Digital ecosystems for smallholder farmers in low- and middle-income countries:

A rapid assessment of digital agriculture ecosystems in Zambia and Kenya

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Colophon

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List of Acronyms and Abbreviations

Ag.tech.	Agricultural Technology
AI	Artificial Intelligence
AGD	Agrodealer; or agro input dealer
ATO	Agricultural Transformation Office
D4Ag	Digital for Agriculture
DFS	Digital Financial Service
GAP	Good Agricultural Practices
GPS	Global Positioning System
HIC	High Income Countries
IoT	Internet of Things
IVR	Interactive Voice Response
KALRO	Kenya Agricultural and Livestock Research Organization
KAOP	Kenya Agricultural Observatory Platform
KCEP	Kenya Cereals Enhancement Programme
KCEP-CRAL	Kenya Cereals Enhancement Programme - Climate-Resilient Agricultural Livelihoods Window
LMIC	Low- and Middle-income countries
MNO	Mobile Network Operator
NARIG	National Agricultural and Rural Initiative Growth Project
NGO	Non Governmental Organization
SDG	Sustainable Development Goals
SHF	Smallholder farmer; or small-scale farmer
SMS	Structured Messaging Service
SSA	Sub-Saharan Africa
USSD	Unstructured Supplementary Service Data
VBA	Village Based Advisor
WAO	Ward Agricultural Officer

List of Definitions

AgrifoodTech: Short for agri-food technology/-ies. Term introduced by the organization AgFunder in 2017 to define innovations that take place across the food supply chain. AgrifoodTech is a growing collective of startups and venture capital investors that aim to disrupt the global food and agriculture industry.

Agri e-commerce: The use of digital platforms to enable selling and buying (usually domestically and to urban consumers) of agricultural produce via online channels which disrupts traditional value chains[1].

Agrodealer or agro input dealer (AGD): A person who sells agricultural inputs, such as fertilizers, seeds, pesticides, livestock medication, to farmers. Agrodealers often manage one or multiple shops that are located at the trading centers of medium to large sized rural communities. Agrodealers traditionally serve as a source of information for farmers, e.g. about the management of pests and diseases, available and suitable crop varieties, and climatological conditions.

Artificial intelligence (AI): The ability of a computer or computer-controlled robot to perform tasks commonly associated with intelligent beings. AI can be programs that behave like humans, operate like humans, think like

1 GSMA. (2020). *Digital Agriculture Maps: 2020 State of the Sector in Low and Middle-Income Countries*. https://www.gsma.com/r/wp-content/uploads/2020/10/GSMA-Agritech-Digital-Agriculture-Maps-2020-1.pdf#page=56

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humans or have their own rational way of processing information and/or behaviour, even being able to learn from experience. Its applications are endless in the many features of technology development.

AgTech: Short for agricultural technology/-ies. The use of technology in crop production, aquaculture, livestock production, and agro-forestry with the aim to improve yield, efficiency, and profitability.

Big Data: Large, diverse, complex data sets generated from instruments, sensors, financial transactions, social media, and other digital means, and typically beyond the storage capacity and processing power of personal computers and basic analytical software.

Digitized integrated value chains: When value chain actors use digital procurement tools that generate transaction records to gain control over activities in the value chain in which they operate. Digitized integrated value chains often come with payment and traceability functionalities[2].

Digital service enabler: An actor that supports creation of an enabling environment for digital technologies in general and in the agricultural sector specifically. Examples of typical enablers in the context of Low- and Middle Income countries include donors, investors, governments, philanthropic organizations.

Digital service provider: A provider of a digital service that may or may not specifically target the agricultural sector. Examples of digital service providers include start-ups, ag.tech companies, financial institutions, and telcos.

Digital service user: Sometimes also referred to as digital service customer. An individual or organization that is using a digital service. May include farmers and farmer cooperatives, aggregators and off-takers, agro-dealers.

Digitalization in agriculture: Part of the agricultural automation process, it refers to the use of different sorts of data using sensors, machines, drones, and satellites to monitor animals, soil, water, plants and humans to perform agricultural tasks. Encompasses digital devices or tools in agriculture that are embodied in agricultural machinery and equipment (such as precision farming tools) and disembodied devices (such as smartphones or tablets) or software tools, such as advisory apps, farm management software, and online platforms.

Global Positioning System (GPS): USA developed military system showing the exact position of an object on earth using satellite signals. Oftentimes used to actually refer to Global Navigation Satellite Systems (GNSS): A generic term describing any satellite constellation, providing positioning, navigation, and timing service. Commonly also referred to as GPS (Global Positioning System) which technically speaking only refers to the system developed by the United States of America military. Other GNSS systems include the Russian GLONASS (Global Orbiting Navigation Satellite System), European Galileo, and Chinese BeiDou-2.

High Income Countries (HICs): The World Bank defines a high-income country as one with a gross nationalincome per capita exceeding $12,056. The gross national income (GNI) is calculated by adding gross domestic product to factor incomes from foreign residents, then subtracting income earned by non-residents.

Intermediary-based value chains: Value chains that are characterized by a low level of formality between actors and a high level of fragmentation in the last mile. Intermediary-based value chains rely on local trade intermediaries (i.e. middlemen) and wholesale open markets for agricultural produce to move from producer to consumer[2].

2 GSMA. (2020). *Toolkit for the Digitisation of Agricultural Value Chains*. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2020/03/GSMA_mAgri_Toolkit.pdf

Integrated value chains: Value chains that are characterized by high levels of formalized relationships between actors and low levels of fragmentation in the last mile. In integrated value chains there is stronger vertical integration, relying on agribusiness and/or cooperatives that procure agricultural produce from individual farmers or farmer groups[1].

Internet of Things (IoT): Interconnection of computing devices in everyday objects (e.g. mobile phones, machinery, drones) via the Internet, which allows these devices to send and receive data in real-time.

Interactive Voice Response (IVR): An automated phone system that interacts with the caller and can gather information by giving choices through a menu and taking action based on the caller's answer. Commonly used at call-centers, e.g. for an automated greeting and to route callers to the right human agent.

Low- and middle-income countries (LMIC): For 2022, the World Bank[3] defines Low-Income countries as those with a GNI per capita of $1.045 or less, Lower middle-income countries with a GNI per capita between $1.045 and $4.095, and upper middle-income with a GNI per capita between $4.095 and $12.695.

Machine learning (ML): A subfield of artificial intelligence that uses and develops computer systems that can learn and adapt without explicit instructions from humans. Machine learning typically requires the use of algorithms and statistical models to perform (complex) data analytic tasks and draw inferences based on that data.

Remote Sensing: Process of gathering information about objects on earth from a distance using aircraft or satellites.

Structured Messaging Service (SMS): Text messaging service that allows users to send and received messages of up to 160 characters on a mobile (telephone) device. SMS uses standardized communication protocols to exchange messages. It is possible to convert text to voice via an intermediary service.

Smallholder farmer or small-scale farmer (SHF): A farmer who performs agricultural activities on a maximum of 2 hectares of land. Activities may entail crop production, livestock production, aquaculture, or (agro)forestry, or a mix of these.

Emerging smallholder farmer: Or Transitional smallholder farmer. A smallholder farmer who is usually practising mixed-farming, with crops and livestock, and who primarily produces for the local market. This type of farmer is often a member of a cooperative to which he (s)he sells the main commodity (e.g. coffee, dairy). Transitional farmers are characterized by generally being more resilient, having better access to resources, and more capacity to invest and innovate compared to subsistence and small-scale farmers.

Unstructured Supplementary Service Data (USSD): A message service that is more interactive than SMS. Characterised by the use of codes that start with * and end with #, e.g. *845# which is the code to access a toll-free service in Rwanda that is operated by VIAMO and MTN Rwanda and provides information on agriculture, health, news, weather etc. A USSD message can have a maximum of 182 characters.

Village Based Advisor (VBA): A Village Based Advisory is a Kenyan champion farmer who promotes agricultural production through training and sharing of agricultural information to other farmers in his/her community. The VBA demonstrates leadership and has influence on farmers' practices and decisions. VBAs are generally more literate and more tech-savvy than an average Kenyan smallholder farmer. VBAs partially replace traditional public extension, thus responding to the issue of a low public extensionist-farmer ratio, and disseminate knowledge at the grassroots level about e.g. high-yielding varieties and crops suitable for the specific location, good agricultural practices (GAP), pest and disease control, post-harvest handling.

3 https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

1. General introduction

Digitalization has taken flight in the past decade in Low- and Middle Income countries (LMIC) and mobile phone technologies and mobile internet reach people in all corners of the world today. Smallholder agricultural systems in low- and middle-income countries can potentially greatly benefit from the transformative capacity of digital technologies. Much progress has been made in the context of digital agriculture in the past couple of years. Hundreds of different digital services and platforms are available for smallholder farmers in the Global South today and more are added every day. However, the adoption and scaling of those services and platforms remain slow-paced. Another challenge is interoperability; different platforms do not speak to each other which forces farmers to adopt multiple systems and further inhibits scalability. Additional barriers for uptake include poor (digital) infrastructure, insufficient (agricultural) funding, high cost to access services, and low digital literacy. Many smallholder farmers (SHF) are furthermore still beyond reach and thus not benefitting from technological innovation and the effects of digitalization.

In this report we share findings from digital ecosystem assessments that were conducted mid-2022 in two case study countries; Kenya, and Zambia (Sub-Saharan Africa). The study was commissioned by the Netherlands Food Partnership on behalf of the Smallholder Farmers Digital Ecosystems Coalition[4], and had the specific objective to explore if and how digital services and platforms are currently used by and impacting smallholder farmers in Low- and Middle-income countries, based on data from the two case countries (see also box 1 for more information about the coalition). In doing so, the study aimed to answer the question; 'What are concrete short and longer-term interventions in smallholder digital ecosystems that could foster the scaling and sustainability of digital platforms?'

The study focused on both the supply and the demand side of the ecosystem, conducting interviews and organizing a workshop with, for example, donors, service providers, government and research institutions, and focus group discussions with smallholder farmers. This first chapter of the report provides a general introduction to recent developments and trends in relation to digitalization, (smallholder) agricultural production, and digital agriculture in LMIC. The content of the introduction provides the necessary background information to understand the context of digital agricultural ecosystems in LMIC, and is based on academic literature, grey-literature, and secondary data. Chapter 1 is the warm-up for the more empirically oriented chapters that come after that and which give the results of the study and finish concrete short- and medium-term interventions in smallholder digital ecosystems that can foster the scaling and sustainability of digital platforms in low- and middle-income countries.

Focus of the study: Smallholder farmers in diverse agricultural production systems

Globally, there are more than 500 million smallholder farmers, who farm on less than 2ha. of land. More than 80% of all farms worldwide are small-scale, and while they account for only one tenth of all agricultural land, they produce approx. 35% of our food globally (Lowder et al., 2021)[5]. Within the pocket of half a billion smallholder farmers there is however immense diversity, with farmers ranging from e.g. absolute subsistence producers to small-producers of high-value commodities for the export market. For the purpose of the study, the scope has been limited to transitioning smallholder farmers i.e. producers with small landholdings who serve a local or international market with the commodity/-ies they produce on their farm. Another factor of diversity among

4 See box 1 and this webpage for more information about the coalition, its mission and vision, and its activities.

5 Lowder, S. K., Sánchez, M. V., & Bertini, R. (2021). Which farms feed the world and has farmland become more concentrated?. *World Development*, 142, 105455.

smallholder farmers that is incorporated in the study is the type of commodity that is produced. Broadly, commodities fall into four sub-sectors of the broader agriculture sector: Crop production; livestock production; aquaculture; and (agro)forestry. Sometimes there is overlap between these sub-sectors, especially between crop production and agroforestry (e.g. production of coffee and cocoa, and crop-tree intercropping systems). Furthermore, in practice do many smallholder farmers in the two case countries follow a mixed-farming approach, i.e. they produce a variety of seasonal and perennial crops, keep one or more types of livestock, and sometimes add aquaculture and/or agroforestry into that mix.

The report is organized as follows: The remainder of this chapter further elaborates on the state of digital ecosystems in low- and middle-income countries in general, and introduces some global trends and developments. The next chapter presents the conceptual framework used for the purpose of the study. Chapter 3 thereafter provides details about the methods used to collect data about the digital ecosystems in the two case countries and to analyze the collected data. Chapters 4 and 5 share the findings from Zambia and Kenya respectively. Finally, Chapter 6 is used to discuss the findings more broadly and to identify possible intervention areas for policy and practice, with specific emphasis on recommendations that can steer the agenda of the Smallholder Farmers Digital Ecosystems coalition in 2023 and beyond.

Box 1: About the Smallholder Farmers Digital Ecosystem Coalition

In mid-2021 a group of stakeholders, existing of farmers' and private sector organizations, NGOs and multilateral agencies (i.e. IDH, IFAD, ISEAL, NFP, Rabobank, and Syngenta Foundation), joined forces. A coalition was formed which is committed to empowering smallholder farmers (SHF) in emerging economies, and improving their livelihoods, resilience, food security, and agricultural productivity.

Most of the partners in the SHF digital ecosystems coalition have broad experience with and invested in digital innovations that target smallholder farmers. But they want to improve the reach and impact of their efforts, and help others to do the same. To achieve this, it is necessary to start with an understanding of why most existing digital platforms and services do not (yet) deliver as promised, before identifying what effectively needs to happen to change this.

Based on collective experiences in the space of digital agriculture, the coalition anticipates that digital technologies will be game changing in accelerating empowerment and transformation in the agricultural sector in low- and middle-income countries. The coalition wants to ensure that also smallholder farmers get better and more efficient access to an ecosystem of integrated and mutually supportive digital services. In September 2021 the coalition submitted a commitment to action to the UN Food Systems Summit commitments registry entitled; 'Empowering Smallholders Through Strengthened Digital Ecosystems'. By the end of 2021 the new born coalition had developed anaction plan and defined goals and activities for 2022. Clim-Eat joined the coalition in 2022.

The coalition on SHF digital ecosystems has the grand ambition for 2030 to achieve comprehensive digital services and platforms that are used by and serve 50 million smallholder farmers and that are

productive and profitable. More specifically, the ambition is to contribute through research, networking, convening and leadership activities to the development of:

1. Consistent approaches to digitalization and data in national agriculture and food policies;
2. Strong capable and sustainable digital service providers that are serving smallholder farmers;
3. Catalytic (public) finance for digital innovation;
4. Digital and physical infrastructure, data, and service interoperability;
5. Appropriate legislation around data ownership and privacy, Open Access, and digital public and private goods;
6. Transparency around smallholder farmers' sustainability and impact data for all stakeholders, including governments, value chain players, and consumers;

1.1. The growing impact of mobile technologies

According to GSMA, 5.4 billion people, or 68% of the world's population, were using a mobile phone by the end of 2021. Additionally, 4.3 billion people were making use of mobile internet. Moverover, since 2015, mobile internet access of the 40 poorest people in the world has doubled from 560 million to 1.2 billion. This means that approximately 58% of them use mobile internet today, but also that still 42% of the poorest in the world are excluded from internet access, because of the cost, (digital) literacy and skills limitations, and safety concerns[6]. The (gender) digital divide is therefore an often debated theme, as these divides arguably threaten the central 2030 SDG principle to 'leave no one behind' (Hernandez & Roberts, 2018[7]; O'Sullivan, Clark, Marshall, MacLachlan, 2021[8]; UNSDG, 2022[9]). Regardless, the fast developments and uptake of mobile technologies have translated into a rapidly increasing number of digital agriculture services that are on offer. While in 2009 there were 53 reported services, this number had increased more than tenfold to 713 by 2019 according to GSMA's report on the state digital agriculture in LMIC (GSMA, 2020)[10]. One can expect that these numbers have only further increased since then. The fast growth of the digital agriculture sector is a response to the high expectations of the transformational capacity of digital technologies and services. This also translates into intergovernmental responses, e.g. a Digital Transformation Strategy for Africa was adopted by the African Union in 2020[11]. The Union's 2020-2030 strategy outlines a vision for a digital ecosystem in Africa that is integrated and inclusive. Digitalization is recognized as a critical factor for economic growth and employment, reduction of inequalities, and promotion of sustainable growth. For our case countries, Kenya and Zambia, digital development is strongly affected by the adoption and use of mobile phone technology. Hence, GSMAs mobile index gives a relevant picture of development over time, in this case also showing the differences between Zambia and Kenya (figures and 2).

6 GSMA. (2022). 2022 *Mobile Industry Impact Report: Sustainable Development Goals*. GSMA. London. Accessed on 22 September 2022 from https://www.gsma.com/betterfuture/wp-content/uploads/2022/09/sdg-main-report-2022-web.pdf.

7 Hernandez, K., Roberts, T. (2018). *Leaving no one behind in a digital world*. K4D Emerging Issues report. Brighton, UK: Institute of Development Studies.

8 O'Sullivan, K., Clark, S., Marshall, K., MacLachlan, M. (2021). A Just Digital framework to ensure equitable achievement of the Sustainable Development Goals. *Nat Commun* 12, 6345 (2021). https://doi.org/10.1038/s41467-021-26217-8

9 UNSDG. (2022). *Operationalizing Leaving No one Behind: Good practice note for UN country teams*. UNSDG. https://unsdg.un.org/sites/default/files/2022-04/Operationalizing LNOB - final with Annexes 090422.pdf

10 GSMA. (2020). *Digital Agriculture Maps: 2020 State of the Sector in Low- and Middle-Income Countries*. GSMA. London, UK.

11 African Union. (2020). *The Digital Transformation Strategy for Africa*. Accessed on 15 November 2022 from https://au.int/en/documents/20200518/digital-transformation-strategy-africa-2020-2030

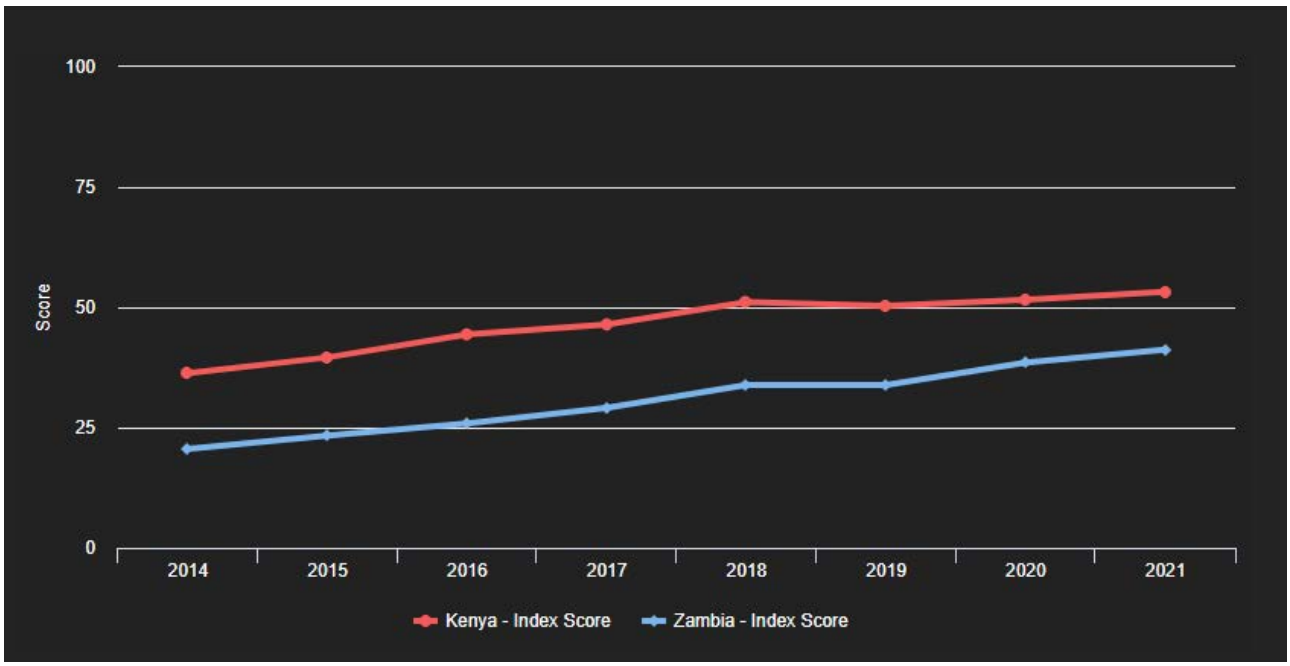


Figure 1: Comparative mobile index score for the two case countries based on GSMA data for the variable categories infrastructure, affordability, consumer readiness, and content and services combined for the period 2014-2021[12]*. Kenya is comparatively the most advanced of the two countries with its 53,2 index score in 2021. Although Zambia is the least advanced of the two (41,2 index score in 2021), it is also the country with the most index growth in the period 2019-2021.*

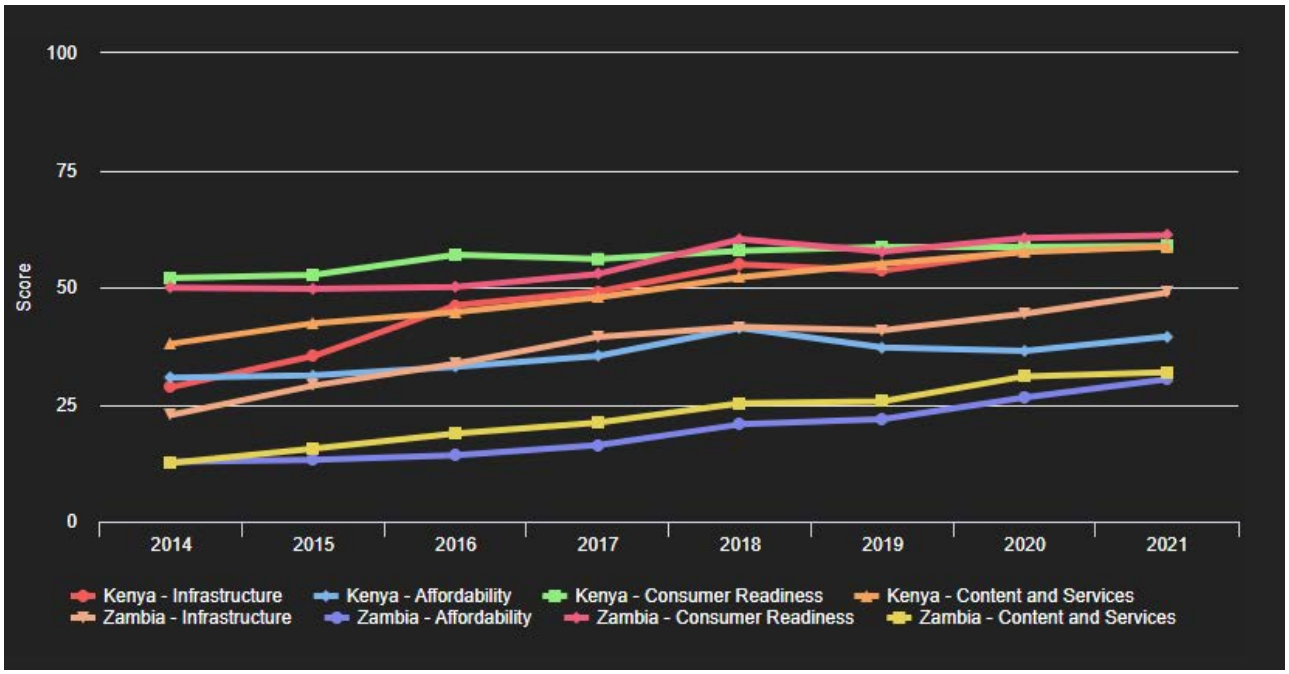


Figure 2: Comparative mobile index for the individual enabler scores on infrastructure, consumer readiness, affordability, and content and services for the two case countries based on GSMA data for the period 2014-2021[13]*. This data makes visible that the lower overall index score for Zambia appears to be caused by the much lower scores for affordability and content and services. However, when looking at infrastructure and consumer readiness it is visible that the two countries are almost on par with each other.*

12 and 13 GSMA. (2022). *GSMA Mobile Connectivity Index.* GSMA. London, UK. Accessed on 27 September 2022 from https://www.mobileconnectivityindex.com/

1.2. Champions securing investments to advance digital agriculture in African ecosystems

Among the 2021 top 100 African Leading Companies, those that attracted the most funding, gained traction, and ositioned themselves as market leaders in their sector, the majority is made up of fintech companies (40/100). In that regard, it is not surprising to see that a reported 82% of Kenya's farmers were using mobile financial services in 2019[14]. Thevast majority of those companies rely on the use of digital technologies, tools, and services. The agricultural sector is getting a smaller share, with 8 companies out of 100 (Agrobotics, Agricorp, Gro Intelligence, Komaza, MicroForestry, One Acre Fund, TwigaFoods, Wefarm). Notably, of those 8, 5 only operate in East Africa (Gro Intelligence, Komaza, One Acre Fund, TwigaFoods, Wefarm) but only two of those have their headquarters in the region (TwigaFoods: Kenya,Nairobi, TwigaFoods; OAF, Kigali, Rwanda) while the others are managed from the United States of America (GroIntelligence, Komaza), and United Kingdom (Wefarm). None of the top 100 companies with an agriculture sector focus is currently operating in Zambia. Nonetheless, during the country data collection exercise, it was also noted that Zambian farmers mobile financial services adoption rate is rapidly growing. When zooming in on only the African case countries Zambia and Kenya, without considering the sector, it appears that only 6 companies operate in Zambia (4 in fintech, 1 in cleantech, 1 in health, 1 in education, none headquartered in the country). Meanwhile, an impressive number of 46 companies were operating in Kenya in 2021, with 10 of them also having their headquarters in the country.

