems. This ranges from the inability to operate the technology, irregular access to technology as well as its benefits (Maywa & Canfield, 2023). Whether this will be the case for Zambia is as yet unclear, and hinges on many variables including how the process is governed at the national level.

4. POLICY AND REGULATORY FRAMEWORK FOR DIGITAL TECHNOLOGIES IN ZAMBIA AGRO-FOOD SYSTEM

Policy and regulatory environments are central to the broader ecosystem in order to enable innovations and adoption of digital technologies. While putting in place policy, regulatory or legal frameworks is important, these may not necessarily result in awareness, effectiveness or implementation of these frameworks. Zambia has many general policies as well as legislation linked to technology and digitalisation and some are new. According to Malambo, Tembo and Chapoto (2023) the Zambian government has provided adequate provisions with regards to the legal framework under which companies and actors involved in the development of digital technologies must conduct their operations. They argue that the institutional framework is adequate for the functioning of different companies involved in digital activities or innovations. The Zambia Information and Communications Technology Authority (ZICTA) is a quasi-government institution which was formed for the purpose of regulating ICT in Zambia. It monitors and oversees companies and other actors within the digital space in the country (ZICTA, 2020).

The World Bank (2020) reported that although Zambia has made great strides towards digital transformation, there is need for the government to develop a digital transformation strategy in order to assist the nation to meet the national development targets. With regards to digitalisation in the agriculture sector, FAO and ITU (2022) reported that although there has been an expansion, yet the Zambian government has not yet developed a National Digital Agriculture Policy. According to the World Bank (2022), Zambia has no specific strategy at the national level that clearly outlines how digital transformation should impact the agriculture sector and there is no singular strategy to promote or shape digitalisation in agriculture. Some key stakeholders have suggested that Zambia needs a digital strategy that is specific to the agricultural sector with a clear road map and objectives that will allow the agriculture sector to achieve digital transformation for various actors.

Digitalisation that is integrated into development plans seems to be in the early stages in Zambia (CCARDESA, 2022). McCampbell and Migisha (2022) noted Zambia has three policies that are directly deal with digitalisation in agriculture: The National ICT policy of 2006; the National Agricultural Extension and Advisory Services Strategy 2017-2020; and the National Agricultural Policy of 2016.

Table 5: Relevant policies and strategies

Agriculture in general	National Agriculture Policy 2012-2030 National Agriculture Investment Plan National Extension and Advisory Services
Digitalisation in agriculture	No policy yet
Digitalisation in general	Accelerating Digital Transformation in Zambia: Digital Diagnostic Report (World Bank,2020). Zambia is among the 17 countries who implement the Digital Economy for Africa (DE4A) Initiative in collaboration with the World Bank. National ICT Policy 2006 National ICT Policy 2023
Rural Electrification and energy supply	Rural Electrification Master Plan for Zambia 2008-2030
Financial inclusion	National Financial Inclusion Strategy 2017-2022 Rural Finance Policy and Strategy 2012

Source: McCampbell and Migisha, 2022.

Agriculture, as the economic backbone of rural Zambia, plays an important role in the development of the country. The National ICT Policy 2006 identified agriculture as one of its thirteen pillars. To support digitalisation in this sector, it made commitments to improve infrastructure in rural areas, integrate and encourage the use of technologies in the sector, increase the competitiveness of farmers and their products with technology, and promote the development of ICT entrepreneurs at SME level to strengthen application of ICTs in agriculture (Ministry of Science and Technology, 2006). The policy set out the following strategies to achieve those goals:

- Create an integrated agricultural information system on agro-technologies and techniques, pricing, and market information for all agro-products to provide strategic information for farmers, government authorities, and other stakeholder at national, provincial and district levels;
- Undertake intensive ICT awareness campaigns for all types of farmers in the use of traditional and new ICT tools at all levels;
- Intensify the use of radio and TV programs and integrate new technologies to reach extension workers and farmers alike;
- Develop weather and agro meteorology early warning systems to support agricultural production and predict as well as prevent disasters;
- Develop incentives for deployment of affordable ICT solutions to support rural connectivity of farmers especially those within the catchments of existing ICT infrastructure;
- Develop and promote ICT skills development among agricultural extension workers and farmers;
- Develop database systems and applications including GIS to support agricultural input resource management as well as to support land and water resource management, environmental monitoring and impact assessment, crop yield assessment and livestock management, among others;
- Develop a monitoring and evaluation system for the conservation and sustainable utilization of natural resources in the agricultural production process;
- Promote two-way information dissemination to support the physical and socio-economic planning process in the agricultural systems.