Champions in agri-food technology

According to AgFunder, 119 AgrifoodTech companies operating in Africa were able to raise funding in 2021, with a total value of 482,3 million USD, an increase of nearly 300 million USD compared to 2020. The growth is expected to continue, with an estimated 400 USD already raised in Q1 of 2022. Put into perspective however, this amount accounts for only 10% of all VC investments in Africa, and a meagre 1% of the global investments in agri food tech[15]. As has become visible already based on the African Leading Companies data, fintech companies dominate when it comes to fundraising. Zooming in on the case countries, 18,4% of the agri food tech funding for Africa was raised by Kenyan companies through 32 different deals. By far the biggest receiver of funding in Kenya is TwigaFoods, which secured 50 million USD series C funding. This fits AgFunder's observation that most of the funding went to midstream technologies: startups combining physical logistics with supply-chain digitization with the aim to create digitized integrated value chains. In the category agrifin tech, 10,5 million USD went to Apollo Agriculture (debt round), which helps small-scale farmers to access credit, inputs, insurance, and markets. Early 2022, Apollo Agriculture raised another 40 million USD series B funding to expand their business to new markets and a wider range of crops. Another 6 million USD in 2021 went to Pula Advisors (series A). The latter is also an insurance intermediary that aims to reduce the risks of crop production for farmers.

1.3. Emerging trends in digital agriculture in LMICs

Deploying advanced technologies for smart farming

The digital agriculture landscape in low and middle-income countries continues to grow rapidly. This growth is primarily underpinned by the widespread adoption of mobile technologies. Not only the digital agriculture

14 M.C. Parlasca, C. Johnen, and M. Qaim. (2022). Use of Mobile Financial Services among Farmers in Africa: Insights from Kenya. *Global Food Security*, 32, (2022): 100590.

15 Agfunder. (2022). *Africa AgriFoodTech Investment Report* 2022. Agfunder. Accessed on 3 October 2022 from https://agfunder.com/research/2022-Africa-agrifoodtech-investment-report/

landscape grows rapidly, current projections suggest that the world's population will reach 9.8 billion in 2050 with the majority of these people living in LMICs. This means that there is a growing demand for food globally. A growing population and growing demand for high quality food puts pressure on food systems to produce more food than ever before.

Digital technologies have allowed for the further development of agricultural intelligence practices, capturing more data stemming from farming activities, which have in turn enabled big data agricultural platforms. Data intelligence is expected to help with increasing efficiency in agricultural production systems[16]. Moreover, digital technologies are used to tailor information (e.g. on soil and crop conditions, weather, presence of pests/diseases, market prices) that is disseminated among farming communities to help them make better decisions. We continue to see more nascent technologies such as remote sensing, unmanned aerial vehicles such as drones, or artificial intelligence[17] being piloted with and deployed at a small scale to foster precision agriculture and to help farmers with adapting to and mitigating the negative impact of an increasingly varying climate[18] (see image 3 below).

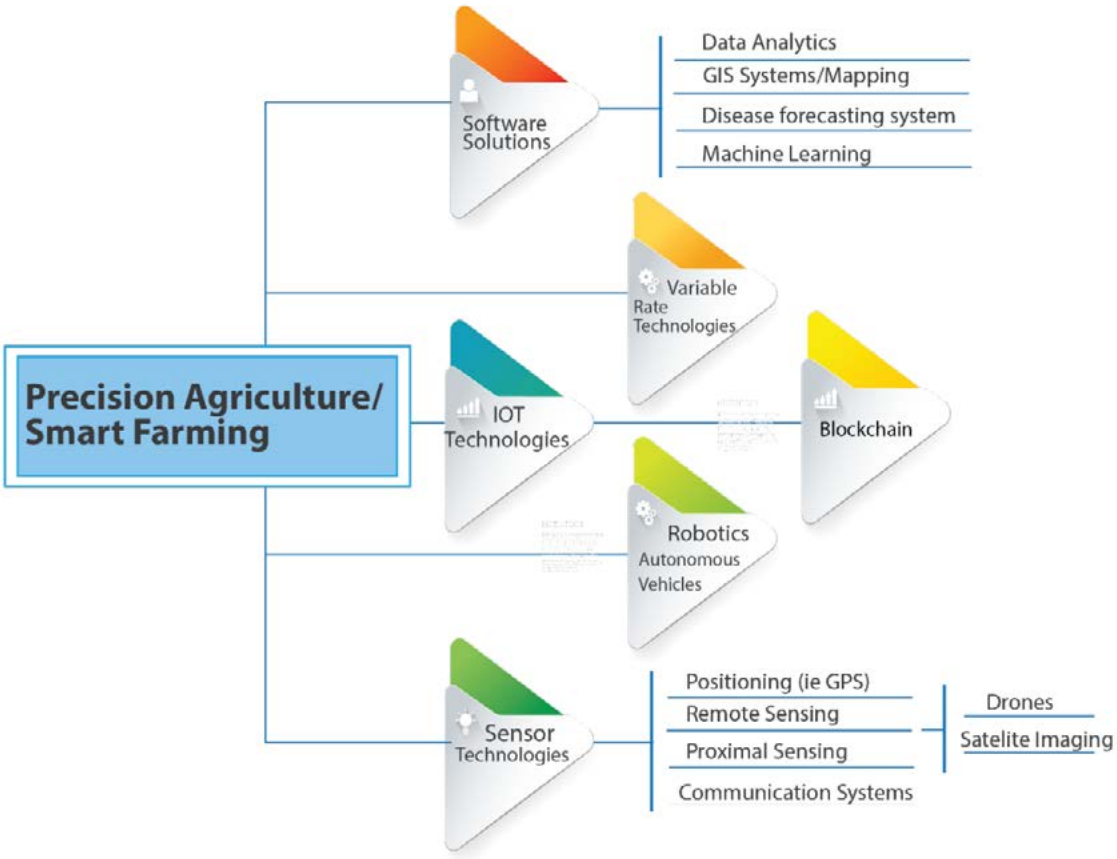


Figure 3: Digital dimensions of precision agriculture (Smart Africa, 2022)[19]

16 Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M.-J. (2017). Big Data in Smart Farming – A review. *Agricultural Systems, 153*, 69–80. https://doi.org/https://doi.org/10.1016/j.agsy.2017.01.023

17 WEF. (2022). *Using technology to improve a billion livelihoods*. https://www3.weforum.org/docs/WEF_Using_Technology_to_Improve_a_Billion_Livelihoods_2022.pdf.

18 McCampbell, M. (2022). *Agricultural digitalization and automation in low- and middle-income countries: Evidence from ten case studies*. FAO. https://doi.org/10.4060/cc2914en
Ceccarelli, T., Chauhan, A., Rambaldi, G., Kumar, I., Cappello, C., Janssen, S., & McCampbell, M. (2022). *Leveraging automation and digitalization for precision agriculture: Evidence from the case studies*. FAO. https://doi.org/10.4060/cc2912en.

19 Smart Africa Secretariat. (2022). *AgriTech Blueprint for Africa*. https://doi.org/10.4060/cc2912en

Actors in food systems continue to, among other practices, explore how to deploy digital technologies for building robust and resilient food production systems. A recent scan study closely looked at around 70 smart farming solutions that are currently dominating in LMICs and compiled 6 key trends that span smart crop management, and smart livestock management access services[20] (figure 4).

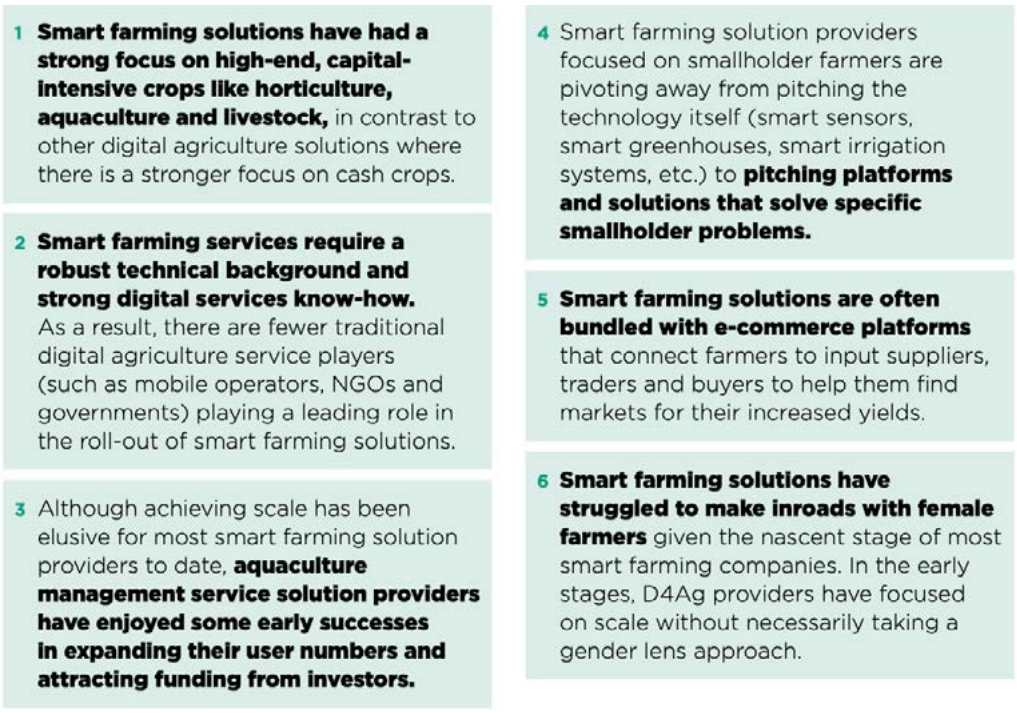


Figure 4: Main trends, Smart Farming Solutions for smallholders in low and middle income countries (GSMA, 2022)

Generating revenue for smallholder farmers through carbon capture

Despite these technologically more advanced trends, it is projected that solutions will continue to be predominantly delivered via mobile applications and will focus on pre-harvest advisory but integrated with market linkage features, especially in LMICs countries[21]. Additionally, the carbon sequestration and credit markets, which are leveraging digital technologies (i.e. digital monitoring, reporting, and verification D-MRV), are rapidly expanding and gaining traction. This is critical for the agriculture sector which contributes 13-21% of global greenhouse gas emissions (IPCC, 2021)[22] and also possibly responsible for one third of all emissions [23]. Rabobank's Acorn solution is one example of a growing variety of similar carbon market initiatives (box 2). Monitoring, Reporting, and Verification (MRV) of the CO2 emission reductions achieved by a certain mitigation effort are a cornerstone of the carbon market. Through MRV the achieved reductions can be reported and certified, and the carbon credits made available to a buyer. When done manually, this process is prone to error, costly, and time-consuming. Hence, digital MRV systems are an interesting alternative that can make the carbon market more efficient, transparent, and trustworthy[24] and that is starting to take flight.

20 GSMA. (2022). *Assessment of Smart Farming Solutions for smallholders in low and middle income countries*. GSMA. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2022/08/Smart-Farming-GSMA-2.pdf

21 Commonwealth Secretariat. (2022). *The state of digital agriculture in the commonwealth*. Commonwealth secretariat. https://state-digitalagriculture.thecommonwealth.org/digital-agriculture/

22 Belenky, L. (2022). *Carbon markets: Why digitization will be key to success*. World Bank. Accessed from https://blogs.worldbank.org/climatechange/carbon-markets-why-digitization-will-be-key-success?cid=SHR_BlogSiteShare_EN_EXT.

23 Crippa et al. (2021). Food systems are responsible for a third of global anthropogenic GHGemissions. *Nature Food. 2*, 198–209 (2021). https://doi.org/10.1038/s43016-021-00225-9

24 Belenky, L. (2022). *Carbon markets: Why digitization will be key to success.* https://blogs.worldbank.org/climatechange/carbon-markets-why-digitization-will-be-key-success?cid=SHR_BlogSiteShare_EN_EXT

Box 2: Rabobank's ACORN initiative

Crops, trees, and the soil are important carbon sinks. The Smallholder Farmers Digital Ecosystems Coalition member Rabobank is leading the Acorn initiative. Acorn aims to support corporate businesses to achieve their CO2-emission offset targets through nature-based carbon removal systems in agroforestry projecten with smallholder farmers in various LMIC countries. Businesses can purchase so-called Carbon Removal Units (CRU) through an online auction. Each CRU represents 1 metric tonne of Co2, which is certified by Plan Vivo and sold ex-post from agro-forestry projects with smallholder farmers (<10 ha) in developing countries. 80-90% of the sale price is said to flow directly back to the smallholder farmer[25].

More nuanced thinking about the the responsible use of data

Digitization in agriculture has brought about unprecedented opportunities to capture but also re-use agricultural data to advance the sector. Thanks to digital agriculture practices, supply chains can be traced, precision agriculture enables treating plants more precisely and also soil testing keeps on becoming accurate. Applying digital technologies to agriculture makes it a data-heavy domain. In recent years, the value of data and how it's fairly captured, stored, and processed has attracted a lot of discourse. This is no different in the agriculture sector. As digital technologies continue to permeate various aspects of agriculture, they are, on the one hand, enabling new practices such as yield forecasting, crop monitoring, soil testing, using remote sensing, IoT and drones. On the other hand, the amount of data that continues to be generated and processed is not equally benefiting all the stakeholders in the agriculture sector which has triggered ongoing discussions around agricultural data governance. As a result, new domains around agricultural data access and use continue to emerge. Models such as data cooperatives, data marketplaces, and data collaboratives[26], amongst others, are coming up and will strongly influence current and future agricultural digital technologies development.

Questioning the farming and economic systems that are supported by digital platforms

Scientists have shared the critique that existing digital platforms and services primarily support conventional agriculture. That is, and agricultural system that promotes the use of chemical fertilizers, pesticides and herbicides, and hybrid-seeds; targets intensification and production increase; and is more suited to mono-crop production rather than mixed-farming systems (Simelton & McCampbell, 2021[27]; Dietzler & Driessen, 2022[28]). Unfortunately, these conventional agricultural practices have been linked to land degradation (e.g. globally and estimated 20-40% of land is already degraded or degrading), and potential production decreases over time in cases of non-judicious use of fertilizers[29]. Regenerative agriculture, in contrast, is argued to benefit soil health, improve yields, reduce (greenhouse gas) emission from agriculture, and enhance farmer resilience against climate and weather impact[30]. Although digitalization in the agricultural sector may this far not have supported a shift to more regenerative agricultural systems this does not mean that it could not do this in the

25 https://acorn.rabobank.com/en/faq/

26 van Geuns, J. (2022). *Farmer-centric data governance assessment: A new paradigm for LMICs*. https://developmentgateway.org/blog/farmer-centric-data-governance-assessment-a-new-paradigm-for-lmics/.

27 Simelton, E., & McCampbell, M. (2021). Do digital climate services for farmers encourage resilient farming practices? Pinpointing gaps through the responsible research and innovation framework. *Agriculture*, 11(10), 953.

28 Ditzler, L., & Driessen, C. (2022). Automating Agroecology: How to Design a Farming Robot Without a Monocultural Mindset?. *Journal of Agricultural and Environmental Ethics*, *35*(1), 1-31.

29 Geisseler & Scow. (2014). Does long-term use of mineral fertilizers affect the soil microbial biomass? *Better Crops*. Vol.98(4).

30 IUCN. (2021). *Regenerative agriculture in Africa report.* IUCN. https://www.iucn.org/resources/grey-literature/regenerative-agriculture-report-opportunity-businesses-and-society

future. For example, IDH visualized six use-cases to show how digital platforms could be leveraged to promote regenerative agriculture (2022):[31]

- Using communication channels to standardize production principles;
- Applying data-driven prescriptive and predictive advisory to mitigate production risk;
- Introducing digital aggregation and market linkages to improve the economics of sourcing;
- Building economic resilience through data-backed finance and payment;
- Leveraging end-to-end traceability for price-premiums;
- Using remote monitoring for course-correction and learning.

Another relevant question, that is more or less directly linked to the conventional versus regenerative agriculture debate, is how digital technologies change the organization of agri-food systems. An analysis of 280 digital services and products by Prause, Hackfort, & Lindgren (2021) [32] showed that digital technologies are used across the agri-food value chain. On the one hand this appeared to increase the retail sector's control over global commodity chains. Yet on the other hand does the use of data provide opportunities for new forms of control and extraction, especially for large tech. companies and, increasingly, also multi-national agri-food companies. According to the authors this introduces a neoliberal capitalistic model into agri-food systems *(idem)*.

Recognizing the power of indigenous knowledge

The focus in digital agriculture is often on the digital innovations themselves, the scientific knowledge that can be disseminated through them, the adoption of those innovations and the knowledge disseminated through them by farmers, and the, primarily quantitative, big data on farmers and farms that can be collected through digital technologies. What remains underrepresented is the indigenous knowledge owned by farmers that is oftentimes less tangible, but passed on from generation to generation, and informs farmers' decision-making and practices. For example, indigenous knowledge held by female farmers in Chad that historically helped them to survive under the country's harsh climatological conditions:
"In the west, people check their weather app to find out if it's going to rain," Ibrahim says. "Our best app is our grandmothers because they can just observe the cloud positions, the bird migration, the wind directions, or the little insects, and say, 'Oh, it's going to rain in two hours!'" [33]

Acknowledging the value of indigenous knowledge also puts inclusive development in a different perspective. It is critical to involve users in the development of digital innovations not only because the objective is to develop digital innovations that fit the needs and demands of a wide variety of potential users, but also to allow developers to learn about existing, indigenous knowledge, combine this knowledge with scientific knowledge, and integrate both into the innovation that is developed. Using the same example from Chad again, it is hence *"vital to involve women in the process, not just to ensure their representation, but because of the knowledge they have, such as how to find water in the dry season."*

31 Borthakur, S. & Meulensteen, T. (2022). *6 ways digital tech can aid the transition to regenerative agriculture*. IDH. Accessed on 14 September 2022 from https://www.idhsustainabletrade.com/news/6-ways-digital-tech-can-aid-the-transition-to-regenerative-agriculture/

32 Prause, L., Hackfort, S. & Lindgren, M. (2021). Digitalization and the third food regime. Agric *Hum Values* 38, 641–655 (2021). https://doi.org/10.1007/s10460-020-10161-2.

33 McCool, A. (2022). *'Grandmothers are our weather app': new maps and local knowledge power Chad's climate fight back*. The Guardian. 25 August 2022. Accessed on 15 November 2022 from https://www.theguardian.com/global-development/2022/aug/25/new-maps-and-local-knowledge-power-chad-climate-fightback-hindou-oumarou-ibrahim

Bringing indigenous people into the discussions about e.g. technological innovations, adaptation to climate change, or impact of changing farming practices on e.g. ecosystems, socio-cultural norms and values, and different understandings of development , etc. can support mutual understanding and dialogue between various stakeholders in the agricultural sector. For example, in the context of the African continent, the well-being concept of Ubuntu values human relations and may value those more than individual development. Dorine van Norren (2022)[34] suggests that when considering Ubuntu, the SDGs would likely be approached differently and change from a developed vs developing countries perspective to a relationship perspective, and from being goal oriented to process oriented. 'Sustainability' becomes 'community of life', 'individuality' becomes 'collective agency', and knowing through measuring' becomes 'knowing through feeling engagement with others'.

34 van Norren, D. E. (2022). African Ubuntu and Sustainable Development Goals: seeking human mutual relations and service in development. *Third World Quarterly*, 1-20.

2. Conceptual framework

This second chapter of the report shares the conceptual approach that informed the study. As elaborated in the introduction chapter; The study focused on digital ecosystems in the context of the agricultural sector; with case studies in two African countries; with a specific emphasis on the opportunities, challenges, and effects that digital services and platforms bring for smallholder farmers; and set out to learn from supply- and demand-side actors who are successful in the digital agriculture ecosystem (so called champions or positive deviants, as further elaborated in the next section). With this in mind, the research team formulated five research questions which each contributed a section of the information that was required to develop concrete recommendations for the Smallholder Farmers Digital Ecosystems Coalition as to what could be relevant interventions that would add value to the development of the digital agriculture ecosystems in the case study countries. This translates in the study's main research questions, which is as follows:

What are concrete short (<1 year)- and medium-term (1-3 years) interventions in SHF digital ecosystems that could foster the scaling and sustainability of digital tools and services in [fill country name]?[35]

To answer the main question, five sub-questions were formulated:

1. What does the existing digital ecosystem for smallholder farmers in [fill country name] look like?
2. What are infrastructural, organisational, and institutional factors that influence the digital ecosystem positively or negatively?
3. What are champions in the existing digital ecosystem?
4. What is the role and influence of human agents in relation to champions?
5. What business models are suitable for champions and how do these models relate to the models commonly used in the digital ecosystem today?

2.1. Positive deviants as champions, and principles for digital design

Identifying positive deviants or champions in digital ecosystems

Within the context of the study, we were interested in individual actors, organizations, initiatives, or services that were somehow setting themselves apart from others in the digital agriculture ecosystem. We could have approached such outliers from two directions: positive outliers (those performing better than average) or negative outliers (those underperforming). In this case we chose to specifically look at positive outliers: Those who developed practices or strategies that are successful, even though these outliers face the same general ecosystem challenges as their peers in the sector. In literature positive outliers are also referred to as positive deviants, or champions, and their study has resulted in approaches such as the Data Powered Positive Deviance approach[36]. In this report we mostly refer to positive deviant as champions. Our study borrows the conceptual

35 In the context of this study the emphasis is on interventions that relate to priority dimensions in the digital ecosystem, with emphasis on smallholder farmers, that were previously identified through a survey among members of the Smallholder Farmers Digital Ecosystems Coalition. These priority dimensions include:
1. Existing digital and data policies and regulations affecting digital agriculture
2. The role of human agents/intermediaries
3. Existing digital and data infrastructure affecting digital agriculture
4. (Scalable) business models of champions
5. Collaborations of change-makers with other organizations in the ecosystem
6. Digital literacy/capacity of change-makers

36 Global Development Institute. (2020). *Launching the Data Powered Positive Deviance Initiative*. http://blog.gdi.manchester.ac.uk/launching-the-data-powered-positive-deviance-initiative/; and
Global Development Institute. (2021). *DPPD Handbook: A step-by-step guide for development practitioners to apply the Data Powered Positive Deviance Method*. https://static1.squarespace.com/static/614dae085246883818475c39/t/6233ca3941781d1d1b3dc497/1647561299003/DPPD_Handbook_Nov_2021.pdf; see also: https://www.datapoweredpd.org/

thinking about positive deviants, but does not adopt the approach itself. In practice this means that, contrary to the Positive Deviance approach, our study relies primarily on qualitative primary data, complemented by qualitative and some quantitative secondary data. Two reasons for this are (1) the scarcity of quantitative, comparable, open-access (big) data on adoption, use, and impact of digital tools and services in the agricultural sector in the cases countries; (2) the ambition of the coalition to have a broad-scope study with focus on grass-roots/local phenomena. Within the context of our study, our primary aim was to identify champions; individuals, communities, or businesses that achieve better results than their peers despite operating under the same conditions with the same challenges and limitations. In other words, outliers from whom something could be learned about the specific practices and strategies that can contribute to developing successful digital agriculture services in the future. By unravelling these factors of success we were then able to derive at entry-point for targeted interventions that can help peer services providers and the digital ecosystem more generally to become more successful.

Principles for digital design in agriculture

In this section we explain how we operationalized principles for digital design to a framework that guided our data collection and analysis in the digital ecosystems in Zambia and Kenya. Various principles for designing digital tools and services in the context of High Income Countries (HIC) and Low- and Middle-Income countries (LMIC) in general and agriculture specifically have previously been established. The most well-known frameworks are probably the nine Principles for Digital Development, and the FAIR data principles. Table 1 gives a broader overview of some of the better known and recent design principles without aiming to be exhaustive.

Table 1: Overview of various recent and relevant principles for digital design frameworks.

Name design principles framework	Developer	Geographic and sectoral focus	Principles included in framework	Link to principles documentation
Principles of good practice in digital climate-informed advisory services	World Resources institute/ Ferdinand et al. (2021)	Global; Smallholder agriculture	- Data quality and assurance - Accountability and transparency - Equity - Co-creation - Financial sustainability - Scalability	https://www.wri.org/research/digital-climate-informed-advisory-services
Principles for digital development	Digital Impact Alliance (2017)	LMIC; Aid and Development	- Design with the user - Understand the existing ecosystem - Design for scale - Build for sustainability - Be data driven - Use open standards, open data, open source, and open innovation - Reuse and improve - Address privacy and security - Be collaborative	https://digitalprinciples.org/principles/

Name design principles framework	Developer	Geographic and sectoral focus	Principles included in framework	Link to principles documentation
UK government Design Principles	Central Digital and Data Office (2012)	UK; Not sector specific	- Start with user needs - Do less - Design with data - Do the hard work to make it simple - Iterate. Then iterate again - this is for everyone - Understand context - Build digital services, not websites - Be consistent, not uniform - Make things open: it makes things better	https://www.gov.uk/guidance/government-design-principles
FAIR principles	Wilkinson et al. (2016)	Global; Not sector specific, focused on data	- Findable - Accessible - Interoperable - Reusable	https://doi.org/10.1038/sdata.2016.18
Unnamed	Steinke et al. (2022)	LMIC; Smallholder agriculture	- Managing stakeholders' expectations - Considering future scaling from early on - Creating a clear and coherent team experience - Understanding local context with limited time budgets - Achieving representation of target users and stakeholders during prototyping - Choosing the right design tools for target context - Dealing with top-down hierarchical settings - Beyond users, considering the local digital ecosystem - Embracing a culture of re-use	https://doi.org/10.1016/j.agsy.2021.103313
Unnamed	Wolfert et al. (2022)	EU; Agriculture	-Fostering multidisciplinary and agile collaboration in digital innovation ecosystems - Organizing a lean, multi-actor approach to trials and use cases - Establishing a common technical infrastructure for collaboration - Identifying value streams with user engagement - Engaging the right partners and stakeholders at the right time - Strategic project planning and dynamic management	https://doi.org/10.1016/j.agsy.2022.103558

The overview makes visible that the diverse design frameworks show a lot of overlaps. Commonalities include, to name a few (1) co-creating with users, (2) focusing on sustainability, (3) developing services that are easy to use, (4) collaborating with multiple stakeholders, (5) considering interoperability and reuse of services and data. In the context of this study, and with the aim to keep the conceptual framework lean and simple, we took the the six core principles for good practice in digital climate-informed advisory services as an entry-point (Ferdinand et al. 2021)[37]. Beyond fitting the research objectives and being simple to use, these principles were also selected because they are directed to smallholder agriculture, and they manage to capture the core of the other principle frameworks. Despite being a good fit, we believed that the existing principle frameworks lacked a couple of elements that would be necessary to include when considering the scope of our study, current knowledge about the field of digital agriculture and digital ecosystems, and the interests of the Smallholder Farmers Digital Ecosystems Coalition, we identified three additional design principles: Farm(er) level impact; value chain efficiency and effectiveness; and environmental sustainability (see table 2 for an overview of the meaning of the nine design principles).

*Table 2 : Overview of the operationalization of the nine design principles that conceptually guided the study. *Except for farm(er) level impact, value chain efficiency and effectiveness, environmental sustainability which were not part of the Ferdinand et al. (2021) framework but added by the authors of this study.*

Design principle	Icon	Link with coalition intersts	Operationalization according to Ferdinand et al. (2021)*	Variables through which principle was approached in the study
Data quality and assurance		Existing digital and data policies and regulations affecting digital agriculture Existing digital and data infrastructure affecting digital agriculture	- Use of international data quality standards - Implementation of data management guidelines - Transparent communication of information accuracy and uncertainty - Rigorous validation of data and related analyses - Enhanced resolution for localized decision-making - Establishment of laws and regulations that govern data access, including open access to public data - Creation of strong national systems - Expansion of existing open platforms	- Data useful for users and stakeholders across the ecosystem - Data equitably accessible to users and stakeholders - Data systems interoperability - Data standards availability and use
Account-ability and transpar-ency		Existing digital and data policies and regulations affecting digital agriculture Existing digital and data infrastructure affecting digital agriculture	- Provide adequate timeline and budget for monitoring, evaluation, and learning - Track and report investments - Formalize operational governance models - Develop a standard set of outcome indicators	- Definitions of responsibility and accountable - Standards for data privacy and consent - Transparency about types of data collected - Transparency about data ownership - Transparency about (3rd party) data sharing and processing - Farmer-centric Data governance models present

37 Ferdinand, T., Illick-Frank, E., Postema, L., Stephenson, J., Rose, A., Petrovic, D., ... & del Rio, C. R. (2021). *A Blueprint for Digital Climate-Informed Advisory Services: Building the Resilience of 300 Million Small-Scale Producers by 2030.* Working Paper.

Design principle	Icon	Link with coalition intersts	Operationalization according to Ferdinand et al. (2021)*	Variables through which principle was approached in the study
Social inclusion and equity		Local & grassroots perspectives Digital literacy/ capacity of innovation champions	- User-centered approach and improved targeting - Promote integrated, two-way and multichannel interventions - Access to productive assets and inputs - Build the capacity for users to equitably engage - Expand the types of knowledge that is utilized and disseminated - Invest in the last mile	- User typologies - (inclusive) innovation access and use - (inclusive) resource access (finance, insurance, inputs & advisories) - (inclusive) knowledge access
Co-creation		Local & grassroots perspectives Collaborations of innovation champions in the ecosystem	- Be demand driven, not supply driven - Build the capacity of target users and service providers so that they can actively participate and engage - Promote diversity of engagement across the value chain - Formalize and embed co-creation in governance and planning - Plan for an iterative process with design, timelines, and budgets	- Technology/service development process - Demand versus supply drivenness - Value proposition of innovation
Financial sustain-ability		(Scalable) business models of innovation champions	- Develop digital services with the main user in mind, focusing on last-mile challenges - Bundle services and promote efficiencies through specialization - Focus on the most responsive segments of the farming populations - Promote the adoption of government standards and regulations in the ecosystem - Shift to an inclusive market system approach when designing and implementing services	- Profitability - Donor funding - (loan) Investment - Subsidies - Financial infrastructure

Design principle	Icon	Link with coalition intersts	Operationalization according to Ferdinand et al. (2021)*	Variables through which principle was approached in the study
Scalability		(Scalable) business models of change-makers/positive deviants Existing digital and data infrastructure affecting digital agriculture	- Promote forward-looking regulation that maximizes consistency across countries/ regions - Improve capacity and resources for cooperative solutions - Bridge the access-engagement gap via innovative solutions - Support governments to initiate and manage public-private partnerships effectively and enhance intragovernmental coordinations - Build on what already exists when and where possible - Establish a coordinated community of practice - Integrate service plans into a longer-term investment plan - Support large-scale farmer outreach for PPP or private enterprise models that have proven effective	- Number of users - Impact & benefits of use - Geographic distribution of users - Enabling environment - Competing innovations
farm(er) level impact		Local & grassroots perspectives Existing digital and data infrastructure affecting digital agriculture The role of human agents/intermediaries	- Create standards a standardized set of indicators to measure impact - Implement a MEL system to measure impact at farm and farmer household level - Use the dimensions of responsible innovation (anticipation, inclusion, reflexivity, responsiveness, to monitor the trade-offs and consequences of an innovation - Aim for measurable, positive, and equal impact	- Production efficiency - Production quality - Farm(er) income/livelihood - Food security - Labour

Design principle	Icon	Link with coalition intersts	Operationalization according to Ferdinand et al. (2021)*	Variables through which principle was approached in the study
Value chain efficiency and effectiveness		Local and grassroots perspectives The role of human agents/ intermediaries	- Establish incentives for stakeholders across the value chain to cooperate and collaborate - Build towards value chains that are transparent, profitable, and trustworthy for all stakeholders - Work towards interoperable or universal, standards for traceability and labelling and certification schemes	- Existing market linkages Producer-buyer/processor linkage - Transparency throughout value chain - Traceability throughout value chain - The role of intermediaries across value chains.
Environmental sustainability		Local and grassroots perspectives (Scalable) business models of innovation champions	- Support innovations that contribute to a transition to ag. 4.0 and regenerative agriculture - Measure the broad overtime environmental impact of the digital innovation itself - Measure the effect of an innovation on agricultural practices - Aim for innovations that are energy efficient, reusable, and recyclable - Promote diversity in agricultural production systems	- Type of agricultural production system promoted - Impact on ecosystem (restoration) - Carbon sequestration and off-setting efforts - Impact on resource consumption

3. Methods

The study used a mixed method data collection approach: ecosystem mapping, identification of innovation champions (referred to as champions in the report), in-depth qualitative assessment of champions and the broader digital ecosystem in the case country. With the data from the complete study it is possible to report insights about the ecosystem from three perspectives: (1) Digital service users (demand side), (2) Digital service suppliers (supply side), (3) Digital service enablers. By bringing the institutional and local perspectives together in the analysis, it was possible to validate if what was reported on in secondary data was confirmed through data, experiences and observations at field-level.

3.1.Digital ecosystem-mapping

In the first phase the focus was on systematically mapping the digital ecosystem, including the different stakeholders and tools and services currently present in the ecosystem both in Kenya and Zambia. This translates into identifying the current and upcoming digital agriculture initiatives in each case study country, and determining their failure or success (thereby considering the design principles), while also determining which organizations develop and implement the initiatives and how they are funded. The ecosystem mapping phase neither aimed to be exhaustive, nor to be repetitive of existing mapping studies. Consequently, the reader will find that the section describing the players in Zambia's digital ecosystem is more extensive than that of Kenya. This is because in the latter case there are a considerable amount of previous ecosystem studies that we could refer to. This first phase therefore relied on a combination of secondary and primary data and builds, where possible, on existing secondary data from previous ecosystem studies.[38] The focus is on identifying what is innovative and unique in a specific case country, also in preparation of the second phase of the study.

3.2. Identification and assessment of champions

In the second phase of the study, champions were identified. The research team worked with local organisations in both countries to identify ecosystem actors and sample farmers to engage during the country assessment. For representativity, while selecting the farmer samples, gender, age and digital literacy levels were considered. Primary data was again complemented by qualitative and quantitative secondary data. Surveys and semi-structured (key-informant) interviews are the main methods used in this phase, complemented by qualitative workshop data collection. The combination of methods allowed the researchers to triangulate primary data from service providers and enablers, and primary data from local and grassroots actors, with secondary data. Identified champions could be both from the supply and demand side of the digital agriculture sector, and were not restricted to a specific type of agricultural service (e.g. finance, advisory, marketing) or technology (e.g. mobile app, voice service).

Analytical approach

For each case country three data collection activities were employed; (1) Focus group discussions (FGD) mainly with farmers, (2) Key Informant Interviews (KII) with other actors in the agriculture sector (i.e. extension agents, agro-dealers), (3) multi-stakeholder workshop by engaging others actors (i.e. development organisations, AgTech companies, etc.). In each country, data was collected in 2-3 selected locations in the country.

38 E.g. by WFP, GSMA, USAID

Table 3, box 3, and box 4 provide an overview of the data that was collected per activity per case country, more details about study locations and respondents are provided in annex 1[39]. Both FGDs and KIIs followed a semi-structured approach, using a FGD topic guide and KII interview guide respectively (annex 3 and 4). Different KII interview guides were used for different types of key informants, e.g. commercial farmers, agricultural produce offtakers. A tailored method and protocol was developed for the multi-stakeholder workshop (annex 5). FGDs and KIIs were audio recorded and narrative transcripts of those recordings were combined with written notes. The combined transcripts were then manually analyzed using a qualitative thematic analysis approach and structured analytical framework and codebook (annex 6). Multi-stakeholder workshop data existed of written notes and paper-based session data. Those data were also analyzed using a thematic analysis approach. Based on the results narrative stories were developed and then triangulated with secondary data and literature.

Table 3: Overview of data collected per country.

Country	Focus Group Discussion	Key Informant Interviews	Multi-stakeholder workshop
Zambia	n=3 Total number of farmers: 31 16 male/ 15 female	n= 6 (2 agrodealers, 1 village bank agent, 1 commercial bank and 2 commercial farmers)	Stakeholder groups represented: Supplier of services/products, Government, (research for) development organisations, non governmental organizations, commercial farmer
Kenya	n=4 Total number of farmers: 32 12 male/20 female	n= 11 (agrodealers, extension agents, commercial farmers)	Stakeholder groups represented: Supplier of services/products, Government, (research for) development organisations, non governmental organizations, commercial farmer

Box 3: Selection of study areas and sampling of respondents in Kenya

In Kenya, The researchers collaborated with the Kenyan partner Local Development Research Institute (LDRI) to sample and mobilize respondents for the study. For the FGDs and KIIs (demand and supply-level data), LDRI sampled farmers and interviewees in three counties: Kiambu (Thika and Githunguri Sub-counties) and Kininyaga in Central province, and Embu in Eastern province). Supply level data was collected in Nairobi city. Data collected through FGDs, KIIs, and a multi-stakeholder workshop was triangulated with secondary data and grey- and peer-reviewed literature.

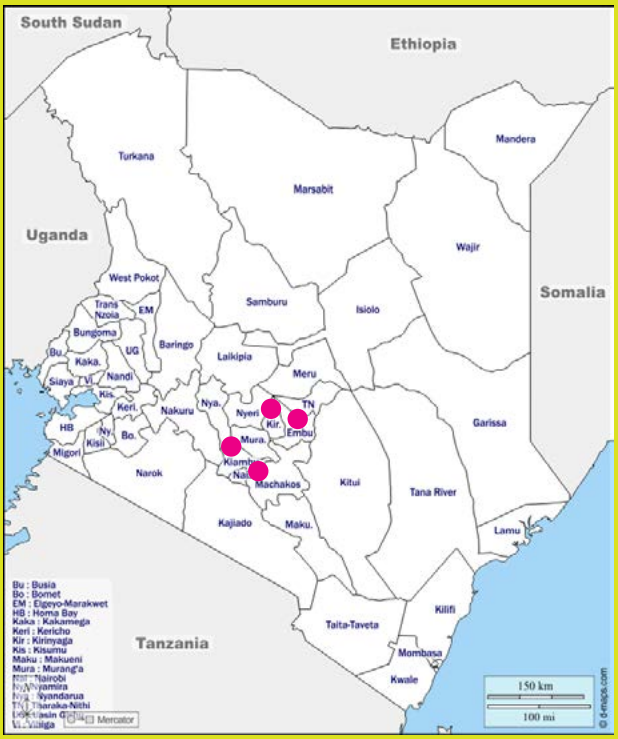
The three counties were selected because LDRI had existing partnerships and networks there as a result of a project that was implemented from 2019 to 2021 during which 1,465 champion farmers (so called Village Based Advisors, or VBA) were recruited, trained, and equipped with seed and information kits to reach over 250,000 farmers in total in Kiambu and Embu. A Village Based Advisory is a Kenyan champion farmer who promotes agricultural production through training and sharing of agricultural information to other farmers in his/her community. The VBA demonstrates leadership and has influence on farmers' practices and decisions.

39 Annexes are available upon request as a separate file

Sampling strategy

Focus Group Discussions

All four FGDs were done with VBAs, the majority of them above 35 years old, and 62.5%/37.5% female/male ratio. VBAs are generally more literate and more tech-savvy than an average Kenyan smallholder farmer. VBAs are also champion smallholder farmers, and selected VBAs typically practised market-oriented mixed farming, thereby combining crops and livestock, generally with a specific focus of one high value commodity (e.g. coffee in Kirinyaga, dairy in Kiambu). In combination with the geographic location of the FGDs, in peri-urban counties with relatively good (telecom) infrastructure), it can be assumed that the selected FGD participants are representative for a typology of smallholder farmers with high user readiness[40] and thus high likeliness to be adopters and users of one or multiple digital agriculture services.



Kiambu county

Githunguri sub-county is traditionally a tea, coffee, and dairy producing sub-county at 1,500-1,800m altitude. Githunguri is well known for dairy farming with approximately 85% of the total households estimated to own dairy cattle (Wambugu et al., 2011)[41]. Plantation crop production is however under pressure due to urbanization and cropland is increasingly converted into residential land. The two focus group discussions (one in Githunguri sub-county) and one in Thika sub-county) with farmers were conducted with 8 farmers each. All were small-scale subsistence or commercial farmers practising mixed farming, that is both crop farming and livestock rearing. Some of the crops that they grow include; maize, beans, Irish potatoes, vegetables, fodder crops like Napier grass, coffee, and one farmer was doing tea farming. Some of the livestock they rear include; exotic dairy cattle breeds, poultry, pigs, dairy goats, and sheep.

Thika sub-county has a semi-arid, low-altitude agro-ecological zone that is covered with shallow, poorly drained, soils. The county receives low rainfall, which limits general agricultural development but makes it suitable for ranching and production of drought-resistant crops. Farmers practice mixed farming, combining crops such as maize, beans, cassava, sweet potato, and vegetables, with fruit trees (oranges, mangoes) and with (indigenous) livestock such as cattle (for dairy), goats, and poultry.

40 McCampbell, M., Adewopo, J., Klerkx, L., & Leeuwis, C. (2021). Are farmers ready to use phone-based digital tools for agronomic advice? Ex-ante user readiness assessment using the case of Rwandan banana farmers. *Journal of Agricultural Education and Extension*. https://doi.org/10.1080/1389224X.2021.1984955

41 Wambugu S., Kirimi L., and Opiyo J., 2011. *Productivity Trends and Performance of Dairy Farming in Kenya*. Tegemeo working paper no 43. Tegemeo Institute of Agricultural Development and policy, Egerton University

Embu county

In Embu county, 8 farmers participated in the FGD. Farmers practice mixed farming, combining crops such as maize, beans, and vegetables, with (indigenous) livestock such as cattle (for dairy), goats, and poultry.

Kirinyaga county

The county has thriving value chains in coffee, tea, rice, and horticulture. In Kirinyaga county, 8 farmers participated in the FGD, all farmers coming from Muriri sub-county or nearby. Farmers practice mixed farming, but with coffee as their main cash crop. The farmers were members of a coffee cooperative, and sold their crop directly to the cooperative. Other commodities produced by these farmers include vegetables, maize, beans, and livestock such as cattle (primarily for dairy), pigs, and poultry.

Key Informant Interviews

- Agriculture officers - their role in the dissemination of knowledge to farmers was imperative to understand how digital services impacted their daily activities when interacting with farmers.
- Agro-dealers - these are the first agents that farmers interact with when they require inputs. Their role as input providers was imperative to understand how digital tools impacted their businesses as well as in the dissemination of information to farmers.
- Large-scale farmers - these are the farmers that produce crops in bulk and conduct a little mechanization. It was important to understand how their farming practices and marketing of agricultural produce were impacted by digital tools.
- Off-takers - their role as aggregators was imperative to determine their use of digital tools in the marketing of agricultural produce.

Workshop participants

A selection was made of actors who are suppliers, or facilitators, or enablers in Kenya's digital ecosystem. It was imperative to select both public and private sector actors who are involved in policy formulations, private sector aggregators and off-takers, research institutions, and farmer organizations to better understand the role of digital services in the agriculture ecosystem, as a way of improving agricultural productivity at the farm level.

Box 4: Selection of study areas and sampling of respondents in Zambia

Data collection in Zambia was conducted through 3 activities. First, Focus Group Discussions (FGDs) were conducted with smallholder farmers in 3 small towns of Chisamba, Chibombo and Mumbwa, all located in Zambia's central province. Second, Key Informant Interviews (KIIs) were also conducted with an agrodealer, a village bank agent, a large-scale farmer, and a commercial bank (i.e., ZANACO). Lastly, a stakeholder's workshop was conducted in the capital city of Lusaka bringing together both the supply and the demand side of digital agriculture technologies. To achieve the above, the research team collaborated with a local organisation called AgriEn, a Lusaka-based network organisation that offers services ranging from improving food access to promoting food security and environmental outcomes for sustainable food systems in Zambia. From the already established working relationship with farmers in the aforementioned 3 towns, AgriEn helped the research team identify FGDs participants. Representativity in terms of age, gender and size of farming activities were also considered during the selection of FGDs participants. AgriEn also worked with the researchers to conduct both the KIIs and the national-level stakeholder workshop.

Sampling strategy

Focus Group Discussions

Three FGDs were conducted in Zambia. Participating farmers were a mix of smallholder farmers and emerging farmers coming from 3 towns namely Chisamba, Chibombo and Mumbwa all located in the central province of Zambia. More about these segments in the Zambian context is provided in further sections. In total 31 farmers that include 15 women and 16 men participated in the FGDs. In terms of age, it was noted that the Zambian farming population is generally old. The average age of engaged farmers is 40 years old.

Chisamba Town

Chisamba is a small town located in the central province of Zambia. The town is about 97 km from the capital city Lusaka. It's home to a predominantly farming community that grows vegetables, beans, soya beans, maize, bananas, onions, and fruits (i.e., watermelon) among others. The FGD in Chisamba attracted 6 farmers that included 4 males and 2 females. These farmers grow soybeans, sunflowers, maize, and horticulture value chains.

Chibombo Town

Chibombo is a small town also located in the central province of Zambia and is close to Chisamba. The main economic activity in Chibombo is farming where about 90% depend on it for their livelihoods. The FGD in Chibombo had 20 participants among which 5 were men and 5 were women, they grow beans, groundnuts, maize, and soya beans value chains.

Mumbwa Town

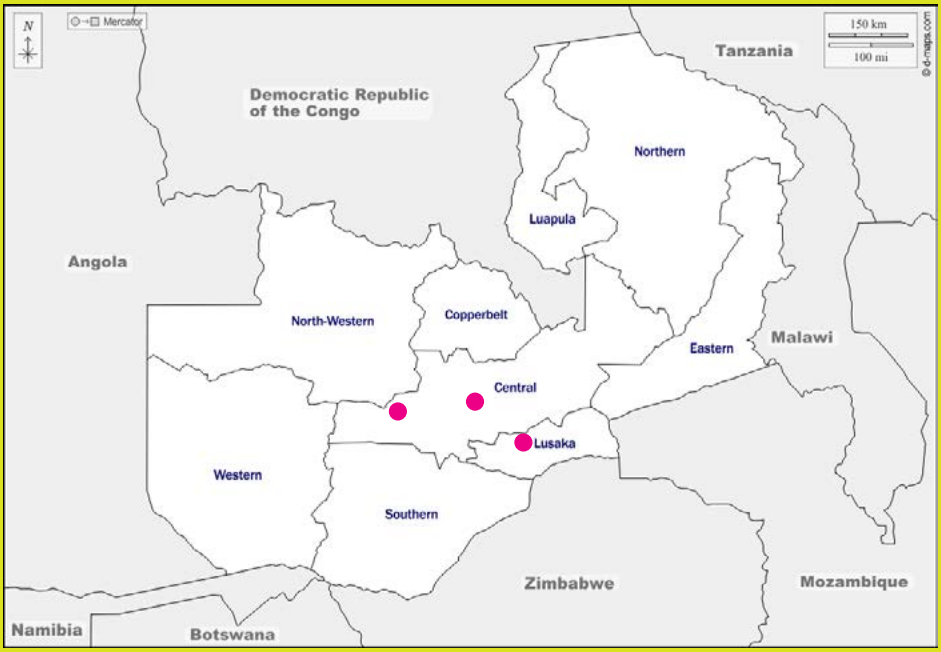
Mumbwa is another small town also located in the central province that is mainly occupied by farming communities. The FGD in Mumbwa included 15 farmers among which 7 were female and 8 were male. These farmers grow Chilli, maize, cotton, soya bean and vegetables.

Key Informant Interviews

- Agro-dealers - these are the first agents that farmers interact with when they require inputs. Their role as input providers was imperative to understand how digital tools impacted their businesses as well as in the dissemination of information to farmers.
- Large-scale farmers - these are the farmers that produce crops in bulk and conduct a little mechanization. It was important to understand how their farming practices and marketing of agricultural produce were impacted by digital tools.
- The Zambia National Commercial Bank (ZANACO) is a commercial bank involved in agriculture finance in Zambia

Workshop participants

The workshop attracted actors from both the supply and demand sides of digital agricultural innovations in Zambia. These include Tech companies, international development organisations, Higher learning institutions, Farmers' representative organisations and the government.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Southern
Zimbabwe
Mozambique
Namibia
Botswana

Results from the case countries: Zambia & Kenya

4. Zambia

Key findings

- **Who are the champions in Zambia's digital ecosystem?**
  - From the supply side, the champions are Mobile Network Operators (MNOs), also referred to as Telcos. They enable a range of mobile-based services for farming communities. These include financial services via mobile (i.e. mobile money) and the dissemination of agricultural information
    via mobile. These services are accessed by farmers directly or via intermediaries such as agro-
  - dealers, Mobile Money agents, or young tech savvy farmers.
    From the demand side, farmers who are moving up the ladder, who perceive farming as an economic activity for their livelihood, who have some level of education and who have been exposed to media platforms tend to be the champions in terms of adopting digital technologies. In Zambia they are called emerging farmers and are predominantly involved in integrated value chains (i.e. dairy, horticulture) or grow for export (i.e. soya beans).

- **Zambia is considered an upcoming or mid-track country with a promising and fast-growing digital ecosystem.** But for advancing digital agriculture at national level, the country lacks a clear plan on how they want to achieve it. Only a few small and isolated initiatives are implemented without a bigger picture. One major gap is the fact that the country does not have a specific digital agriculture policy or strategy to guide all the efforts in a coordinated manner.

- **Internet connectivity in Zambia remains scarce in rural areas where most SHF live.** Where it's available it's deemed expensive by farming communities. Zambian farmers tend to be older hence prefer traditional ICT channels such as Radio and TV as source of agricultural information because it comes at no cost and in their local languages.

- **The adoption of mobile financial services is increasing fast in Zambia.** However, charges imposed by Telcos who provide financial services (i.e. mobile money) were reported to be high for an average farmer. Moreover, the number of fraudsters and scammers trying to con farmers who are using mobile payment is also increasing.