(Ministry of Science and Technology, 2006)

A decade later, though, Zambia's Second National Agricultural Policy (2016) did not prioritise digital advancement in the agricultural sector, and digitalization was not reflected in the National Agricultural Policy (NAP). The ambitions which were identified previously in the ICT Policy 2006 for digitalization of agriculture in Zambia were not integrated and did not result in particular agricultural plans and strategies (Ministry of Agriculture, 2016; Ministry of Science and Technology, 2006; McCampbell and Migisha, 2022).

On framework that mentions the use of ICT tools in extension and advisory services is the National Agricultural Extension and Advisory Services Strategy (NEASS), which aims to "contribute to the effective and efficient information dissemination and uptake of responsive innovations in order to increase sustainable agricultural production and productivity that assures household income, gender sensitivity and national food and nutrition security" (Ministry of Agriculture, 2016). This strategy commits the Government to continue promoting the inclusion of ICTs in order to expand advisory services. However, the NAEASS did not provide detailed information about ICT use in agricultural production itself, or in value-chains.

In October 2023, the government launched the 2023 ICT Policy. The Policy recognizes that most of the digitalization in the economy is accounted for in the service sectors and not in the productive sectors like agriculture. The 2023 ICT Policy does not bring out much about digitalization in agriculture apart from stating that line Ministries will facilitate the provision of various electronic services such e-agriculture and e-commerce (Ministry of Science and Technology, 2023).

CCARDESA (2022) reported that a digital strategy for agriculture was to be produced for Zambia, which would identify the potential this technology has to complement extension services and information systems to increase agriculture productivity. The use of digital technologies and ICT in Zambia's agricultural sector is still in the early stages but has potential. Whether the Ministry of Agriculture has any future plans to include the aspect of digital technologies in agricultural strategies or policies is still unclear. Interviews conducted with the Ministry of Agriculture officials revealed that currently, there are not plans to develop a strategy on digitalization in agriculture. One officer indicated that this would require the ministries of Agriculture, Transport and Communication, and Science and Technology, plus the Smart Zambia Institute, among others, to come together to develop such a document or strategy. The Ministry of Agriculture may have to drive this agenda, together with the Ministry of Science and Technology.

The World Bank (2020) and McCampbell and Migisha (2022) argue that while advancement is taking place in silos, there is minimal collaboration across Ministries and departments. The review I conducted of existing agricultural policies and strategies, and interviews with some Ministry of Agriculture officials found that there is very little policy prioritisation of digitalisation in agriculture - however in practice, this might be different. CCARDESA (2022) argued that lack of legislation or policies does not limit the development of digital technologies and innovations – as farmers themselves, and private companies, are taking action in the absence of state strategy.

While the domestic regulatory environment is under-developed, at the regional level Zambia is currently implementing the Digital Economy for Africa (DE4A) in collaboration with the World Bank, an initiative aimed at supporting transformation of Africa through digitalisation. In line with this agenda, Zambia has put in place a national Smart Zambia Institute (SZI) whose mandate is to implement the SMART Zambia project (Ministry of Science and Technology, 2022). As an early adopter of digitalisation, the World Bank noted that Zambia needs a digital innovation system approach to address the wider scope of legislation and regulation in order to reduce policy fragmentation and enhance policy coherence, as well as stimulate the involvement of private sector beyond commerce (Ministry of Science and Technology, 2022).

5. CONCLUSION

Zambia's digital ecosystem is still in the early stages and there are some digital technologies available for use by farmers. However, there is inadequate information on the adoption of these technologies by farmers as well as the effects of these technologies on Zambia's food systems. In terms of policy and legislation, Zambia has not yet developed a policy on digitalisation in agriculture and most of the digital interventions in agriculture are done by non-state actors, or supported by parts of the state, but in silos. The lack of national policy and a strategy leads to fragmented interventions with very little impact in terms of shaping the course of digitalisation. Advancement of digital technologies in agriculture can cause negative effects including displacement of labour in agriculture, a boom in cybercrimes and data protection concerns, reproduction of entrenched inequities in the global systems, and lead to new forms of value-chain control and value extraction. With the range of potential benefits and risks, more needs to be done to understand, and inform the development of adequate governance of digital technologies in Zambian agriculture.

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