- **Few SHF, mostly young or educated, posses smartphones and thus are able to use social networks such Facebook and WhatsApp to access agricultural content (i.e. YouTube channels for agricultural best practices) or advertise their produce mostly via WhatsApp groups.** Overall, there is reluctance to pay for digital agricultural services. Farmers prefer free services except a few emerging farmers who are willing to pay for market linkage digital solutions in order to sell more and increase their profitability.

Table 4: Summary of key findings from Zambia according to the nine design principles

	Supply-side	Demand-side
Existing digital services	Mostly supplying DFS (i.e. MNO's mobile wallet), input sourcing and advisories. Social networks (i.e., Facebook groups, WhatsApp groups predominantly used by smallholder farmers to learn, sell, and network.	They access advisories (mostly via traditional digital channels like TV and Radio, social networks like Facebook and WhatsApp) groups, and mobile wallets. There is a growing mistrust of information accessed via social networks. There is demand for more transparent market linkages solutions even if they are paid services (demand mostly coming from emerging farmers).
Policies regulations and infrastructure	Internet/broadband infrastructure is still mostly underdeveloped. The Zambian digital agriculture ecosystem suffers from not having a specific AgTech strategy at the national level.	Internet coverage is still poor in remote/ rural areas. Internet prices are still very high for a typical farmer in Zambia.
User engagement 	A few actors provide user support remotely or via networks of community-based agents or enrolled/trained intermediaries.	Internet coverage is still poor in remote/ rural areas. Internet prices are still very high for a typical farmer in Zambia.
Digital inclusion 	The supply-side targets both men and women but uptake by women is still low. Most solutions are not available in local languages. Mostly urban and peri-urban farmers are serviced.	SHF possess smartphones in good numbers but don't seem to exploit them to the maximum.They predominantly use them for basic tasks (i.e. calls, mobile money). SHF tend to be illiterate and want to engage in the local language
Scaling, sustainability, business models 	Most services depend on donor funding. The predominant business models are freemium, subscription and own capital investment.	SHF aren't willing to pay (i.e. Mobile money charges). Emerging and commercial farmers want to pay where there is value for money, especially market linkages.
Data governance 	It's a relatively new topic. The government just started to look into it and recently launched a new Ag-Data Hub yet to be operational. Private sector actors (i.e., banks) are starting to receive data-sharing requests from tech companies.	Farmers are predominantly worried by the increasing number of scammers and fraudsters targeting their mobile money wallets. Unfortunately, farmers indicated that no specific actions are taken to counter such practices. Furthermore, SHFs don't really care about giving away their data as long as the offered services respond to their needs or come from a provider they know well/trust.

	Supply-side	Demand-side
farm(er) level impact	Supply side actors use digital and non-digital channels to disseminate agricultural best practices and advisories to help farmers be more productive.	No evidence gathered on whether digital solutions are gamechanger to help farmers be more productive.
Value chain efficiency and effectiveness	Despite a low uptake, AgriTech companies are offering market linkage digital solutions to farmers.	Farmers mostly sell via physical markets and aggregation points in their communities. emerging farmers demand for more market access digital solutions to allow them to sell at better prices.
Environmental sustainability	A few actors are using digital technologies to disseminate climate-smart agricultural practices to farmers.	Despite being cognisant of the shocks brought about by climate change, farmers predominantly apply traditional farming practices. No particular practice to promote agriculture in an environmental and sustainable manner was identified except a few farmers who are starting to closely monitor environmental degradation (i.e. soil testing).

4.1. Country Profile

Table 5: Country profile of Zambia

General country data	
Country population (000) (+ year)	18.384 (FAOstat, 2020) increased from 15.879 in 2015 (FAOstat, 2015) 2,8%/year population growth (ZamStats, 2020)
Share of rural population (%) (+ year)	10.343 (FAOstat, 2020) increased in absolute numbers (from 9.550 in 2015 (FAOstat, 2015); decreased in percentage: 56,26% of population in 2020, 60,14% in 2015
Total land area (000)	74.339
Literacy rate (Adult literacy rate, population 15+ years, both sexes (%))	87% of population 15 years+ (FAOstat, 2018)
Electrification rate (Access to electricity (% of population)	43% (total population); 14% rural population (FAOstat, 2019)

General Agriculture data	
Total Agricultural land (1000 ha)	23.836 (FAOstat, 2019) of which 0,2-8 for organic production (FAOstat, 2019; 2017 resp.)
% population involved in agriculture	50% (FAOstat, 2019) Stable % from 54,5 in 2013 to 49,6% in 2019
% Contribution of agriculture to nominal GDP	Decreasing from 15,6% in 2004 to 2,7% in 2020 (2,9% in 2019 before COVID-19 pandemic) (World Bank, 2021 in IAPRI[42], 2021). Fluctuations and overall decline attributed to variable rainfall patterns and extreme climate events (esp. drought) (IAPRI, 2021, p.11)

42 Mulenga, B., Mulako, Kabisa, M., Chapoto, A. (2021). Zambia Agriculture Status Report 2021. IAPRI. Lusaka, Zambia.

Mean Per Capita Income (PCI) of farmers[1]	GDP in 2020: 19.320 (millions of USD) (World Bank, 2020 in FAO, ITU. 2022)
Prevalence of moderate or severe food insecurity (%)	Moderate to severe food insecurity: 51,4% (FAOstat, 2019); severe food insecurity: 23,2% (FAOstat, 2019)

Proxies for economic scale of agriculture per sub-sector	
Crop production: Average crop land area (ha 1000)	3.836 (FAOstat, 2019)
Crop production: Primary crops produced for home consumption	Nationally: Maize (89,7% of farmer households; 53,3% of cultivated area), groundnuts (55,6% of farmer households; 9,6% of cultivated area), cassava (35% of farmer households; 11,2% of cultivated area), sweet potato (16,6% of farmer households), mixed beans (16,3% of farmer households) (IAPRI, 2020) some regional differences in top 5 crops
Crop production: Primary crops produced for export	Cereals (esp. maize), oilcrops (esp. groundnut, soybean), fruits and vegetables, tobacco, pulses (FAO, 2020)

Proxies for economic scale of agriculture per sub-sector	
Livestock production (no. In Millions) (e.g., small ruminants, cattle, pigs, poultry)	Cattle: 3885336; Sheep: 174001; Goats: 3957252; Pigs: 1166924 (IAPRI, 2021)
Aquaculture: Primary types of aquaculture systems/value chains	Upward trend due to local and regional (Angola, DRC) demand between 2005-2020. 18,69% increase in aquaculture and 3,94% increase in capture fisheries production (2020). 2020 total production, 94.943 MT capture fishery; 45.670 MT aquaculture (IAPRI, 2021)
Aquaculture: General production location	unknown

Proxies for digitalization

Mobile index scores for the year 2021 (adapted from GSMA. 2022)

Proxies for digitalization	
Mobile cellular subscriptions (per 100 people)	Increased from 70 in 2013 to 104 in 2020 (FAOstat, 2013-2020)
Mobile device ownership	52.1% of total population (GSMA, 2019)
Population with access to internet, share of total population (%)	Increasing: 14% (FAOstat 2018), 19% (FAOstat, 2019)
4G coverage	49,10% of total coverage (GSMA, 2019)
Digital literacy rate (%)	Unknown
Cost of mobile data per Gb	1.36 USD (Cable, 2020 in FAO, ITU 2022)[43]
Digital inclusion	47% of Zambians not digitally-included. Gender digital divide 34% (women) and 56% (rural people) respectively not digitally included (UNCDF 2022)[44]

Relevant policies and strategies	
Agriculture in general	National Agricultural Policy 2012-2030 (NAIP)
Digitalization in agriculture	No national policy yet
Digitalization in general	Accelerating Digital Transformation in Zambia: Digital Economy Diagnostic Report (World Bank, 2020) Zambia is one of 17 countries who implement the Digital Economy for Africa (DE4A) Initiative that is supported by the World Bank
Environmental/ecosystem protection/ restoration, environmental sustainability, climate change	National Policy on Climate Change (2016); National Climate Change Learning Strategy (2021)
(rural) electrification and energy supply	Rural Electrification Master Plan for Zambia 2008-2030
Infrastructure (electrification, telecommunication)	See electrification
Financial inclusion	National Financial Inclusion Strategy 2017-2022 Rural Finance Policy and Strategy 2012

Zambia is a land-locked lower-middle income country with a population of over 18 million (FAO, 2020). The country ranks 146th out of 190 countries and 7th out of 16 SADC countries on the UNDP Human Development Indicators ranking (UNDP, 2020). Zambia is one of the poorer countries within the Southern African region, with an average Gross National Income of 3.560 USD per capita (World Bank, 2020). While countries like Kenya, Ghana, Nigeria, and Rwanda have received extensive attention and investments in the digitalization of their agricultural sectors in recent years, visible also in the vast numbers of available digital platforms in these countries. The traditionally narrow focus on a limited number of countries on the African continent has also been reflected in assessments of the digital agriculture ecosystem on the continent. For example, Porciello et

43 FAO & ITU. (2022). *Status of digital agriculture in 47 Sub-Saharan African countries* . https://doi.org/10.4060/cb7943en.

44 UNCDF. (2022). *Zambia Inclusive Digital Economy Status Report 2022.* Accessed from https://www.uncdf.org/Download/AdminFileWithFilename?id=16949&cultureId=127&filename=uncdf-ide-status-report2022final-recovered-2pdf.

al. (2021)[45] concluded that 75% of the published evidence on digital agriculture innovations in Low- and Middle-Income countries came from 7 countries, of which five were African: Kenya, Ghana, Uganda, Nigeria, and Tanzania. Clearly, Zambia has received much less attention. However, there are signs that this is changing, with more actors expressing interest in the country. In a recent assessment of the state of digitalization in Southern Africa's agricultural systems, Zambia ranked 10th out of 16 countries. Meanwhile the country ranked positively in the assessment for digital business, and digital skills, it ranked comparatively low for digital government and innovation-driven entrepreneurship[46]. Zambia's mobile connectivity index score is rising according to GSMA[47], e.g. from 33.9 in 2019 to 38.5 in 2020 and 41.2 in 2021, while the 2019 average index score for SSA measured 37.57 points.

4.2. The digital ecosystem in Zambia

Studies by CCARDESA and the World Bank established that digital advisory services are the most common digital innovations, aiming to address the persistent knowledge gap among users, in particular farmers in Zambia (CCARDESA & World Bank Group, 2022[48]). This is in line with a 2021 literature review study with a more general focus on low- and middle-income countries that similarly found that the majority of studies focus on the provision of digital advisory and extension services (Porciello et al. 2021). The 2022 CCARDESA assessment identified 26 innovations in total (figure 6), ranging from the aforementioned digital advisory, to financial services, to procurement, e-commerce, and smart farming. Good support is available for Zambia's start-up ecosystem. For example, several incubators exist, including BongoHive Technology and Innovation Hub, and Jacaranda Hub.

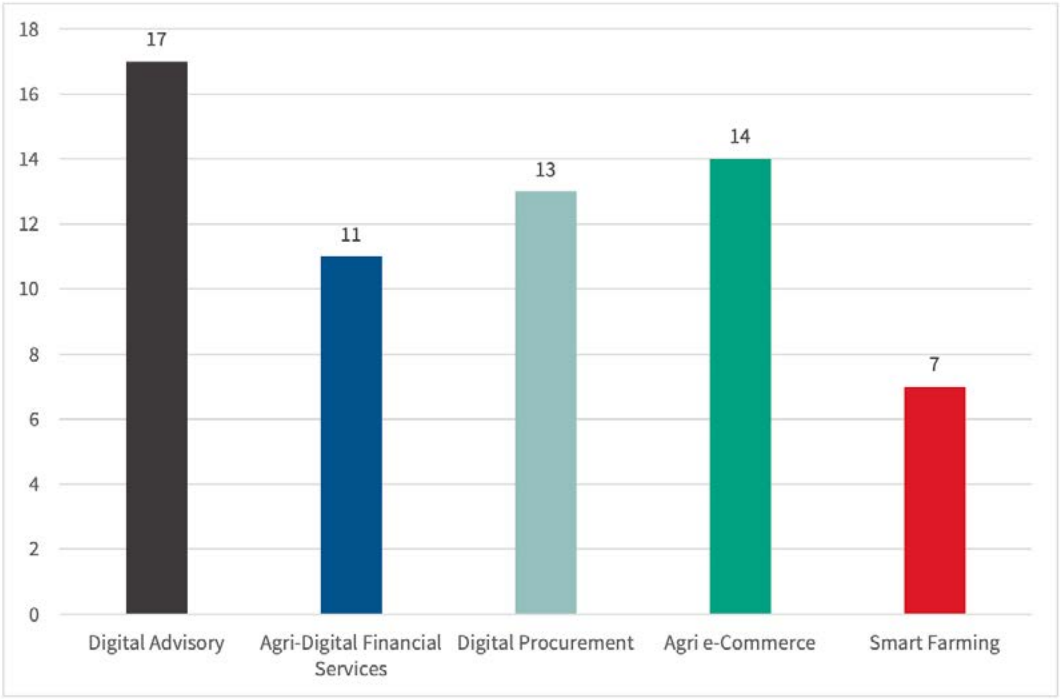


Figure 5: Digital agricultural innovations in Zambia (adapted from CCARDESA 2022).

45 Porciello, J., Coggins, S., Otunba-Payne, G., & Mabaya, E. (2021). *A Systematic Scoping Review: How are farmers using digital services in low- and middle-income countries?* Cornell University. https://hdl.handle.net/1813/103771.

46 UNCDF. (2021). *Inclusive Digital Economies Score: Zambia 2020.* https://www.uncdf.org/article/7345/inclusive-digital-economy-scorecard-ides-report-zambia.

47 GSMA. (2022). *GSMA Mobile Connectivity Index.* GSMA. London. Accessed on 27 September 2022 from https://www.mobileconnectivityindex.com/.

48 CCARDESA & World Bank Group. (2022). *Assessment of digitalization in the agricultural systems of the SADC region: Situational analysis.* https://www.ccardesa.org/sites/default/files/knowledge-products/CCARDESA%20SADC%20Digitalisation%20Study%20-%202022.pdf

One identified government initiated platform, led by the SMART Zambia Institute, is the Zambia Integrated Agriculture Management Information System (ZIAMIS). The platform responds to the challenge of incomplete and siloed agricultural and climate data in the country[49]. Originally, the main aim of ZIAMIS was to effectively distribute agricultural inputs through registration of agrochemical, fertiliser, livestock services, seed, and input suppliers on the platform and an e-voucher system (Chikobola & Tembo, 2018)[50]. By 2018, 1.5 million farmers were reportedly registered on this platform. Today, the Government of Zambia regards ZIAMIS as an integrated platform that supports the country's Ministry of Agriculture with various processes that, beyond farmer registration and input distribution, include monitoring and reporting of farming activities. During the in-country assessment, a stakeholders workshop was organised by bringing together mostly the supply side of digital agricultural innovations. In total, 14 organisations attended the workshop (annex 1) ranging from international organisations to local higher learning institutions, public sector organisations and local AgriTech companies. Although invited, the key actors missed during the workshop are the Telcos.

During the workshop, an ecosystem mapping exercise took place to identify and cluster existing digital agriculture services and platforms in Zambia. Table 6 captures existing solutions/platforms and the specific domain where solutions are offered to farmers.

Table 6: Existing digital agriculture services and platforms in Zambia

Type of platform	Finance access	Input access	Data profiling	Production advisory	Post-harvest	Value chain traceability	Market information & access	Resilience/ risk reduction	Other (including bundled services)
Lima Links		■	■		■	■			
AgriPredict			■	■	■				
E-Musika	■		■	■		■	■		
260 Brands					■	■	■		
Community harvest register			■		■	■			
AgriPay	■	■	■			■	■		
Digital Insurance Solution for Index/ Parametric Insurance	■		■	■			■	■	
Mafisa	■	■		■					

49 Nkole, N. (2022). *Digitising agriculture in Zambia through Ag-Data Hub: Data hub developed to spur agriculture growth.* Zambia Daily Mail, 25 July 2022. Accessed on 23 September 2022 from https://aiccra.cgiar.org/news/news-agdata-hub-zambias-daily-mail

50 Chikoboloa, M. & Tembo, G. (2018). Gaps in the implementation of the e-voucher system in Zambia: Implications for strategies to make the model efficient and effective. *African Journal of Agricultural and Resource Economics.* 2018,13, 2, 193-197. https://afjare.org/media/articles/7.-Chickobola-Tembo.pdf

Type of platform	Finance access	Input access	Data profiling	Production advisory	Post-harvest	Value chain traceability	Market information & access	Resilience/ risk reduction	Other (including bundled services)
Maano App				■		■			
Union SS Farmers									■
Ziamis		■	■	■	■	■	■		
Kutwala					■			■	
Kestrel Agro					■				
IDE platform					■				
Farming as a business CFB Group							■		
Farmer to Market		■	■			■	■		■
Ag1 Global							■		
Kazang / MTN Money	■								
Lupiya	■								
Better world innovation		■		■			■		
Stock Keeper			■	■		■		■	■
ZAAB			■	■			■	■	
Pelum (Enroute to Digital)		■	■					■	
Valley logistics							■	■	

On the other hand, when we asked smallholder farmers to indicate which solutions they use to find agricultural information, access to market and capital, etc. we found a more nuanced reality. While table 6 above shows that a good number of digital solutions exist today, the reality is that farmers predominantly use radio and TV to access agricultural information. Those farmers who are targeted by the government may also receive information via SMS. Farmers mostly receive and make payments using mobile money. A small portion uses social networks (i.e. WhatsApp groups, Facebook) to do marketing and sell their products. Among all the listed solutions/platforms, only 3 (i.e. Mano App, AgriPredict, AgriPay) were mentioned by farmers. This shows a gap between the supply and demand of digital agricultural solutions in Zambia.

4.3. Champions in Zambia's current digital agriculture ecosystem

Supply side champions

During the country study activities in Zambia, it was noted that the country has a widespread mobile service penetration even in rural parts. Arguably, that's why there is a boom in the uptake and use of mobile financial services. Farming communities use mobile money to make or receive payments. From the pool of 31 farmers interviewed during the focus group discussions in the 3 towns (Chisamba, Chibombo and Mumbwa) one thing stood out. Almost all of them use mobile financial services for their farming activities and other households need payments. Mobile Money services from the three leading Telcos (MTN, Airtel and Zamtel) are used by farmers to buy input from agro-dealers, receive payments when they sell their produce or for other personal needs. A few other farmers reported using Mobile Money services to pay for or procure goods for their households' needs. Below is a testimonial by Farmer Henry, a farmer who just retired to fully focus on farming. Before he was doing farming but combining it with serving as a head teacher in his community in Chisamba. He grows vegetables, beans, soya beans, maize, bananas, and onions:

"When I purchase input from the agro-dealer, I pay using Mobile Money. I also pay for electricity and TV subscription through my mobile money account. There are mobile phone apps that allow me to deposit and pay for these services on the phone. Moreover, when I sell my produce either locally or supply it to big buyers in the capital city Lusaka, I receive the payment into my bank account which I can access via my mobile phone, or they pay me in cash, and I deposit it in my mobile money account. I have a bank account at ZANACO which is linked to my mobile money account. I bank more on my phone than in the bank because the banks have queues and so it makes it very faster for me and I can even do it at any time of the day, which I find very convenient. I am able to access agents at proximity whenever I need to cash-in or cash-out. I also pay the workers with the same mobile money. All I need is their mobile phone numbers."

The widespread coverage of Telcos in rural Zambia has also been a great leverage for the Government but especially the Ministry of Agriculture to reach farmers. Mobile phones are used as an important medium to diffuse agricultural information across Zambia. More specifically, the ministry of agriculture has developed two systems namely the Zambia Integrated Agriculture Management Information System (ZIAMIS) and the Farmer Input Support Program (FISP) that are integrated with around 1 million smallholder farmers' mobile phone numbers in order to receive extension and agricultural information via SMS across Zambia[51]. Apart from mobile-based services powered by Telcos, the recent Digital Ecosystem Country Assessment (DECA)[52] for Zambia by USAID revealed that, despite existing challenges around internet connectivity access and affordability, the number of Zambians using smartphones but particularly those accessing social media platforms both in urban and rural areas is increasing. Overall, commonly used digital platforms by Zambians include social media

50 Money FM. (2022). *Govt. maintains number of FISP beneficiaries for 2022-2023 agriculture season.* https://www.moneyfmzambia.com/2022/06/30/govt-maintains-number-of-fisp-beneficiaries-for-2022-2023-a

51 USAID. (2022). *The Zambia Digital Ecosystem Country Assessment report.* https://www.usaid.gov/digital-development/zambia-digital-ecosystem-country-assessment.

platforms like Facebook, YouTube, and WhatsApp. During farmers' engagement in Zambia, it was noted that the use of these social networks is picking up, especially among young farmers. These farmers use these social networks to exchange with peers about agricultural best practices and knowledge. Although small, another segment of farmers is turning to these social networks (i.e., Facebook pages, agricultural YouTube channels or Farmer's WhatsApp groups) to market and sell their produce. Despite the increasing number of promising AgTech startups, no evidence was found that the solutions on offer are widely used in the 3 towns. Similarly, despite existing, mostly donor-driven, initiatives in the literature on digital agriculture in Zambia, no evidence on how they are being adopted by farmers was gathered while engaging farmers.

Demand side champions

The Focus Groups Discussions (FGDs) included smallholder farmers and emerging farmers. The former, in the Zambian context, practice agriculture on a small piece of land (not bigger than 20ha) and predominantly produces for household consumption. This may be due to the fact that s/he has inadequate agronomic skills, access to (economic) resources, access to labour, or limited land ownership. On the other hand, emerging farmers cultivate slightly bigger lands (above 20ha), and are transitioning from small-scale, semi-subsistence production to more commercial farming. It's reported that this segment has been rapidly increasing over the last decade in Zambia (figure 5). This is, to a certain extent, due to the fact that this segment is considered viable and has thus been receiving tailored support or intentional targeting from the Ministry of Agriculture[53]. Furthermore, emerging farmers are: *"...typically larger than smallholders, have a more entrepreneurial mentality, have a basic level of financial management and are growth-oriented. Emerging farmers are an interesting target group because they have the potential to develop into full-scale commercial farmers..."*[54]

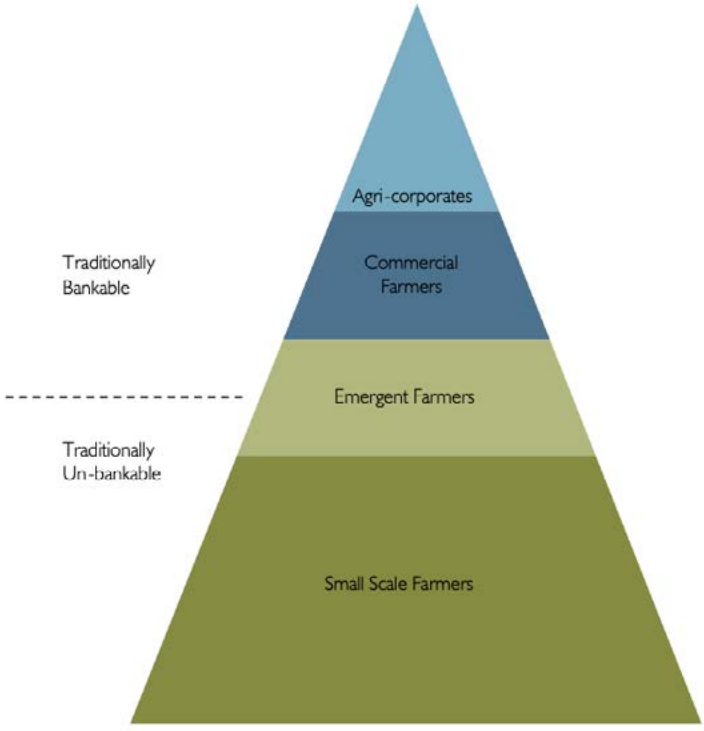


Figure 6: Farmers' Typologies in Zambia (CABRI, 2014)[54]

53 Sitko, N.J. and Jayne, T.S., (2014). Structural transformation or elite land capture? The growth of "emerging" farmers in Zambia. Food Policy, 48, pp.194-202.

54 CABRI. (2014). Zambia case study Innovative Financing of Agriculture in the SADC Region. https://www.cabri-sbo.org/uploads/files/Documents/report_2014_cabri_value_for_money_agriculture_3rd_dialogue_english_zambia_case_study.pdf

From the demand side of digital agricultural innovations, the champions in Zambia are emerging farmers. Because of their entrepreneurial spirit and aspirations to grow their farming activities, they are willing to adopt digital technologies in order to be more equipped with best agricultural practices, increase their productivity, be more resilient while confronted with climate shocks, and link to markets to sell. Should accessing these services via a digitally-enabled solution require a cost, emerging farmers expressed interest in paying so long as they get value for their money.

4.4. Local and grassroots perspectives on digital agriculture

This section captures perspectives from farmers on various aspects of digital agriculture in the 3 regions where data was collected. When asked about the sources of information that farmers trust the most, it was noted that they tend to trust traditional digital channels such as radio (i.e. Komboni Community Radio) and TV. In addition, they prefer in-person exchanges with peers. A small percentage reported using social networks like Google or YouTube to verify agricultural information or learn about emerging agricultural practices with the aim to increase their productivity (table 8). In terms of farmers' experiences, while using online tools (i.e. social networks) or accessing online content, despite the poor quality and high cost of internet connectivity in rural areas, farmers are increasingly adopting social networks to access agricultural information, communicate with peers, and link to markets (tables 9 and 10).

Table 8: Overview of sources of information that farmers trust the most.

Chisamba	Reasons why farmers trust the source	Chibombo	Reasons why farmers trust the source	Mumbwa	Reasons why farmers trust the source
Radio (agriculture development program. E.g., Radio 1)	The radio stations are in the communities close to the farmers, so they trust the information they disseminate.	Google	They use Google to verify weather information (i.e. rainfall patterns)	Radio	The radio stations are in the communities close to the farmers, so they trust the information they disseminate.
TV	For farmers, TV provides more evidence as they can see the case studies themselves.	In-person information exchange (i.e., extension officers, agro-dealers, farmers)	Most trust Extension officers because they don't usually have access to other forms of communication such as the internet. They also get information from nearby Agriculture knowledge training centers.	TV	For farmers, TV provides more evidence as they can see the case studies themselves. TV provides practical guidance.

Chisamba	Reasons why farmers trust the source	Chibombo	Reasons why farmers trust the source	Mumbwa	Reasons why farmers trust the source
Printed booklets	These hard copy booklets are produced by the Ministry of Agriculture and farmers trust the institution as the custodian of the agriculture sector.	YouTube	YouTube helps farmers compare agricultural practices by other farmers in the country and beyond.	In-person information exchange (i.e., extension officers, agro-dealers, farmers)	Farmers prefer and trust in-person engagement with extension officers, agro-dealers and other farmers while seeking agricultural information.

Table 9: Overview of farmers' experiences while using online tools (i.e. social networks, applications) and content.

Chisamba	Chibombo	Mumbwa
- Compared to seeing extension officers in person, the experience of the internet as a media and platform to acquire information, experience, and review in a short period of time is best and easier because one can access various sources of information online.	- Farmers mentioned that they use WhatsApp and Facebook Groups from their zones and camps to access agricultural information.	- Farmers reported using voice notes to share information via WhatsApp groups. Lead farmers share information about agricultural practices or notice when there is an outbreak of a disease. - Farmers mentioned that the voice note acts to their advantage because they just listen to what is being said without having to read. And usually it is said in their local dialects they understand very well. If needed, they are able to also ask questions.
- Sourcing agricultural information online is quicker and is efficient because farmers don't need to rely on local programs aired on TV or Radio which happen on a weekly basis.	- Despite owning smartphones to a moderate extent, elderly farmers (locally labelled as BBC: born before computers) are reluctant to use digital tools because of fear and lack of knowledge. In some cases, their children perform the tasks (i.e., joining forums, posting questions, etc.) for them.	
- One farmer reported that he subscribed to an online blog where he receives agricultural information and has been practising what he's being taught and advised. The blog is interactive and allows him to ask questions. He also reported having learned how to use GPS to measure his plot.	- Farmers lack information on how to use digital agricultural solutions or how to navigate the use of a particular digital solution on mobile phones, the internet etc. which inhibits farmers' uptake of these solutions.	

Chisamba	Chibombo	Mumbwa
- One farmer mentioned that he uses Tik Tok to find fast and up-to-date agricultural information.	- Farmers use the internet (i.e., Google, YouTube) to search for online agricultural information and social networks (i.e., WhatsApp, Facebook) for ordering input such as seeds, market and sell their produce, enquire about market prices.	
	- Network coverage is still limited and poor. When coupled with data bundle high prices it limits smallholder farmers from accessing digital agricultural solutions.	

Table 10: Perceived advantages and benefits of smartphones compared to basic and feature phones according to Zambian farmers.

Chisamba	Chibombo	Mumbwa
1. Smartphones allow farmers to access various content (i.e., educational content on spraying, and applying fertilizers). They were also able to collect GPS coordinates of their farms. 2. Some farmers deemed smartphone purchase prices higher than what they generate as monetary value to their farming activities.	1. Using smartphones allows joining WhatsApp groups which makes it possible to access audio and video content on various topics (i.e., pest management, weather updates, farming practices, etc.) 2. Using smartphones helps farmers to be able to sell, via social networks, and thus be more profitable. 3. Respondents indicated that their Motivation in using smartphones was that it made Input sourcing easier e.g. through agrodealers when supplies come or new seed is available, they are able to be notified through various groups they belong to.	1. Despite low literacy rates, farmers reported that using smartphones allows them to join WhatsApp groups through which they access voice notes on various agricultural practices. The Voice note acts to their advantage because they just listen to what is being said without having to read. 2. Using smartphones allows farmers to join WhatsApp and Facebook Groups which helps to network with other peer farmers e.g., soya beans farming group. 3. Smartphones allow using visuals which helps in disseminating training content/materials.

Farmers indicated that content in their local languages is still scarce (table 9). It was noted that farmers who possess smartphones are under utilising them because of the high cost and poor quality of mobile data. Nonetheless, there are perceived advantages and benefits of using smartphones such as being able to access a variety of agricultural information, being able to sign up for social networks groups (i.e. Facebook, WhatsApp) and communicate with peers, lead farmers and also market their products to buyers. Trust is another challenge mentioned by farmers especially when moving to online selling and trading. Farmers expressed disappointment in the many buyers who don't honour their commitment when they are supplied ordered products. They either don't pay the agreed amount or delay payment (up to 30 days), or just decide to buy from other farmers.

Table 11: Challenges faced by farmers while using smart and feature phones.

	Chisamba	Chibombo	Mumbwa
Challenges that farmers face while using apps to access agricultural information	1. The cost of buying an internet bundle is high. 2. The quality of the network is not reliable. It's on and off sometimes good and other times too bad- 3. The fear of hackers who can hack social networks and mobile money accounts. 4. Less educated farmers struggle with accessing content via apps because of language and literacy barriers. 5. Shared information (i.e., via WhatsApp or Facebook groups is not trusted because it's contradictory and comes from members who are not experts) 6. Overall, the cost to acquire a smartphone is still high as expressed by the majority of farmers.	1. Smartphones and internet data bundles are very expensive. 2. Some sources of information (i.e., Apps) are difficult to use and require an advanced level of technical skills that a big number of farmers do not possess. 3. Sometimes poor internet connectivity leads to transaction failure as reported by one agrodealer. 4. There is a poor internet network in some areas. 5. There is fear of joining some WhatsApp groups because of differences in religious beliefs between the groups' owners and other farmers. 6. Content in the local language is unavailable. 7. The Maano mobile app by the World Food Programme (WFP) does not work well with the basic phone because you need to take pictures so you can bid on the platform for the product you wish to sell. 8. Some smartphones are sub-standard and consequently fail to connect to the internet or take pictures when needed 9. Some farmers still struggle to operate smartphones. 10. Due to other households' expenses, some farmers still struggle to afford smartphones.	1. Inaccurate market prices and weather information are shared with farmers. Some sources of information diffuse inaccurate information. 2. Although farmers are able to sell their produce (i.e., via Facebook and WhatsApp groups), some buyers do not abide by the sale agreements (i.e., failure to pay, failure to collect goods, etc.). 3. Some farmers sell via social networks from their homes and are not comfortable with buyers identifying their residential addresses which have led to cases of theft and robbery. 4. Smartphones are expensive. The same applies to internet data bundles. 5. Much of the content on agriculture available via Facebook as well as YouTube is in English making it harder for those that are older and have basic education to follow through and use the apps.

Zambian farmers make or receive payments via Mobile Money, Microfinance, and banks. Payment in cash is still predominant, and village savings and loans associations (VSLAs) use is dominant, especially among women farmers. Apart from the widespread mobile money based payment transactions, respondents indicated that they had not benefited from a variety of financial products (i.e., input financing, labour financing, equipment financing, microloans for other households' needs etc.). This is a missed opportunity because the important transaction data generated via Mobile Money can allow the design of small micro-loans. Furthermore, if integrated with Financial Services Providers (i.e. Banks, MFIs) this transactional data could allow credit profiling and lead to the development of financial products.

Table 12: Financial services used by farmers in Zambia

	Chisamba	Chibombo	Mumbwa
(Airtel) Mobile Money	- Used by SHF farmers to purchase input from agro-dealers or receive payments from local buyers.	- Used by SHF farmers to purchase input from agro-dealers or receive payments from local buyers.	- Used by SHF farmers to purchase input from agro-dealers or receive payments from local buyers. - In Mumbwa, women farmers mentioned that Airtel money helps them to save without necessarily having to walk distances to submit the money to a bank.
Bank	- Small-scale farmers who sell big quantities either individually or via cooperatives. They predominantly grow cash crops (i.e., soya) or other crops for export (i.e., maize)	- There were however also farmers that received payments through cheques however, this was said to be for higher volume sales.	- A few farmers who grow big quantities use the local branch of AB Bank. This was triggered by a specific agriculture account or product named "Tumba".
Cash	- Less educated traditional SHF who sell at local markets and who deem the traditional banking system as not suitable to their needs (i.e., no volume of transactions, ineligible for loans)	- Less educated traditional SHF who sell at local markets and who deem the traditional banking system as not suitable to their needs (i.e., no volume of transactions, ineligible for loans)	- Less educated traditional SHF who sell at local markets and who deem the traditional banking system as not suitable to their needs (i.e., no volume of transactions, ineligible for loans)
VSLAs	- Mostly Women - Unbanked – or ineligible to loan criteria by financial services providers (i.e., Banks, MFIs)	- A number of the women participants indicated that they were part of a savings group where they were able to access small loans.	- Deemed fast and helpful for farmers to solve day to day needs which require small amounts of money.
Microfinance	- So mostly we have resolved to small financial service providers such as microfins such as Agora, Inzwe, village banking, etc because it is easier and quicker to borrow because you pay them according to what you make.	- The integration between a microfinance (FINCA) and a mobile wallet (Airtel Money) allows farmers to access capital on their mobile phones and also bank with the MFI, which is convenient.	- Some farmers belonging to cooperatives are paid via MFIs and SACCOs (bulk payments) when they supply their goods to buyers.

Importantly, smallholder farmers engaged through focus group discussions expressed increasing doubts as they give away personal data to onboard social networks such as Facebook. Generally, farmers engaged in the FGDs aren't willing to share their personal data (table 13). Some farmers are keen to share data about their farming activities in case it would enable the design of digital solutions that respond to their needs but chiefly becoming more productive and being able to link to markets. Additionally, some farmers who sell (via phone calls, WhatsApp groups, Facebook pages) their produce and require that buyers come to collect it from their homes mentioned they would prefer having selling points to avoid that buyers identify their homes which can trigger thefts, especially when it's known that one has sold certain quantities and got paid a certain amount.

Table 13 : Summary of farmers' sentiments when giving away personal data.

Type of data	Chisamba	Chibombo	Mumbwa
Personal Phone number	- Farmers aren't willing to share these data: ▪ ID numbers ▪ Passwords ▪ Fingerprints ▪ Access to their contacts, emails, and messages - Farmers are willing to forego their personal data if they know to whom they are giving the data. That's the case with farmer registration that each farmer has to do by approaching the nearby extension officer. - Farmers reported not having any issue with sharing the data (i.e., date on farming activities, age) because once identified they receive input from the government. - Farmers mentioned that they are open to sharing any personal information as long as they'll receive something else in return. This may include information on market prices and where to sell.	- The following were said to be data they were not willing to share: ▪ Account Number ▪ PIN L ▪ ocation ▪ House Number - Asked if they know who gets access to the data that they provide through the digital products/services that you use, they indicated that they did not know who uses this data. - Farmers indicated they do not find it difficult to give away their personal data as long as it plays out for their benefit (i.e. being more informed about agricultural practices, markets).	- Data farmers would not be willing to share through a digital platform ▪ Age ▪ Grade (Education) (Because they impede access to some services such as loans ▪ Marital status (Next of kin?) ▪ Denomination - Farmers in Mumbwa indicated not being aware of who gets access to their data whenever shared to access digital products/services. - Farmers mentioned they are OK with giving away their personal data if they are able to first verify who the data processor is (i.e., platforms, digital solutions providers).

In all the 3 towns in Zambia, farmers were asked whether the Covid19 pandemic had an impact on their agricultural activities and whether using digital technologies proved useful during the pandemic days. Overall, engaged farmers mentioned that the restrictions of movement, as well as the limitation of physical contact, forced them to leverage their mobile phones in order to sell their products and also receive the needed agricultural information. Moreover, it was reported that the imposed restrictions to make transactions in cash paved the way for increased uptake and use of mobile money. Additionally, WhatsApp was frequently used for communication either with peer farmers or with buyers. On the other hand, farmers expressed discontent with the cancellation of their regular physical meetings (i.e., agriculture and commercial shows, National trade fair) for 2 years. Farmers mentioned these gatherings are preferred because they allow physical interactions for knowledge sharing and deal brokering. Importantly, farmers stressed that the experience, depth, and richness such physical gatherings offer can't be matched by digital mediums whatsoever.

4.4.1. Existing in-/exclusion practices of potential users (and solution providers)

The United Nations Capital Development Fund (UNCDF) established an inclusive digital economy scorecard for Zambia (Coupienne & Harihareswara, 2021[55] ; UNCDF, 2021[56]). Overall, the country has a 48% digital economy score, placing it at the top-end of the start-up phase and close to expansion phase. The UNCDF report concluded that a focus on advancing infrastructure and innovation were critical to build an inclusive digital economy in Zambia. Zooming in further on ICT access and use by Zambian households and individuals, a 2018 survey by the Zambia Information and Communication Technology Authority (ZICTA, 2018[57]) showed that only 6.8% of the country's population reported knowing how to use a computer, suggesting low digital skills and literacy across the country. At the time, only 53.5% of Zambia's population were active users of a mobile phone, with additionally only 83.4% of those active users also being owners of a mobile device that was actively registered to a mobile network operator. Reported ownership of smartphones was 29.6% of all mobile phone users in 2018. While internet use counted for 14.3% of the population in 2018, a significant rise from 8.8% in 2015, the internet penetration rate rapidly increased further hitting 57.6% by the end of 2020 (ZICTA, 2020[58]). Lack of knowledge on how to use the Internet, access to appropriate devices, interest in using internet-based services, and access to such services were stated as the main reasons for non-adoption. When it comes to digital agricultural innovations of services, farmers in Zambia mentioned they are reached through information dissemination sessions held at events such as agricultural district fairs. Then, farmers are informed by the supply side about existing and new services. For adopted services, farmers reported that they are trained by the supplier beforehand. One mentioned example is the Maano App. Its users, i.e. farmers, are trained on how to use it and are also encouraged to call the customer support team for help whenever needed. Some service providers only offer certain services in the capital city. One farmer claimed that, while he had hoped his issues would be resolved locally, he was asked to visit MTN but the office in the capital city of Lusaka in order to claim back an amount he had sent to the wrong beneficiary by mistake. From the supply side, they target both women and men farmers. Lately, some women-specific programmes have been rolled out in rural Zambia (i.e., AgriFin Women Initiative). Farmers reported that both women and men can access mobile phones but with a tendency to prioritize, as part of a household, men because they are the face of households' farming business activities.

55 Coupienne, F. & Harihareswara, N. (2021). Overcoming exclusion in digital economies, in *Development Co-operation Report 2021: Shaping a Just Digital Transformation*, OECD Publishing, Paris, https://doi.org/10.1787/c031bb3b-en.

56 UNCDF. (2021). *Inclusive Digital Economy Scorecard (IDES) Report - Zambia.* https://www.uncdf.org/admin/editors/ArticleItem/Index/7345?articleTitle=inclusive-digital-economy-scorecard-ides-report-zambia

57 ZICTA. (2018). *2018 National survey on access and usage of information and communication technologies by households and individuals: A Demand Side Assessment of Usage of ICTs in Zambia.* https://www.scribd.com/document/547839710/Zicta-Ict-Survey-2018.

58 ZICTA. (2020). *Information and Communication technologies Sector: Annual Market Report.* https://www.zicta.zm/storage/posts/attachments/VBLO7yFUYGKGjGXCZMOTTkpXCD6iUL9quUoOi4fe.pdf

Much as women may do most of the on-the-farm activities when it comes to marketing and selling, men take control, and this justifies why they ought to possess mobile phones and active mobile money accounts. On the other hand, women farmers were reported to be the majority using social networks (i.e., WhatsApp, Facebook) mostly for social activities. Overall, farmers expressed the need to have more farmers-specific mobile phone acquisition schemes that can allow them to purchase them on loan and pay in instalments.

4.4.2. The role of human agents and intermediaries in the digital agriculture System

As far as agriculture as a sector is concerned, there is no specific strategy at the national level that clearly sets out how digital transformation ought to impact the agriculture sector in Zambia. At the conducted stakeholder workshop, participants mentioned the need to have an agriculture sector-specific digital strategy or roadmap that puts forward clear objectives and milestones that will see the Zambian agriculture sector being more digitised to benefit all the actors. According to FAO, a common practice in Zambia has been to "commit piecemeal resources to ICT4Ag on an ad-hoc basis which results in high costs and lower impact". Moreover, the Zambian digital agriculture ecosystem lacks a holistic and multi-stakeholder approach that helps solve existing siloed and small-scale interventions[59]. The recent Zambia inclusive digital economy report[60] also affirms that as part of national efforts to accelerate the digital transformation for socio-economic development, the agriculture sector needs to have specific plans to further leverage digital technologies. For smallholder farmers' user support and outreach activities (i.e., for scale and new product marketing), service providers rely on local actors namely extension officer agents, agro-dealers, and lead farmers. This is done by targeting specific farmers or through local agricultural events and fairs. One organisation, AgriPredict, which offers bundled services (weather information, market access, crop disease diagnosis) to farmers works with Lead farmers to target and onboard more users. It also provides user support, mostly via phone calls, to farmers in need. In addition, farmers mentioned that they mostly seek help from agro-dealers whenever they face challenges with digital payments or any other tech-related challenges as they navigate online content. Similarly, farmers approach the widespread Telcos' mobile money agents for support when they face challenges with their mobile wallet accounts. Some farmers also indicated that because they have limited access to online agricultural information and also want to remain informed about developments on best agricultural practices, they frequently exchange with extension officers, who remain very few in Zambia. The current officer-to-farmer ratio in Zambia is estimated at 1 extension officer serving 1,136 farmers[61].

4.5. Existing digital and data infrastructure

Zambia's internet coverage is estimated at 90% for 2G and 80% for 3G. However, internet adoption and usage rates are still very low, particularly in rural areas, compared to the average of other Sub-Saharan countries. This is predominantly caused by the high cost of the internet and the non-existence of compelling services. Additionally, internet-enabled smartphones are still expensive for the average Zambian. In the context of Zambia, it also reported that the urban-rural digital divide is much wider that the gender divide[62]. According To

59 CCARDESA (2020). *Digital Agriculture County Study Annex – Zambia.* https://www.ccardesa.org/sites/default/files/knowledge-products/CCARDESA%20Digital%20Agriculture%20County%20Study%20-%20Zambia.pdf

60 UNCDF. (2022). *Zambia Inclusive Digital Economy Status Report.* https://www.uncdf.org/article/7656/zambias-digital-transformation-will-strengthen-the-economy-and-create-moreequitable-society.

61 Times of Zambia. (2021). *Zambia: More Agro Extension Officers Welcome.* All Africa News: https://allafrica.com/stories/202104010263.html

62 USAID. (2022). *Digital Ecosystem Country Assessment (DECA) – Zambia.* USAID. https://www.usaid.gov/digital-development/zambia-digital-ecosystem-country-assessment

the Zambia Information and Communications Technology Authority (ZICTA) statistics[63] there is an important disparity in terms of internet and smartphone usage between urban and rural areas. Rates in the rural areas, where the majority of farmers live, were reported to be, back in 2018, 1.8% for internet usage and 4.7 smartphone penetration. Where the internet is accessed in Zambia, it's mostly via mobile. In Zambia, two main Telcos namely Airtel Zambia and MTN Zambia are providing mobile internet subscriptions to about 99% of the population. The former has the largest market share estimated at 48.5%, while the latter has about 40.9% of Zambia's mobile internet users market share. A third Telco, Zamtel, has a relatively small market share estimated at 10.6%. Similarly, Airtel Zambia and MTN Zambia dominate the digital financial services sector in Zambia mostly accessed via mobile phones. It's estimated that only 52.1% of the Zambian population has access to mobile devices (ITU, 2022). This segment includes smallholder farmers who constitute approximately 70% of rural populations in Zambia. One major challenge the telecom industry in Zambia continues to grapple with is excessive taxation. As a result, it inhibits possibilities for expanding 4G coverage and improving the affordability of services, which would benefit rural populations, including rural farmers. currently largely using 2G networks[64]. In response to the growing need to share agricultural data to stimulate digital innovations and product development at the ecosystem level, the government of Zambia, in partnership with other actors, recently launched a digital agriculture data hub (Ag-Data Hub). This hub will serve as an agricultural data collection and sharing platform with various actors including the government, the private sector, start-ups, and academia. Furthermore, the just-launched Ag-Data hub will act as a central platform for digitising and integrating agricultural data collected from key institutions to improve agro-advisory services to Zambian crop, livestock, and fish farmers. These institutions include, among others, The Zambia Meteorological Department (ZMD) in the Ministry of Green Economy, the Ministry of Agriculture, the Department of Fisheries in the Ministry of Fisheries and Livestock, and the Disaster Management and Mitigation Unit (DMMU).

4.6. Existing digital and data policies and regulations

Currently, Zambia has three policies that relate directly to the digitalization of the agricultural sector: The National ICT Policy 2006; the Second National Agricultural Policy 2016; and the National Agricultural Extension and Advisory Services Strategy 2017-2020 (see also the section on 'relevant policies and strategies' in table 5). A study by the World Bank (2022)[65] found that Zambia's 2006 National ICT Policy recognized agriculture as one of its key pillars for investment in ICT infrastructure, encouraging use of digital technologies, increasing competitive farming through technology use, and promoting development of ICT entrepreneurs and SMEs. Yet, the prioritisation of digital development in the agricultural sector is not reflected in the country's later Second National Agricultural Policy (2016), meaning that previously identified ambitions for digitalization in the country have not been embroiled and did not translate into specific agricultural strategies and plans. Data governance is a relatively new topic in Zambia. From the supply side of digital agricultural solutions, only a few actors signalled that they've just started to look into it because of the growing demand to share data across the ecosystem. That's the case, for instance, for Zanaco, Zambia's leading private bank. Of late, they've been receiving requests from tech companies and startups to share data about their operations countrywide which would lead to more product development. The increasing number of requests they receive has led them to develop an internal data sharing framework that was being finalized at the time of the interview.

63 Zicta. http://onlinesystems.zicta.zm:8585/statsfinal/ICT%20Indicators.html.

64 USAID. (2022). *Digital Ecosystem Country Assessment (DECA) – Zambia.* USAID. https://www.usaid.gov/digital-development/zambia-digital-ecosystem-country-assessment

65 CCARDESA & World Bank Group. (2022). *Assessment of digitalization in the agricultural systems of the SADC region: Situational Analysis.* Assessed on 4 July 2022 on https://www.ccardesa.org/sites/default/files/knowledge-products/CCARDESA%20SADC%20Digitalisation%20Study%20-%202022.pdf

4.7. Successful and unsuccessful business models

The early days of Zambia's digital transformation journey were marked by an important investment in internet connectivity infrastructure. This was primarily driven by the government in partnership with development partners such as the Government of China. This resulted in all the provinces having links to the national fibre backbone. This important investment in digital infrastructure enabled increased access to internet connectivity which led to the emergence of Zambia's digital innovation ecosystem[66]. Despite being nascent, the ecosystem continues to attract actors such as innovation hubs which are helping tech startups launch digital innovations in the areas of FinTech, Agriculture and others. The government of Zambia, through ZICTA, has ambitions to continue to support tech startups and companies to boost their entrepreneurial and technical capabilities in order to integrate ICT into all major sectors (i.e., tourism, agriculture, and education) and Zambia's digital economy. Nonetheless, access to innovation funds remains a critical barrier[67]. Actors from the Zambian Tech ecosystem still lack access to affordable long-term financing as they aspire to grow their businesses.

A recent mapping report that identified 26 digital agricultural innovations in Zambia[68] claimed that the majority of the companies behind these innovations use subscription-based models or charge transaction fees while serving farmers (or farmers' cooperatives). This is not different from what was identified during the stakeholders workshop in Lusaka, Zambia. The dominant business models are subscription-based, free and commission or transaction-based (table 14). During the preparations of the workshops, the net was cast wide to invite various national digital agricultural solutions providers, however not all attended the workshop. From the demand side, not many farmers reported to be paying to access or use digital agriculture services or platforms. An exception was one farmer in Chibombo who subscribed with the AgriExpect Zambia, a knowledge sharing digital platform. He pays around $2/month to receive vegetables growing agricultural best practices educational content. For other farmers engaged during the FGDs in Zambia, they are willing to pay for about the same amount per month to receive tailored agricultural content. Clearly, more needs to be done to further unearth the kind of digital agriculture services are willing to pay which would inform the development of various business models from the supply side. Table 8 summarizes existing business models from some of the actors who attended the workshop.

Table 14: Identified business models of services providers in Zambia

Organization	User Engagement, customer base	Business model
AgriPredict Solutions	▪ Over 90,000 farmers on the platform in all provinces of the country ▪ Mostly smallholder and youth farmers	▪ Over 90,000 farmers on the platform in all provinces of the country ▪ Mostly smallholder and youth farmers
QUALIKEEPER	▪ Currently in demo (can't answer how many are adopting) ▪ Target is small, emerging and commercial livestock farmers	▪ Subscription-based ▪ Free (thanks to donor funds)

66 World Bank. (2022). *Accelerating Digital Transformation in Zambia.* https://openknowledge.worldbank.org/handle/10986/33806.

67 UNCDF. (2022). *Zambia Inclusive Digital Economy Status Report.* https://www.uncdf.org/article/7656/zambias-digital-transformation-will-strengthen-the-economy-and-create-moreequitable-society.

68 CCARDESA (2020). *Digital Agriculture County Study Annex– Zambia.* https://www.ccardesa.org/sites/default/files/knowledge-products/CCARDESA%20Digital%20Agriculture%20County%20Study%20-%20Zambia.pdf

Organization	User Engagement, customer base	Business model
Climate Smart Agriculture Alliance Zambia (CSAAZ)	▪ CSAAZ target is to reach 700,000 smallholder farmers by 2025 ▪ Currently 1000 farmers have accessed the services	▪ Free (thanks to donor funds)
Lima Links	▪ The target is to reach 100,000 farmers countrywide. Currently they serve 50,000 farmers mostly located in The Central Province, Copperbelt, Lusaka and The Southern Province.	▪ Currently free for farmers (thanks to donor funds) ▪ Subscription-based for input suppliers
Community Harvest	▪ Targeting 50,000 farmers ▪ Has 600 users to date	▪ Freemium ▪ Own capital investment
FISP-MOA	▪ One million smallholder farmers nationwide so far	▪ Freemium ▪ Exploring revenue sharing models via integration with 3rd parties' services providers (i.e Banks, insurance)
Hematon Agro Services	▪ 8,000 plus farmers in Lusaka, Central Province, Copperbelt and North Western province ▪ 5 offtakers (manufacturing companies in Lusaka and Mumbwa)	▪ Subscription based (yearly) ▪ Own capital investment
Kutwala	▪ Currently distributing fresh produce to Lusaka-based businesses ▪ The produce currently sourced comes from within Lusaka Province	▪ Kutwala buys the produce from farmers at a pre-agreed price then distributes it to buyers with a markup. ▪ They also apply a commission-based model on transactions.
NutriGreen	▪ Small scale farmers in Lusaka, Copperbelt and Livingstone ▪ 4,000 registered (trained 286 users/ adapted) ▪ Extension services and education support	▪ Free education and marketing content ▪ Own capital investment ▪ Generates revenue through consultancy and paid agribusiness services.

5. Kenya

Key findings

- **Who are the champions in Kenya's digital ecosystem?**
  - Overall champions: Mainstream social media platforms owned by Alphabet and Meta
  - At the digital agriculture platform level: Platforms and services with local intermediaries in the communities who hold trusted relationships with farmers and extension agents
  - At grassroots level: Transitioning farmers with medium-level digital literacy; who own a smartphone and can purchase data bundles; who produce for more integrated value chains such as dairy, horticulture, coffee; and who produce conventionally with the use of agricultural inputs.
  - Despite what may be expected based on literacy, income, tech. savviness, and innovativeness levels, commercial farmers are not champions of digital agriculture platforms.
- **A mismatch exists between the ecosystem that is portrayed in the literature and institutional reports on Kenya versus what is visible and used by actors at grassroots level, which raises questions about the Return on Investments in digital agriculture in Kenya.**
- **Agricultural specific platforms and services versus mainstream social media:**
  - Farmers use WhatsApp and Facebook to obtain information, buy and sell; some farmers also Youtube and Google search
  - Adoption of digital agriculture platforms in the advisory category (e.g. Yara connect, ICow, AgriBot, Ishamba) usually follows a recommendation of a platform by a trusted human intermediary
  - If not cash-based, financial transactions rely on Safaricom's M-PESA platform. Many other digital financial services, like credit services, operate on their own platform but rely on M-PESA to perform transactions.
- **Farmers verify information obtained via social media and agricultural platforms with their most trusted source of information, the public extension agent.** This raises the question if digital agricultural advisory reduces or increases the burden on traditional public extension.
- **Farmers use WhatsApp groups/WhatsApp status and Facebook groups and timelines as agri e-commerce platforms to sell produce belonging to intermediary-based value chains.** The lack of transparency and traceability that come with these informal marketing channels creates risks and uncertainty and some kind of rating or verification system for buyers and sellers may be required
- **Data governance and data management are, although relatively new topics, actively picked up at a national level.** This is timely, seeing that farmers become increasingly critical about data sharing and ownership. Yet, to succeed, these initiatives need support and adoption from digital service providers and enablers throughout the sector.

Table 15: Summary of key findings from Kenya according to the nine design principles

	Supply-side	Demand-side
Existing digital services	Mostly supplying DFS (M-PESA), input sourcing, and advisory services	SHF access advisories, DFS (M-PESA), and input sourcing apps. Most farmers use social networks (i.e. WhatsApp, Facebook, YouTube – Social Agriculture) these serve as benchmarks for other digital agriculture solutions/products.
Policies regulations and infrastructure	Internet/broadband infrastructure coverage is still concentrated in towns and urban areas.	Internet and network coverage is satisfactory but poor in certain remote villages. Data perceived as expensive.
User engagement 	Mostly done via local agents or activators or via toll-free hotlines.	SHF farmers mostly seek help from peers or trusted intermediaries, even when tech-savvy. Sampled farmers appeared well connected with existing local networks of agents representing various services providers.
Digital inclusion 	Supply-side targets both men and women. Some solutions/content are not available in local languages.	In the sample, both women and men SHF possess smartphones. Cash crops are predominantly grown by elderly farmers who tend to be laggards.
Scaling, sustainability, business models  	Most services depend on donor funding. Predominant business models: freemium, cost-sharing with Telcos and	Willingness to pay for services is limited among SHF
Data governance  	It's a relatively new topic. The government just published a data governance framework which is yet to be operationalised.	Farmers are worried about giving away their data (PII, location) when using apps. Concerns about the increasing number of scammers and fraudsters on social media. Limited data literacy; they don't really care about Terms of Service.

5.1. Country Profile

Table 16: Country profile of Kenya

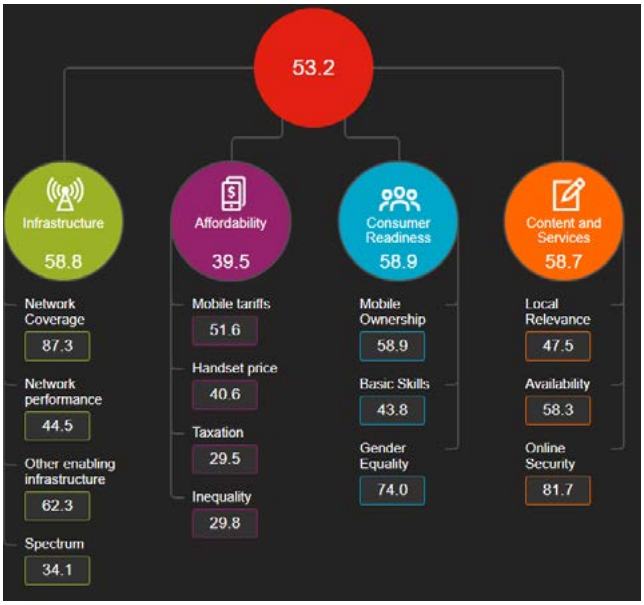
General country data	
Country population (000) (+ year)	53,771 mln (FAO, 2020)
Share of rural population (%) (+ year)	33,517 mln (FAO, 2020) or 66% of all Kenyan farms are smallholder farms (<12 acres) 73% of the population belong to rural communities (Osiemo et al., 2021[69])

69 Osiemo. J., Girvetz, E., Hasiner, E., Schroeder, K., Treguer, D., Juergenliemk, A., Horst, A., Jarvis, A., and Kropff, W. (2021). *Digital Agriculture Profile: Kenya.* CCAFS. https://www.fao.org/3/cb3958en/cb3958en.pdf

General country data	
Total land area (000)	56,914mln hectares
Literacy rate (Adult literacy rate, population 15+ years, both sexes (%))	Adult literacy rate, population 15+ years; 82% (FAO, 2019)
Electrification rate (Access to electricity (% of population)	70% of total population, 62% of rural population (FAO, 2019)

General Agriculture data	
Total Agricultural land (1000 ha)	27.630 (FAO, 2019), of which 6.330 cropland (2013-2019) (FAO, 2019), 154 under organic agriculture production (FAO, 2019), 3.611 forestland (FAO, 2019) of which 153 planted forest (FAO, 2019),
% population involved in agriculture	Slowly decreasing from 59% in 2013 to 54% in 2019 for the total population (FAO, 2013; 2019), and 70% of the rural population (FAO, ITU, 2022). This is reflected in approximately 4.5 million smallholder farmers, of whom 3.5 million produce crops, 600.000 are pastoralists, and 130.000 are fishermen (FAO, ITU, 2022).
% Contribution of agriculture to nominal GDP	Agriculture, forestry, and fishing, value added (% of GDP); 21% in 2019 increasing to 23% in 2020 (FAO, 2019;2020). Alternative source; agriculture, forestry, and fisheries contribute 35,2% of Kenya's GDP in 2020 (FAO, ITU, 2022). Agriculture contributes to the livelihood (employment, income, food security) of 80% of the Kenyan population (ITU, FAO, 2022)
Mean Per Capita Income (PCI) of farmers[1]	1.202,1 USD/capita GDP (Osiemo et al., 2021)
Prevalence of moderate or severe food insecurity (%)	69% of total population moderate or severe food insecure, 26% of total population severely food insecure (FAO, 2019)

Proxies for digitalization



Mobile index scores for the year 2021 (adapted from GSMA. 2022)

Proxies for digitalization	
Mobile cellular subscriptions (per 100 people)	98% of Kenyans own some type of mobile phone, 80% have a mobile subscription (Osiemo et al., 2021)
Mobile device ownership	114 cellular subscriptions per 100 people in 2020 (up from 104 in 2019, and 70 in 2013) (FAO, 2013; 2019; 2020) Device ownership: 57,51% of the population (GSMA in FAO, ITU, 2022).
Population with access to internet, share of total population (%)	25% of Kenyan households (Osiemo et al., 2021)
3G and 4G coverage	3G: 95,8% of the population; 4G: 64,3% of the population (FAO, ITU,
Internet use (% population)	Approximately 25% in 2019 (FAO, ITU, 2022), 99% mobile internet vs 1% broadband internet subscription (FAO, ITU, 2022)
Mobile network providers and market share	Safaricom (71,2%), Airtel (17,6%), Telkom Kenya (7,4%), Finserve Africa/Equitel (3,8%) (FAO, ITU, 2022)
(Gender) digital inclusion	43% of men against 34% of women own internet-enabled smartphones. Among youth (18-35) the uptake is 49% (Osiemo et al., 2021)

Relevant policies and strategies	
Agriculture in general	Agricultural Sector Transformation and Growth Strategy (ASTGS) (2019-2029)
Digitalization in agriculture	D4Ag strategy
Digitalization in general	Kenya National ICT Policy (2019), defining current and future strategy for evolving and emerging technology landscapes in Kenya. Focus areas: mobile first, market, skills and innovation, public service delivery. National Broadband Strategy 2018-2023 All 47 countries have ICT roadmaps that align with local country development plans and the National ICT Master Plan Digital Economy Blue Print, defining how Kenya's and Africa's economic growth can leapfrog and improve through digitalization. Five pillars: digital government, digital business, infrastructure, innovation driven entrepreneurship, digital skills and values.
Data protection and privacy a. in general and b. in agriculture	Privacy and Data Protection Policy 2018; Kenya Data Protection Act 2019; Kenya Data Protection (General) Regulations 2021
Infrastructure (electrification, telecommunication)	National Broadband Strategy (NBS) 2018-2023 e.g. aiming to provide broadband services to all Kenyan citizens, improving digital literacy in schools, increasing 3G coverage to 94% of the population by 2020.
Financial inclusion (esp. Ag. and SME finance (digital and non-digital)	Finance Bill 2020 introducing a digital services tax for services provided through digital marketplaces in Kenya

5.2. The digital ecosystem in Kenya

A major strength of Kenya's digital ecosystem is the presence of strong MNOs, in particular Safaricom and its subsidiaries (i.e. MPesa). Additionally, many start-ups have their head office or branch offices in the country which creates a vibrant start-up culture. It is therefore not without reason that Nairobi has been dubbed Silicon Savannah[70]. Kenya has also seen expansive investments in the telecommunication sector, translating into good access to mobile networks and internet in most of the country, good availability of technological hardware, and a population that is becoming increasingly tech savvy and therefore perceived as open to digital agriculture solutions. Additionally, there is strong private sector engagement in digital innovations in the country[71]. This context with many emerging digital innovations, competing digital service providers, and a youthful and well-educated population that can access and is interested in digital tools and services is perceived as a fertile ground that digital service enablers are willing to support and that attracts bi- and multilateral donor investments and start-up funding. Having a dense start-up sector also creates opportunities for exchanging knowledge, successes and failures, and chances to experiment with e.g. data frameworks, shared data spaces, bundling of services, etc.

(Impact) investments in digitalization (in the agricultural sector)

Kenya is a large receiver of Foreign Direct Investment (FDI) on the African continent: 1.3 billion USD in 2019 of which the ICT sector is a big recipient (UNCTAD, 2020). This finding aligns with the top 100 African companies and the Agrifoodtech investments that were discussed earlier in section 1.1 in the general introduction. As elaborated in that section, important recipients of funding include TwigaFoods, Apollo Agriculture, and Pula Advisors.

5.3. Champions in Kenya's current digital agriculture ecosystem

Kenya has more than 100 institutions who offer digital agriculture services in Kenya, and more than half of them are also headquartered in the country[73]. Available services cover the entire value chain, ranging from agricultural advisory services, to weather information services, to financial services, to digital marketplaces and price information, etc. Some of the well-known services and service providers who operate in Kenya include DigiFarm, iCow, DigiCow, TwigaFoods, Hello Tractor, Apollo Agriculture, and diverse services offered through the governmental organization KALRO.

Despite the thriving start-up scene and financial investments, the many publications on deployment of digital agriculture in Kenya, and the seemingly daily addition of new projects and services, the study findings gave a more nuanced view when looking at the champions in the ecosystem (both supply and demand sides):

- Overall champions: Mainstream social media platforms owned by Alphabet and Meta
- At the digital agriculture platform level: Platforms and services with local intermediaries in the communities who hold trusted relationships with farmers and extension agents

70 Iazzolino, G. (2021). *What about the crates? Rethinking digital farming in Kenya*. LSE. https://blogs.lse.ac.uk/africaatlse/2021/03/25/what-about-crates-rethinking-digital-farming-agriculture-agritech-kenya/.

71 Digital Frontiers Project. (2020). *Digital Ecosystem Country Assessment (DECA) Kenya*. USAID. https://www.usaid.gov/digital-development/DECA/Kenya

72 Osiemo et al. (2021). *Digital Agriculture Country Profile: Kenya*. FAO and the World Bank.

- At grassroots level: Transitioning farmers with medium-level digital literacy; who own a smartphone and can purchase data bundles; who produce for more integrated value chains such as dairy, horticulture, coffee; and who produce conventionally with the use of agricultural inputs.
- Despite what may be expected based on what is generally assumed about the literacy, income, tech. savviness, and innovativeness levels of commercial farmers in LMIC, the commercial farmers included in the study were not champions of digital agriculture platforms.

5.4. Local and grassroots perspectives on digital agriculture

5.4.1. Which platforms and services do farmers and other grassroots actors use?

Although there are dozens of different digital agricultural advisory services that farmers and other grassroots actors could potentially access and use, their actual use by these actors is minimal. Digital service providers also recognize that the adoption of digital services is quite low. The study results from the three sub-counties suggest that only a handful of services are used by farmers (annex 2; table A). Among the smartphone applications, a total of 10 different applications were mentioned. Table 17 summarizes which services were used and with what purpose. Services owned by agro-input distributors (M-Tolori, Yara connect, Greenlife app) were mostly used to 'window-shop', while the e-commerce option (i.e. placing an order via the application) was hardly utilized. Another four applications are used (primarily by large-scale farmers and AGDs) to obtain weather information. Finally, two livestock specific applications (digiCow app[73], iCow app[74]) were used by farmers in Kiambu.

Table 17: Summary table providing an overview of the 10 digital agriculture services used by farmers and grassroots actors in the study areas, primarily to access agricultural information/advisory.

	Service name	How it is used by farmers and grassroots actors
Agri input services	M-Tolori	Used by farmers to: - Look up information about inputs - Check and compare prices of different agri-input products
	Yara connect	
	Greenlife app	
Weather information services	Weather app	Used by (large-scale) farmers to obtain (seasonal) weather forecast information
	Digifarm	
	KAOP	
	Yara Farmgo	
	AgriBot	AGDs push weather information to farmers via the chatbot
Livestock services	digiCow app	Used by (dairy) farmers in Kiambu to: - Obtain information about dairy production - Including instructional videos and audio - Have a farm monitoring system - Train farmers in the community (digiCow was used for this purpose by a VBA)
	iCow app	

73 https://digicow.co.ke/

74 https://icow.co.ke/

Conventional SMS services, TV, and radio remain important today

To find widespread adoption of agricultural information services, one either needs to look at conventional media such as radio and TV/. Programmes such as 'mugambo wa murimi' by Inooro TV, 'Shamba Shape up' by Citizen TV/Royal media services, and 'KTN farmers programme' by Standard media group were accessed by many farmers both on radio and television. Another, non-digital, conventional channel that remains relevant and widespread are the so-called Agricultural Training Centres (ATCs). Farmers access agriculture information by physically visiting ATCs. Furthermore, farmers visit these centres to learn or if the ATC holds a field day, farmers are invited through posters, SMSs, and public address systems. During these field days, the farmers are given fliers for further reading.

Looking at services that are accessed via SMS, the study found more diversity in the three counties. The government services are especially strongly present on SMS. Farmers receive seasonal weather forecasts from the ministry of agriculture, and general GAP information from KALRO, and information about the production of specific crop types and crop issues from a service like KCEP (on cereals). More weather information is received from Solidaridad, AgriTrade Kenya, AgriBot, and Ishamba. AgriTrade is also mentioned as a provider of information about seed variety selection and, together with Syngenta, information about pest and disease management. SMS services from the Ministry of Agriculture are also used by farmers to obtain information about market prices and upcoming events. Agri-bot provides, besides weather forecasts, general information about agricultural production.

Box 5: Two different stories: How off-takers communicate with their clients

Many Kenyan farmers sell most of the agricultural products they produce to middle-men who bulk commodities and sell it with a profit to processors, supermarkets, and markets in bigger cities. For middle-men, or off-takers, it is critical to know which farmer sells what product, at what time, and in which quantities. How do off-takers obtain this information?

Using the tools that farmers are using

Samuel is an off-taker in Kirinyaga county who primarily trades in cabbages. He buys cabbages from smallholder farmers, collects them with a truck at the farm gate, and sells them in the open market with a profit. Mr. Kariuki relies on conventional tools and media to obtain information. He trusts in the information that Inooro FM gives him via the radio. When asked about his awareness about digital platforms that could provide him with agricultural or market information, he says not to be aware of the existence of such platforms. When visiting farmers by motorbike mr. Karkiuki prefers to carry a basic phone because a smartphone could easily fall, and get scratched and damaged. He also does not need the smartphone, because most of the farmers he buys cabbages from are older and use basic or feature phones themselves. He hence does all of his communication via phone calls, and sometimes uses SMS. When it comes to financial transactions, this off-taker works either with cash money or an M-PESA account.

Using Facebook and WhatsApp to reduce fragmentation in intermediary-based value chains

Janet is a young female off-taker who buys horticultural produce from farmers in Kiambu county and

sells it with a profit to a Kenyan supermarket chain. Janet sources higher value horticulture crops such as lettuce, leeks, and kale. Whenever she fails to find the right quantity or quality of the products that the supermarket chain demands from the smallholder community, she supplements with produce from her own farm. Social media is an important source of information for Janet. Although Janet is a savvy user of social media, she is not aware of the existence of many applications dedicated to agriculture that she could potentially access on her smartphone.

Facebook posts from farmers help her to locate the farmers who are selling the products that she needs. Vice versa, Janet can post a message in a Facebook or WhatsApp group to inform farmers that she can offer them a market for a certain product and that they can get in touch with her.

Janet also uses Facebook and WhatsApp groups and status to sell her own horticultural and livestock produce. She finds it a challenge that it is not certain if and when she will get a customer for a product that she advertises on social media. This is of course a challenge with agricultural commodities since they are often perishable. Another challenge is that it is hard to determine if someone who expresses interest in a product through social media is really serious about buying it.

Rapid scaling of web-based and social media platforms in the agricultural sector

Being emergent farmers and therefore more tech savvy than an average smallholder farmer, the VBAs in the FGDs obtained much of their information by browsing the Internet, starting with a search query in Google search or YouTube. Other web-based information sources that were mentioned, primarily by AGDs, were all related to seeds, fertilizers, and other agricultural inputs, and include Mbeguchoice.com, KEPHIS.org[75], syngenta.co.ke, easeeds.com, simlaw.co.ke. Most of these webpages are only available in English, even those with a co.ke domain name.

Also widely adopted by the farmers and other actors included in the study are WhatsApp and Facebook. Numerous different groups on WhatsApp and Facebook of which grassroots actors are members were mentioned (see table X). These two platforms serve as a source of agricultural information that encompasses farming best practices, new varieties, weather data, advisories and market linkages. Farmers reported that they sign up for WhatsApp groups to access a wide range of agricultural information (i.e. where to find inputs, where to sell produce, etc.). The same is the case for Facebook Groups, e.g. groups like DKF-Farm Fresh, Pig farming Kenya, Broilers chicken market selling and buying Kenya, Kuroiler poultry farmers buying and selling poultry products, and Yara Kenya, among others, are all used to access GAP information, find answers to agricultural challenges, and buy and sell inputs and produce. Besides the groups on WhatsApp and Facebook, transitioning and large-scale farmers also use their timelines and WhatsApp status to sell produce within their own networks.

Trusted sources of information

In terms of trusted sources of information, the data provides no clear winner (table 18). In contrast, the mentioned sources of information range from Google search queries and YouTube, to extension agents and fellow farmers, to platforms like Yara Connect and AgriBot. What stands out here however, is that the widely used social media platforms are not recognized as trusted sources of information. This is in accordance with the widespread practice of farmers to verify the accuracy and suitability of information obtained

75 By the Kenya Plant Health Inspectorate Service (KEPHIS): https://www.kephis.org/

through social media with an extension officer. Interestingly, the same practice was reported for information obtained through Google search queries and YoutTube, even though these are also seen as trusted sources of information (at least in Kiambu county).

At the level of the agricultural extension officers, WhatsApp plays an important role. WAOs are members of WhatsApp groups with farmers where they respond to queries and verify information that is shared. On a one-on-one basis, farmers reach out to a WAO on WhatsApp if they have a problem in their farm for which they seek a diagnosis or cure (e.g. a disease or pest) or to verify the trustworthiness of information that was obtained elsewhere. WhatsApp has improved the information exchange process between farmers and extension officers, primarily because of the ability to exchange photos. Due to this function, a WAO can diagnose a problem with relative certainty without the need to visit the farmer.

Table 18: Overview of sources of information that farmers trust the most.

Kirinyaga	**Reasons why farmers trust the source**
SMS from MOA	The farmers have experienced that their information is most of the time reliable
Coffee Forum group on Facebook	Farmers get their questions answered hence information is reliable, they also receive information on chemicals to use in case of pest attacks.
Extension officers	Farmers call the ward agriculture officers if they need clarification or assistance. Similarly, extension agents from the coffee cooperative societies (to which farmers belong) are a phone call away. Farmers use WhatsApp to send photos of the problem, e.g., crops infested by pests to these extension agents. The officers can then give a response as to the remedy of the problem via WhatsApp or visit the farm.
Embu	**Reasons why farmers trust the source**
Weather forecast app	It has given accurate weather information for the last 3 years
Yaraconnect	Because the products used based on recommendations, especially fertilizers, reportedly helped to improve farm productivity
LDRI and Extension Officers	They have been of much help in the past and are always available when their help is needed
Kiambu (Githunguri)	**Reasons why farmers trust the source**
Google	It can be easily accessed at any time and place as long as one has data bundles and it has plenty of information
YouTube	They trust YouTube because apart from listening, YouTube gives them a chance to see the practical bit of anything agricultural-related that they google. Also, any information they get from YouTube they usually verify with the extension officers.
Agri-bot	They trust Agri-bot because it was introduced to them by the Microsoft team who were working in collaboration with LDRI and farmers trust LDRI since it has been training them on the maize value chain and giving them sample seeds.

Kiambu (Thika)	Reasons why farmers trust the source
Google	It can be easily accessed at any time and has plenty of information
Fellow farmers	They trust agricultural information they receive from fellow farmers through seeing what they have done and worked on their farms.
Extension officers	They trust them since they provide reliable information to them but it is hard to access them since they are few in the ward serving so many farmers (ratio of extension officer to farmers is too high)
TV and radio programs e.g. 'Mugambo wa Murimi'	They trust these programs because they usually invite agricultural experts who advise farmers and therefore the information, they give is informative and reliable

Experienced opportunities and challenges with using smartphones and digital platforms

Zooming in on the accessibility, usability, and ease of use of various digital (agriculture) platforms, farmers reported that they find them generally easy to access and use. Here it needs to be noted that the majority of the farmers were referring to the access and use of mainstream social media here, and not to dedicated digital agriculture platforms, because this is what they use. However, a limiting factor perceived by farmers is that not all platforms are available in local languages (table 19). English is always available, sometimes also Kiswahili (e.g. AgriBot is available in English and Kiswahili), but support for other Kenyan languages is uncommon. It may be a reason why TV and radio programs remain a very popular source of information for farmers, because those are also aired in local languages and thus remove language barriers.

Table 19: Overview of challenges that farmers encounter with the use of mobile services, primarily based on their experiences with social media use.

	Kirinyaga	Embu	Kiambu (Githunguri)	Kiambu (Thika)
(Smart)phones in general	Network connectivity especially in rural areas is a problem		Poor network coverage in some interior rural areas	Poor network coverage in some interior rural areas
	Bundles are never enough to maximize the use of the internet	Expensive to buy smartphones and bundles. If a farmer doesn't have money, then cannot afford it	The use of social media requires the use of data bundles which are expensive and not affordable to all farmers	The use of social media requires very pricey data bundles
			Battery power runs out fast on smartphones	Applications like WhatsApp and Facebook consume a lot of battery power
		Language barrier – most of the content is in English which can be detrimental for the illiterate farmers		Some farmers are not connected to the electricity grid, or sometimes experience power blackouts

	Kirinyaga	Embu	Kiambu (Githunguri)	Kiambu (Thika)
Specific to digital agriculture services			A lot of pop-up ads and push messages when using agricultural-related applications like iCow, Digicow, etc.	
			Some applications load very slowly and most of the farmers become impatient	
			Privacy challenges: When installing apps farmers are required to fill in personal information, but are not aware who uses that information, for what purpose.	

When asked about the perceived benefits of using a smartphone over a feature phone (table 20) primarily mentioned that it helped them to access information about anything related to agriculture at their own pace and at a time of their convenience. One farmer in Embu said that the smartphone is 'like a mini office for farmers', and farmers in Kiambu illustrated that the basic phones were limited in functions because one could only make and receive calls and SMS messages, and receive USSD messages, but for example not take and send pictures. The smartphone, in combination with the access to social media platforms, has also made new market channels available for farmers and enables them to have more control over the sales of their produce. A third benefit of the smartphone and social media is the ability for farmers to communicate in groups, and with diverse actors.

Box 6: The pros and cons of the use of social media in the context of agricultural production according to Kenyan study results

What farmers like about social media is that they can access it at their own pace, where and when they want, and have (or at least perceive) a certain level of control over who can and cannot see their posts and activities on social media, which provides a sense of control over data. Social media are also perceived as user-friendly, i.e. easy to access and use by anyone. Another benefit of social media according to farmers is that it can be accessed at one point in time intensively, allowing the farmers to benefit from the 1 hour data packages that African MNOs offer and which are more affordable than data packages with a long(er) use-time. To farmers this matters, as the cost of data is widely perceived as a barrier to the use of Internet-based services. Thus, mainstream social media currently trumps available digital agriculture applications. Importantly, social media allow the less literate or the elderly to access audio and video files in local languages, which are deemed practical and useful. Farmers also like the networking aspect of connecting

or belonging to social network groups set up to discuss specific agricultural topics (i.e. agricultural best practices, market linkages).
However, social media comes with a limitation. Farmers reported issues with scammers who are active on social media, especially Facebook and WhatsApp, and a fear of hackers. The issue with scammers is also visible in that farmers report trusting Facebook and WhatsApp less than, for example Google Search or YouTube.

Table 20: Perceived advantages and benefits of smartphones compared to basic and feature phones according to Kenyan farmers.

Advantages of smartphones compared to feature and basic phones			
Kirinyaga	**Embu**	**Kiambu (Githunguri)**	**Kiambu (Thika)**
1. Access to markets via WhatsApp groups enabled farmers to sell their agricultural produce 2. Networking with peer farmers allowed the exchange of knowledge, e.g., the Coffee Forum group on Facebook allowed farmers to exchange ideas and learn from one another 3. Farmers received training on group mobilization as a means of dealing with brokers who exploit them. This training was on farmers' WhatsApp groups 4. Farmers can order agricultural or livestock inputs and receive them on time 5. Farmers can access information on chemicals and pesticides	1. It's like a mini office for farmers. The farmer can use materials from the internet as a source of reference 2. Access to information on high-yielding varieties through google 3. Marketing of agriculture produces through WhatsApp 4. A library where farmers can google and get information 5. Information can be accessed at any time 6. Farmers can communicate in groups via WhatsApp groups 7. Farmers find buyers for their produce via social media platforms which helps with market access	1. It helps in knowledge sharing: Farmers with smartphones have online discussion forums and share their knowledge with others which is impossible with feature phones 2. Identifying Pests & Diseases: Farmers may encounter pests and crop diseases that are new to them. With a smartphone they can snap a picture of the ailing plants and send it to their extension officers. The extensionist can help to identify the issue and also quickly provide a solution. This is cost-saving and spares farmers the normal time and transport costs when going to consult extension officers (who are few and serve many farmers.) 3. It is a reliable source of agricultural information since they can use smartphones anytime to search for any agricultural information either from YouTube, Google, Facebook, WhatsApp, or agricultural-related applications or through calling or texting relevant people 4. Smartphones make it easier for farmers to sell their agricultural produce without necessarily having to go physically to the market. This also helps to eliminate the exploitation of farmers by brokers	1. It helps in knowledge sharing, that is, farmers with smartphones get enlightened by using smartphones through googling, and social media 2. It is cost-saving and time-saving because they do not have to incur transport costs while going to consult their extension officers who are scarce and also it takes a shorter time to get responses or help from the officers 3. With smartphones, farmers can download and save videos related to agriculture and watch them later during their free time which is not possible with the feature phone 4. It fastens technology transfer since through a smartphone farmers can access information about new technologies which other farmers are using, for instance, one farmer learned about plantain and where to get plantain seedlings from Facebook. 5. Smartphones make it easier for farmers to sell their agricultural produce without necessarily having to go physically to the market

Financial services

With Kenya being the birthplace of M-Pesa and all the success stories it has generated, it should not come as a surprise that M-PESA is the most commonly used agricultural financial technology (agrifin tech.) among farmers. The study shows that there is widespread dependence on the MNO Safaricom's M-PESA platform and infrastructure. Besides cash and bank transfer transactions, M-PESA is clearly the most widely used platform by all grassroots actors (annex 2, table B). Farmers and off-takers liked that with M-PESA the need to physically meet a buyer or seller is removed, which saves time and money. In Thika, farmers mentioned that with M-PESA the risk of sending agricultural produce to a client outside the community is reduced, because the client pays before the produce is sent off. On the other hand, farmers in Kirinyaga and Embu complained about issues with delayed or reversed transactions, money that is sent to the wrong M-PESA account, and fraudsters that try to access farmers' M-PESA accounts. Some farmers also complained about the charges for each M-PESA transaction, which was also a challenge that was mentioned by a digital service enabler during an interview.

Not only is M-PESA the most widely adopted fintech platform, other agrifin tech. services that were used to e.g. access credit and loans, such as M-shwari, Fuliza, Zenka Mobile Loan App, and Tala Loan App, are either a subsidiary of Safaricom's M-PESA, or link up with M-PESA to transfer the approved funds into a farmer's account. On the one hand is it easy to see Safaricom's success-story with M-PESA which has digital financial services made accessible in a rather inclusive way in Kenya. On the other hand does the study clearly show a strong dependency on one player both at the digital service user and at the digital service provider level. The question is if such a monopoly is beneficial and healthy in the long term.

Box 7: The cost of a smartphone

Figure 7: Advertisement for Safaricom's Lipa mdogo mdogo programme through which farmers can get a smartphone on a loan with a KShs 500 down payment followed by KShs 20 daily payment (source: Safaricom).

Although farmers consider smartphones to be expensive, and find the cost of data bundles a challenge, there generally appears to be consensus that these costs outweigh the benefits such as unlimited access to information that is of interest to a farmer. Farmers sometimes access smartphone devices on a loan but farmers in Thika complained that the phones are quickly disconnected if a farmer defaults paying a (daily) instalment. Other farmers obtain smartphones through a loan with a SACCO (interest rate 8%). Interestingly, the exact smartphone that a farmer obtains when participating in loan schemes may be determined by the loan provider. For example, in the case of Safaricom's Lipa mdogo mdogo programme, the loan taker always receives the same model smartphone from Safaricom with pre-installed Android Go and all Google Go applications.

Community financial services are still around

In addition to the aforementioned services, many farmers also still use the traditional village Savings and Lending Associations (VSLA) and community self-help groups to save money and access loans. VSLAs convene on a monthly basis and are structured in a way each committed member gives a monthly contribution. Collective savings are used to disburse loans to members on a need basis and the money that remains is either banked into their registered group bank account or the group treasurer keeps the money until they hold their next monthly meeting. A gender element here is that VSLAs and self-help groups are primarily accessed by women because they tend to be affiliated with so many groups where they can access credit/ loans. Similarly, a high proportion of women are members of SACCOs like Githunguri Dairy Cooperative Sacco where they can access loans depending on their shares. According to local farmers, a higher percentage of men are loan defaulters and therefore it becomes difficult for them to access credit and loans as compared to women.

Value chain specific financial and insurance services

Specific, more integrated, value chains, offer farmers who are members of cooperatives financial services. An example present in the study was Githunguri Dairy farmers Cooperative which uses an app called GDC. The app enables farmers to deposit, withdraw, save, and get financial statements and other services in the comfort of their homes using their smartphones so long as they have an active mobile money account. For GDC, as long as the farmer saves money or rather has adequate shares with the cooperative, they qualify to apply for a loan. Since the majority of the farmers in the Githunguri sub-county are dairy farmers, many receive digital agricultural financial services through the cooperative.

Another service provider that was mentioned several times, especially in Kirinyaga and Embu, is Apollo Agriculture. Apollo bundles various services; finance, farm inputs, insurance, market access, and advisory. The services that farmers in Embu and Kirinyaga were referring to included input credits, and crop insurance. Kenya based Apollo Agriculture is hence one example of a digital service provider and platform that has received much media attention, investments, and won awards that is also visibly present and used by smallholder farmers in Kenya.

The influence of the Covid-19 pandemic on the use of digital platforms

The Covid-19 pandemic has affected farmers' use of mobile phones and some digital platforms. The restrictions in movement and lockdowns caused reduced access to physical markets for smallholder farmers. Those with smartphones took advantage of social media like Facebook and WhatsApp to find buyers for their agricultural produce. Sold produce was sent to buyers via Copia[76] or directly to a buyer with public transport (matatu). M-PESA helped to facilitate the financial transactions that came with these sales. The restrictions for group gatherings made farmer meetings and training sessions difficult, hence farmers used their mobile phones to consult their peers and extension agents and to seek information.

5.4.2. Existing in-/exclusion of practices potential users and solution providers

In the two counties that were visited, focus group participants responded differently to questions related to equal access to digital technologies and digital agriculture services. For example, in Kiambu, farmers perceived that access to and the use of mobile phones by men and women was unequal. Contrary to the common understanding that women are more affected by the digital divide than men, the Kiambu farmers reported

76 Copia is a retail platform that operates in Kenya and Uganda and that directly links producers with middle- to low-income consumers which operates through over 30.000 agents. https://copia.co.ke/

the opposite. According to them women have somewhat better access to phones and use them more often than matter, according to them this is caused by the custom that men delegate their farming responsibilities to their wives who, in turn, do all it takes to feed the families. This increases women's financial capabilities and ability to purchase mobile phones. They acquire the phones to be able to plug into agricultural supply chains and source agricultural information to increase productivity. According to the farmers, women are also more motivated to access various digital platforms via their mobile phones, and to obtain new knowledge and learn new skills, which would make them the primary users of digital platforms. It needs to be noted that the latter is anecdotal and could not be verified within the scope of this study.

In regard to accessing credit and loans, Kiambu's farmers also argued that women had better access, primarily because they are more often members of VSLAs, SACCOs, and self-help groups. This is confirmed by various studies with an LMIC focus (e.g. Abdulai et al. (2022[77]); Seidu, (2018[78]); Greaney et al. (2016[79]). Since few farmers reported the use of agrifin tech. services, and nearly everyone reported the use of M-PESA, we were not able to collect data on a possible gender divide in relation to the access and use of agrifin tech. services. In Embu and Kirinyaga county there was no reported difference in access and use of smartphones and digital platforms. However, farmers in Embu reported that ultimately the man is more powerful and, for example, in a case where the man loses or breaks his phone he will claim the wife's phone.

Engaging users in digital agriculture in Kenya

A current trend in the digital agriculture sector in LMIC is the adoption of participatory approaches and a recognition of the need to actively engage users in the development and implementation of digital agriculture services. The interest for co-creation and a motivation to engage with stakeholders and users also became apparent in the workshop with supply-side actors and enablers in Kenya. For example, a representative of CGIAR's Digital Innovation initiative elaborated that when developing digital platforms, co-creation, or rather user engagement, is very critical so as to ensure the platform being developed is user-friendly and meets the expectations of the intended users. Also, it is good to evaluate the impact of digital platforms so as to ascertain if they are adding any benefits to farmers and other intended users. In line with this, a study participant from TruTrade Africa had the strong conviction that one should keep it simple: Stick to one function and do that very well. In their particular case the simplicity is in their bulking and trading model and the lean yet effective use of digital tools in this model. As a start-up they have been asked by other service providers and enablers to add more functions and services to their model, but they are hesitant to do so as it would add complexity. In a similar fashion, the CGIAR representative argued that simple solutions can be beautiful, and that it is essential that service providers match the affordances of their service with the digital capabilities of their users. To achieve this it is firstly important that digital service providers become demand rather than supply driven, and that they engage with users over a period of time to observe and measure the impact, trade-offs and consequences of their service. Secondly, demand driven may also mean that the same service is offered in different ways. A workshop participant illustrated this with an example from the food and beverage sector is the brand Coca-Cola, which sells a fizzy softdrink that globally looks, smells, and tastes the same, yet the packaging is adapted to the demands (and economic capacity) of the local consumer: Big bottles for families, small cans for children, cheaper 300ml bottles in LMIC. In a similar

77 Ibrahim Abu Abdulai, Shaibu Bukari & Moses Naiim Fuseini. (2022). Women's self-help groups and asset accumulation in periurban Wa, Ghana. *African Journal of Science, Technology, Innovation and Development*, 14:4, 906-918, https://doi.org/10.1080/20421338.2021.1917041.

78 Seidu, Amos Mahama. 2018. *Access to finance with VSLA groups*. IN: CTA. 2018. Experience capitalization: Insights on rural development in West Africa. Experience Capitalization Series 3. Wageningen: CTA: 13-17.

79 Brian P. Greaney, Joseph P. Kaboski, Eva Van Leemput. (2016). Can Self-Help Groups Really Be "Self-Help"? *The Review of Economic Studies*, Volume 83, Issue 4, October 2016, Pages 1614–1644, https://doi.org/10.1093/restud/rdw004

way do some digital agriculture service providers already offer their service in different ways, e.g. Agri-Bot can be accessed through SMS or WhatsApp. Diversification to various communication channels and the use of human intermediaries were also some of the ways used by workshop participants to reach different types of users and be more inclusive (table 21). However, digital service providers could still do more to tailor their service to the needs and capacities of diverse potential users (i.e. customers).

Table 21: Overview of the diverse users of services offered by supply side actors included in the study and how these service providers reach their users and adapt to their needs and demands with the aim to be more inclusive.

Organization	Users of their digital solutions	How they reach and meet the needs and demand of listed users (type of user engagement)
Mazao na Afya (M-tolori)	Farmers and stockists	Use of Bulk SMS, social media, road shows and farmers' training
WFP	Farmers, extension workers, donors, entrepreneurs	In-person engagement, phone calls, SMS, radio programs, digital applications
Tru Trade	Farmers, aggregators and buyers	They usually onboard farmers on a digital platform which they use to pay them through M-pesa once they deliver their produce to the aggregation centers-or the farmer service centers
Agrifin	Farmers organizations, donors, research firms, off-takers, decision making organizations-govt and other service providers	Through in-person engagements for farmers, digital training for agents and through e-commerce information for off-takers
Viamo	NGOs, Extension workers, government agencies, donors and organization implementers	IVR, SMS, Chatbots- makes it easier to access information in different languages.
Pelum	Farmers, member organizations	Create market linkages for farmers through having a digital platform for marketing organic products in Kenya.

5.4.3. The role of human agents and intermediaries in the digital agriculture ecosystem

There appears to be a link between the adoption of a digital agriculture service and the presence of an (human) intermediary who either represents the digital service provider or who acts as an advocate for the service provider. This clearly suggests that human agents play an important role when it comes to the adoption and use of digital agriculture services at grassroots level. Data from Kiambu furthermore shows that a popular service like Agri-Bot, which was introduced to farmers by intermediaries, also provides technical backstopping to farmers with a hotline that can be called. Farmers praised this service, saying that Agri-bot's technical team is usually quick to respond to any reported issue. Such technical backstopping is absent when it comes to mainstream social media. In case of technical issues with these platforms, farmers either turn to someone with technical knowledge (e.g. visiting a cyber cafe) or reinstall the application as a way to troubleshoot. Farmers may furthermore consult their children or tech-savvy relatives and peers when they experience technical challenges with the use of phones and digital services.

Two specific actors were mentioned as intermediaries who raise awareness about digital agriculture solutions and provide support with the use of such solutions to farmers: the Ward Agricultural Officers, and the Village Based Advisors, i.e. public extension agents. Farmers also actively seek support from these two actors when they seek trustworthy agricultural information or feel the need to validate information that was obtained through internet-based sources. VBAs, being farmers and users of digital agriculture services and social media themselves, access agricultural information which they share with peer farmers. There are also instances where agro-dealers advise farmers on digital services, e.g. those that can be consulted to obtain information about inputs (i.e. fertilizers, seeds), varieties and their dosage.

5.5. Existing digital and data infrastructure

The sample of farmers included in the study were all transition farmers, of which the majority owned a smartphone. Considering accounts from farmers and extension agents, approximately 40 to 50% of all (smallholder) farmers in the included sub-counties owned a smartphone. Especially older farmers who do not (yet) access smartphones. Overall, mobile network and internet connectivity in Kenya is satisfactory. However, farmers reported that instances of poor network and/or internet connectivity still exist, primarily in remote areas. More importantly, the cost of mobile data is deemed high by some farmers. This affects farmers' use of digital platforms and services. In some cases it means that a farmer decides not to use a platform because of the recurrent cost of data. An example of adapted use came from a farmer who explained that he uses 1 hour bundles (5Kes/500mb/1hr) and maximizes their use during that hour, for example by browsing or watching agriculture related movies on Youtube. The farmer explained that these short time bundles are much cheaper than bundles that are valid for a longer period of time. Despite farmers' creativity, the issues with internet accessibility and affordability would need to be addressed to pave the way for increased uptake of digital agriculture solutions. The issue of affordability of mobile internet is recognized in other studies too. For example, although Kenya has a 90% internet penetration rate (with 3G services covering 95.8% of the population, and 4G coverage covering 64.3% in 2020) (FAO, ITU, 2022)[80], and both the rural-urban gap has reduced in the past few years (GSMA, 2021)[81], thus creating a shrinking divide in coverage and therefore access to mobile internet, there remains a significant 'usage gap' that is primarily caused by the affordability of mobile internet (idem).

At the level of digital service providers and enablers, there is a reported lack of institutional capacity to understand digitalization and digital ecosystems, and what a digital transformation (could) mean for Kenya's agricultural sector in terms of benefits and trade-offs. At the moment there is a clear lack of a data-sharing ecosystem, which is becoming problematic given the overwhelming number of service providers competing for a place in the sector, the amount of similar (personal and farm) data that all these service providers collect, and the increasingly critical stance of farmers towards data sharing in combination with their limited data literacy level. Yet, at the same time, there are still pockets of data that very few actors are able to access; e.g. ground truthing data, data on social dynamics, changing digital literacy rates, incomes sources).

80 FAO, ITU. (2022). *Status of digital agriculture in 47 Sub-Saharan African Countries.*, FAO, Rome. https://www.fao.org/3/cb7943en/cb7943en.pdf

81 GSMA. (2021). *The state of Mobile Internet Connectivity Report.* GSMA. https://www.gsma.com/r/wp-content/uploads/2021/09/The-State-of-Mobile-Internet-Connectivity-Report-2021.pdf. The rural-urban gap refers to the likelihood that a person living in a rural area is using mobile internet compared to a person living in an urban area.

Box 8: Kenya's Unified Agricultural Data Platform

An ongoing initiative of the Kenyan government is the Unified Agricultural Data Platform (UADP). Kenya's Agricultural Transformation Office (ATO), which has the mandate to coordinate the implementation of the Agricultural Sector Transformation and Growth Strategy (ASTGS), is also in charge of establishing the UADP. Aim is to unify agricultural data at a national level in the platform and make it a public data source. The more seamless access and exchange of data between diverse actors operating in the agricultural sector should foster faster innovation and scaling and reduce:

- Duplication of data collected by different organizations
- Data fragmentation by bringing different actors together
- Data burden on the farmer side since the organization can now access data from ATO rather than conducting surveys with farmers every now and then and they are seeking/collecting similar data.

5.6. Existing digital and data policies and regulations

Data infrastructure and institutional context

Kenya developed an ambitious policy framework (The Digital Economy Blueprint[82]) that should help the country and Africa as a continent with economic growth and leapfrogging through digitalization. A defined sub-goal of the policy is that ICT contributes 10% to Kenya's economy by 2030. Notably, the blueprint pays minimal attention to the agricultural sector, despite this sector being critical for the country's GDP, export, and the livelihoods of the population (FAO, ITU, 2022). The importance of the agricultural sector is however recognized elsewhere. For example, in 2019 the Kenyan government launched the Agricultural Sector Transformation and Growth Strategy (2019-2029) in which it acknowledges the importance of data and technology, and the opportunities that digital services and analytics offer for the sector (idem). Nevertheless, a 2020 study by Makini et al.[83] found a shortage of policies, legal and institutional frameworks that specifically support digitalization and digital development in the agricultural sector. This issue of a lack of a data sharing framework, and an e-extension policy were also highlighted as a challenging factor by digital service enablers who participated in the study. Interestingly, a data governance framework for agriculture does exist since 2022 (in fact MoA is the first ministry to develop such a framework) and is publicly available through the webpage of Kenya's Ministry of Agriculture[84]. The framework should help with the development of a thriving data economy, and following its publication the ministry aims to enter into data-sharing agreements with partners. Beyond the challenges with existence (or finability) of policies and frameworks, study participants mentioned that transformations in agriculture need to come with sufficient financial and infrastructure support which, according to them, is missing.

Things may change quickly though; the Agricultural Transformation Office has developed a data governance framework that sets the tone for guiding principles and policies for data collection, handling, processing, and sharing amongst stakeholders while ensuring personal farmer data is secure and kept confidential. The

82 Republic of Kenya. (2019). *Digital economy blueprint: Powering Kenya's transformation.* https://www.ict.go.ke/wp-content/uploads/2019/05/Kenya-Digital-Economy-2019.pdf.

83 Makini F.M., Mose L.O., Kamau G., Mulinge W., Salasya B., Akuku B., and Makelo M. (2020). *The Status of ICT Infrastructure, Innovative Environment and ICT4AG Services in Agriculture, Food and Nutrition in Kenya.* FARA Research Report. Vol 5(11)P 75. https://library.faraafrica.org/wp-content/uploads/2020/03/The-Status-of-ICT-Infrastructure-Innovative-Environmentand-ICT4AG-Services-in-Agriculture-Food-and-Nutrition-in-Kenya-.pdf

84 Kenya Ministry of Agriculture, Livestock, Fisheries and Cooperatives. (2022). *Data governance Framework: For Farmers' registration data and roadmap towards its operationalization.* https://kilimo.go.ke/wp-content/uploads/2022/04/MoALFC-Data-Governance-Framework-2022.pdf.

framework seeks to empower stakeholders with tools and processes to deliver digital innovations, and make farmers confident and trusting enough to interact with the digital solutions that are made available to them. The framework should furthermore create awareness among farmers about their digital and data rights.

Table 22: Challenges perceived by farmers that relate to distrust in social media platforms and data exchange.

Specific to mainstream social media			Hacking of social media accounts by fraudsters	Hacking of social media accounts by fraudsters
	Fear of scammers		Being scammed on Facebook, especially when marketing agricultural produce	Being scammed on Facebook, especially when marketing agricultural produce.
	Misconduct in some of the groups especially on WhatsApp and Facebook. Some users of these groups post wrong or misleading information or content that is not related to agriculture and irrelevant	Misconduct in the WhatsApp groups	Getting misleading information through social media platforms	Getting misleading information through social media platforms
			Social media has no privacy thus farmers fear that their personal information is exposed to everyone in the world	Social media has no privacy thus farmers fear that their personal information is exposed to everyone in the world
			There are a lot of jokers on social media platforms especially Facebook who use derogatory language on other people's posts	

Farmers' perceptions about data and the safety of social media

Although farmers demonstrated enthusiasm around using smartphones and deemed them necessary tools in their day-to-day farming activities, they were also preoccupied with some perceived risks (table 22). These risks include having their social media accounts, especially Facebook accounts, hacked and being conned by scammers who reach out to them via social media platforms. That some of the farmers included in the sample possessed above average digital literacy was demonstrated by an account of a young farmer in relation to protecting himself from scammers: He's been avoiding suspicious links by only clicking on secured web links which he identifies by first checking whether they contain an "s" as part of the webpage URL. More generally, farmers say that they avoid sharing very personal information via social media platforms, e.g. phone numbers, and personal photos, as these could be used by conmen. This can however not prevent farmers from experiencing that when they post on social media, they often receive comments on their posts that include insults or derogatory language.

Generally, both men and women farmers expressed that they have concerns about their personal data whenever they use online digital agricultural solutions. When sharing their personal and farm data through digital products and services, farmers mentioned that they do not feel comfortable sharing their personal information since they are not sure what will happen afterwards when the data lands in the hands of third parties. Table 23 shows which specific types of data farmers are not willing to share through a digital platform and why. In line with this, a key informant from the start-up Yielder stated that he observed that Kenyan farmers are becoming increasingly critical when it comes to data sharing and data ownership. According to the interviewee this may be due to the overcrowdedness of the digital agriculture ecosystem in the country and the lack of clear returns on investment of the services that are offered to farmers.

Despite the concerns about data, farmers acknowledged that they do not read or attempt to understand the terms of service that they have to accept on installation of a smartphone application or when registering for a new digital (agriculture) platform. Reasons given by farmers for not reading the terms of service are that they find them too long, written in a small font-size, and difficult to read and understand. The Terms of service are most of the times also not available in the local languages.

Table 23: Summary of farmers' sentiments about sharing personal data.

<table>
<tr><th>Type of data</th><th>Kirinyaga</th><th>Embu</th><th>Kiambu (Githunguri)</th><th>Kiambu (Thika)</th></tr>
<tr><td>Personal Phone number</td><td></td><td></td><td>To avoid being conned by scammers</td><td rowspan="3">They do not feel comfortable sharing their personal information since they are not aware of the third parties that will get access to their data</td></tr>
<tr><td>Location data</td><td rowspan="2">Fear that someone could hack their phone and access their M-PESA and bank accounts</td><td rowspan="2">Fear that someone could hack their phone and access their M-PESA and bank accounts</td><td>To avoid being tracked by fraudsters</td></tr>
<tr><td>Personal Identification Number</td><td>It contains all their details and information and therefore should be private</td></tr>
<tr><td>Year of birth</td><td></td><td></td><td>Because most people use their year of birth as a pin for their vital accounts like bank accounts. Also, women prefer not to give their year of birth which can tell how old they are</td><td></td></tr>
<tr><td>Personal photos</td><td>Could be used maliciously</td><td>Could be used maliciously</td><td></td><td></td></tr>
</table>

5.7. Successful and unsuccessful business models

Before discussing business models of kenyan digital service providers, a weakness that was reported by actors across the sector needs to be noted. Both grassroots level actors, and digital service providers and enablers argued that the country's digital agriculture ecosystem has become crowded with many different initiatives who often operate in silos and implement many different interventions that lead to duplication of applications and data sources. This introduces the other weakness of Kenya's digital ecosystem by a representative of an international research institute is the absence of clear and sustainable business models at the level of the digital service providers, and absence of a systemic perspective and investment frameworks at the digital service enabler level. Combined, these weaknesses create a high risk of market failure.

Commonly used business models in digital ecosystems in general today include:

- Subscriptions (B2C, B2B)
- Indirect payments (B2B)
- Pay-per-use (B2C)
- Freemium model (B2C)
- Data monetisation (B2B)
- Advertising (B2B)[85]

The primary and secondary study data shows that, today, the majority of the in Kenya available digital agriculture services have a Business to Consumer model, often following a freemium model. Consumers in this case are primarily (smallholder) farmers. How do service providers stay afloat if they cannot generate revenue and profit from farmers (yet)? Of the actors who participated in the multi-stakeholder workshop, many received at least some donor grant funding (e.g. VIAMO, TruTrade Africa, Kenya Government supported Subsidized Fertilizer Initiative, and Agri-Bot).

Experimentation with data monetisation, pay-per-use, and subscription models are ongoing but very small scale or only in the pipeline. For example, AgriFin plans to experiment with a subscription model for their SPROUT platform, and KALRO intends to monetize the data on their Agdata Hub for the use by companies (while leaving it a public good for other actors, e.g. farmers). The context in which digital agriculture services are implemented is challenging however. Smallholder farmers are not used to paying for services, especially when it comes to information and advice. In other cases farmers' 'payment' remains invisible to them, for example when they sell produce via an off-taker at a lower price. A representative of AgriFin suggested that farmers are only willing to pay for services to which they can attach revenue, e.g. agrovet services, but not for knowledge and information that have no direct value proposition attached to them. It is questionable if farmers are willing to pay for services. For example, farmers in the study FGDs complained several times about digital services which (farmers suspected to) charge for their services e.g. SMS services that cost the farmer airtime, an application that requires the use of data bundles. Interestingly, the fact that social media requires data bundles too did not appear to be an issue, which ultimately makes it very difficult for digital services providers (especially those operating in the advisory sphere) to compete with mainstream social media that are built on a data monetisation model.

85 Here we follow a taxonomy that was introduced by the Digital Agrifood Collective Community of Practice in their Commercial Viability Assessment Tool: https://www.nlfoodpartnership.com/documents/283/Tool__Commercial_viability_assessment.pdf

5.8. Summary

	**The grassroots actors who are served and the services they receive** There are two types of grassroots actors, especially among farmers and off-takers: Those that are unaware of the existence of many services and smartphone applications; and those that are aware but who feel like the supply side of the digital ecosystem is flooded with a lot of services and applications and that it is difficult to choose a specific service. Many farmers do not see the need of using dedicated agriculture apps when social media can provide them with all the information they need. Farmers adopting digital agriculture services primarily do this to seek information, e.g. weather forecasts, input prices and suitable inputs, production of niche commodities, management of pests and diseases.
	**The types of value chains for which digital services are most effective today** Farmers operating in intermediary-based value chains benefit from social media platforms in the sense that it allows them to reduce their transaction costs by not selling through an off-taker. The trade-off is that the farmer now incurs the risks that are normally carried by the off-taker (e.g. market dynamics, pay-outs, transportation).
	**(data) accountability and transparency are becoming an issue and affect with whom farmers interact** Farmers struggle with determining the quality and reliability of agricultural content on social media and, sometimes, in digital agriculture services. They prefer to engage with extension officers as a trusted source of information thereby potentially adding to the workload of those extension officers.
	**Digital agriculture services struggle to attract paying users, and generate revenue and profit.** Use of digital agriculture services is seasonal, either provoked by the service provider (e.g. most MoA services are seasonal, farmers start receiving messages just before the planting season start) or because of dropping service demand from the farmer who is also considerate of the limited memory-space on his/her phone and possible data-cost if an applications remains installed on the phone. Farmers' willingness to pay for services, beyond the cost of mobile data, is very limited.
	**Competition and fragmentation threaten scalability of agriculture specific services** Kenya's digital agriculture ecosystem has rapidly expanded and become crowded. Coordination between digital service providers and enablers is weak, creating issues with supplication of services, fragmentation of content and data, competition between service providers without a clear value proposition for farmers, and a failure of services to scale and become financially sustainable. The unintended consequence is that mainstream social media by big tech companies are taking over and becoming champions in the digital agriculture space.

	**Co-creation is on the agenda but does not (yet) materialize in services with clear value propositions** Many digital service providers still develop services that are supply- rather than demand-driven, and fail to engage with their users and adapt their services to the capacities and needs of those users. Service providers also do not invest sufficient resources in explaining the value proposition of their service to farmers and other grassroots level actors, like extension officers, local NGOs, AGDs. Being that the latter are trusted intermediaries at grassroots levels, they act as gatekeepers and are critical to have on board as supporters of a service.
	**Data sharing and data governance are high on the agenda** Several (government) initiatives to govern personal and farm data, and to aggregate agricultural data and make it a public source are underway. These initiatives have potential to help with reducing fragmentation and market failure in Kenya's digital agriculture ecosystem if receiving sufficient financial and human resource support and being supported by enough enabling actors in the sector.
	**The real impact of digital services on farmers, farms, and the agricultural production system is unclear** There is a general lack of empirical evidence of the (indirect) impact and potential unintended consequence of digital agriculture services and data collection and sharing on farming practices and smallholder farmers' household livelihood and resilience. In the absence of such evidence, the value proposition of digital services is unclear to farmers which reduces their trust in and adoption of services.
	**New themes are attracting attention but not yet visible in services at grassroots level** Broadly speaking the absence of empirical evidence of the impact of digital agriculture services and mainstream social media on e.g. agricultural practices and decision-making by farmers it is difficult to predict if and how digital agriculture will affect environmental sustainability. Specific services and approaches targeting the environment, e.g. carbon off-setting and credit programmes, advisory on nature-based solutions do not yet capture wide scale interest by last-mile intermediaries or adoption by farmers.

6. Conclusions and recommendations for policy and practice

This final chapter first summarizes the key lessons that were derived from the case studies in Zambia and Kenya. Next, and based on the country study data, the chapter presents country-specific as well as general recommendations and action points for policy and practice were identified. The identified recommendations are our answer to the study's main research question: 'What are concrete short and longer-term interventions in smallholder digital ecosystems that could foster the scaling and sustainability of digital platforms?'

Highlights and key-lessons from Kenya and Zambia

According to the Boston Consultancy Group (2021)[86], the digital agriculture ecosystems of individual countries in the Global South are in different stages of maturation (figure 6). Following their assessment, Kenya has moved to the final stage (robust scaling stage) which would entail the presence of robust digital infrastructure and innovation capacity to support mass scaling of digital agriculture solutions. Our study results show that Kenya has indeed strong internet connectivity and data infrastructures. Additionally, it has a vibrant tech innovation ecosystem which has attracted and boosted start-ups and some of the leading AgTech companies on the continent (e.g. John Deere, Syngenta). Nonetheless, the study results also discovered that some challenges persist, like the actual awareness about and adoption and use of the services by farmers, the visibility of the services' value proposition to farmers, and the financial sustainability of the supply side actors.

Regarding Zambia, we already elaborated that the country's digital ecosystem is less mature compared to Kenya. We would categorize the country at the end of the digital inflection point or early in the moderate digital capacity stage (figure 6). Moderate digital infrastructure is present, and there are several public and private sector led initiatives. However, there is still a need for broadscale capacity development, and digital agriculture initiatives lack impact and scale at this point in time. In addition, the country still lacks well articulated and agriculture specific strategies on how to integrate digital technologies into agriculture for national socio-economic transformation.

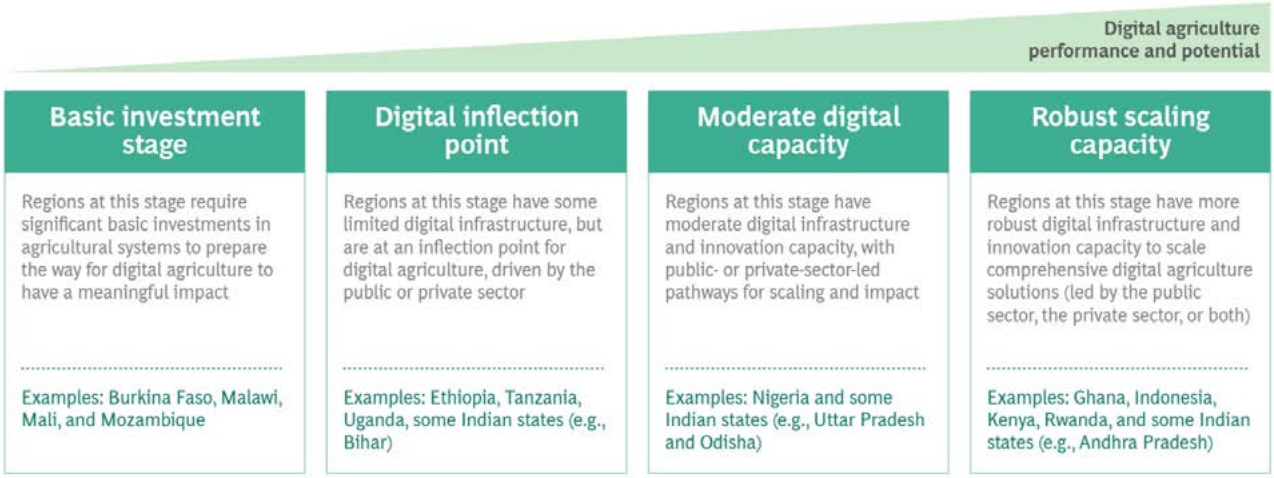


Figure 8: Countries go through various stages before reaching full maturity while developing the national digital agriculture ecosystem. Adapted from Boston Consultancy Group, (2021).

86 Baskaran-Makanju, S., Hoo, S., Mitchell, C. Larson, J. Unnikrishnana, S., Vasudevan, S., Zrikem, Y. (2021). *The digital agriculture revolution will take more than innovation.* Boston Consultancy Group. Accessed on 23 September 2022 from https://www.bcg.com/publications/2021/digital-agriculture-and-development

Recommendations for interventions to improve digital ecosystems in Kenya and Zambia: short- and longer-term actions

The recommendations presented below specify (1) actions that can be taken by one or more coalition members (possibly building on past, ongoing, or planned projects of coalition member organizations or projects by other (local) actors in the sector that the coalition could add value to, and (2) contributions that the coalition could make to improving the entailing digital agriculture ecosystem(s) and/or agricultural systems more generally through learning, knowledge exchange, and advocacy.

Kenya

Recommended intervention	*Establish a verification system for buying and selling agricultural products and produce*
Challenge in SHF ecosystems addressed by intervention and why that is important	Despite the various digital agricultural marketplaces that have been developed for farmers, the Kenyan case shows that farmers rely on Facebook groups, Facebook timeline, WhatsApp groups, and WhatsApp status to buy and sell. The challenge with these media is that farmers cannot verify the reliability of a buyer or seller. In both Kenya and Zambia, farmers reported issues with scammers who are active on social media, especially Facebook and WhatsApp, and fear of hackers.
Design principles responding to	
Coalition priorities responding to	▪ Digital and data infrastructure affecting digital agriculture ▪ Scalable (business) models
Timeframe for the intervention	Short-term, the coalition could assess how members could contribute to making the use of social media as a source for agricultural information and marketing safer for farmers. Furthermore, explore the demand for local alternatives and/or agriculture sector specific alternatives to mainstream social media. Medium-term, the coalition can advocate for both collaboration and aggregation of funding in the digital agriculture ecosystem to support the development, scaling, and maintenance of alternative platforms, i.e. the development of a 'Facebook' for agriculture. This would be a sort of 'platform of platforms' that offers a 360 degree experience to farmers. The coalition may also do advocacy around the sharing of data stemming from social networks to benefit ecosystem actors through the design and roll out of new products (i.e. financial products).

Lead and support actors	Short-term interventions can be a joint effort of the full coalition, with coalition members acting as influencers and advocates for smallholder farmers vis-a-vis commercial parties operating social media platforms to establish a safe and accessible digital space where farmers can exchange information, buy and sell. Potentially also support countries to come up with data governance policies that protect data subjects while using social networks into farming activities. Medium -term interventions: Rabobank, IFAD, i.e. actors with their footing in the financial sector.

Recommended intervention	*Establish farmer-friendly, safe, integrated, and affordable social media platforms for farmers*
Challenge in SHF ecosystems addressed by intervention and why that is important	Looking at the services that are made available to smallholder farmers and what they in practice use there is a discrepancy. Most farmers in the 'adopter' category appear to prefer informal channels over formal digital agriculture service providers, in other words, they choose general social media such as Facebook, WhatsApp, Youtube, and Internet search via Google search over dedicated agricultural services. Even if it is not driven by a preference but by a general lack of awareness about the existence and availability of agricultural applications, the fact remains that uptake of general social media is much more advanced at this point in time. Thus, farmers rely on Facebook groups, Facebook timeline, WhatsApp groups, and WhatsApp status to buy, sell, and learn, and network. However, current features do not respond to all farmers' needs and leave room for malpractices that affect farmers negatively.
Design principles responding to	
Coalition priorities responding to	▪ Local and grassroots perspectives ▪ Scalable (business) models
Timeframe for the intervention	Medium-term: The coalition could establish a system where buyers and sellers can review and rate each other. Well regulated online marketplaces can be set up as a pilot and assess whether they can be a solution to this issue.
Lead and support actors	The coalition members can do advocacy around the customization and integration of social networks to better respond to farmers' needs. Potential partners include Meta, Alphabet, Microsoft if the aim is to make specific existing platforms safer by collaborating with the private sector.

Lead and support actors	Alternatively, national and regional institutions with governing power if the aim is to govern existing platforms top-down. This intervention can only succeed if it can either convince and onboard developers of mainstream social media, or if it manages to attract enough investments

Recommended intervention	*Generate evidence of the impact of digital services on the public extension system*
Challenge in SHF ecosystems addressed by intervention and why that is important	Farmers perceive a need to first verify the trustworthiness of information that is obtained through non-conventional advisory channels. To fulfil the demand for information verification, farmers fall back on traditional intermediaries and trusted information sources. The majority of the farmers turn to their extension officer for this. Farmer's distrust in information that is obtained through web pages, social media, message services, or application may in fact increase the burden on the few available extension officers, thereby breaking the promise that digital agriculture would introduce a new trustable source of information and as a result reduce the burden on human extension agents and increase the efficiency and effectiveness of (public) extension services.
Design principles responding to	
Coalition priorities responding to	▪ Human agents and intermediaries ▪ Digital literacy and capacity of change-makers ▪ Local and grassroots perspectives
Timeframe for the intervention	Short-term: The coalition could work together with the Ministries of Agriculture in the case-countries to establish the real impact of digital agriculture and social media on the activities and workload of extension officers. The coalition may furthermore identify entry-points to actually strengthen and unburden existing extension services by enhancing reliability of and trust in available digital resources so that these can become the go-to resources for farmers and other last-mile actors.
Lead and support actors	Syngenta foundation, IDH, GFN may support generation of evidence on the effectiveness of digital extension services and social media and trade-offs for public extension.

Recommended intervention	*Develop evidence on suitable business models and funding mechanisms for digital agriculture in Kenya*
Challenge in SHF ecosystems addressed by intervention and why that is important	Kenya is one of the main recipients of start-up and grant funding in Africa's digital agriculture sector (and LMIC more broadly) but the evidence on the ROI of those investments is minimal, many start-ups fail or are forced to remodel, and reliance on (donor) funding is large.
Design principles responding to	
Coalition priorities responding to	▪ Scalable (business) models
Timeframe for the intervention	Short-term: Conduct a study on start-up and donor funding mechanisms and flows in Kenya's digital agriculture ecosystem Medium-term: Be a frontrunner of alternative investment and business models that lead to sustainable digital agriculture services.
Lead and support actors	Rabobank and IFAD can commission or execute an assessment of existing business and funding models that are in place in Kenya, their effectiveness, and suitable alternatives.

Zambia

Recommended intervention	*Advocate for investments in last-mile connectivity*
Challenge in SHF ecosystems addressed by intervention and why that is important	Mobile network and internet coverage is incomplete in Zambia, making it inaccessible and unaffordable for smallholder farmers. Improving this would have a positive impact on the adoption and use of digital agricultural solutions.
Design principles responding to	
Coalition priorities responding to	▪ Local and grassroots perspectives
Timeframe for the intervention	Short-term: The coalition can organize national level dialogues to explore investment and partnership opportunities around advancing internet connectivity, availability, and affordability in rural Zambia.

Timeframe for the intervention	Long-term: Some coalition members might consider co-investing in last-mile connectivity solutions in the long-term.
Lead and support actors	A coalition members such as IFAD can play a catalytic or conveying role that would enable PPPs to establish more internet rollout initiatives that benefit rural areas.

Recommended intervention	*Support the development of a national agricultural technology strategy*
Challenge in SHF ecosystems addressed by intervention and why that is important	Clear guidance to various ecosystem actors is lacking which causes fragmentation in the sector(with actors focusing on ad-hoc, non-sustainable AgTech initiatives).
Design principles responding to	
Coalition priorities responding to	▪ Digital and data policies and regulations affecting digital agriculture
Timeframe for the intervention	Short-term: The coalition can support Zambia to draft a digital agriculture strategy which lays out guidelines and rules for the development of a sustainable and responsible digital agriculture ecosystem. Medium-term to long-term: The coalition can convene or support interventions at national and sub-national level that support implementation of the national strategy.
Lead and support actors	Coalition members like Clim-Eat, ISEAL, and IDH could help the government of Zambia to develop a tailored digital agriculture strategy with clear goals and milestones, including goals that support climate change mitigation and adaptation, sustainable agricultural practices, and SDG targets.

Kenya + Zambia

Recommended intervention	*Join forces in developing and maintaining open data platforms (Kenya) and data governance frameworks (Zambia) with public and private sector data*
Challenge in SHF ecosystems addressed by intervention and why that is important	Although (big) data has been dubbed the 'new gold' or 'new oil', the fragmentation of data has hitherto tempered the findability, accessibility, interoperability, and reusability of data. As a result, information about diverse agricultural technologies and practices and evidence of their impact on (smallholder) farmers

Challenge in SHF ecosystems addressed by intervention and why that is important	remains scattered and, consequently, it remains unclear to farmers how (digital) technologies may help (smallholder) farmers. Arguably data is the most precious (private) asset private sector actors possess. As a result, they don't openly share it with competitors or other private sector actors. This is in most cases at the detriment of data subjects who would otherwise benefit from more services and products availability. Information about diverse agricultural technologies and practices and evidence on their impact on (smallholder) farmers remains scattered. If more private sector data is shared and integrated for services design and delivery, it could benefit various ecosystem actors, lead to development of new services, and, ultimately, impact last-mile users (i.e. smallholder farmers).
Design principles responding to	
Coalition priorities responding to	▪ Digital and data policies and regulations affecting digital agriculture
Timeframe for the intervention	Short-term: The coalition can do advocacy around the notion of data as a public good. In mature ecosystems such as Kenya, the coalition can conduct policy dialogues and public consultations around the notion of agricultural data as a public good, and actively collaborate with the public and private actors implementing data platform initiatives, e.g. by making data available, supporting financially, or providing expert knowledge. These activities would be conducted with the aim to unlock more multi-stakeholder data sharing at country level. In Zambia, the focus can be on raising awareness and building the capacity of the public sector, e.g. supporting the ministry of agriculture to draft their data governance framework and an operationalization plan.
Lead and support actors	Syngenta foundation, NFP, and IDH can advocate for the notation of data as a digital public good. The full coalition could support and potentially collaborate in national and international efforts by other actors (E.g. Kenya's ATO, GIZ DIASCA, CGIAR DI/DX).

Recommended intervention	*Develop the capacity (Zambia) and presence (Kenya) of intermediaries who can create awareness of farmers about and trust in digital solutions (Kenya) and develop farmer's information seeking behaviour (Zambia)*
Challenge in SHF ecosystems addressed by intervention and why that is important	farmers' awareness about, trust in, and adoption of digital services. Not all supply side actors have such intermediaries present in the communities, and this appears to affect the success of the services they offer. On the other hand, it was observed that local actors such as village based agents (VBA) in Kenya or

Challenge in SHF ecosystems addressed by intervention and why that is important	agro-dealers in Zambia sometimes assume the role of intermediary for some services on a voluntary basis. In some cases these actors partially incur the cost of the adoption of services by or dissemination of digital advisory to smallholder farmers. In summary, the digital literacy of intermediaries is often low (especially in Zambia), awareness of available services and their value proposition limited, and remuneration for intermediaries insufficient.
Design principles responding to	
Coalition priorities responding to	▪ Human agents and intermediaries ▪ Digital literacy and capacity of change-makers
Timeframe for the intervention	Short-term: Invest in and establish a curriculum to train intermediaries in digital and data literacy. The coalition could alternatively support local intermediaries by developing suitable (financial) support and incentive systems for them. Medium-term: Collaborate with digital agriculture service providers to develop communication materials and train intermediaries on the use and usefulness of diverse services (and potentially also on access and use of public data). At the national level, the coalition can act as convener and bring together intermediaries and various service providers to discuss diverse solutions, their general value proposition, and how intermediaries could benefit from them. Intermediaries can then be equipped to serve as "one-stop" points for accessing various agricultural services (digital, non-digital) and earn a certain commission fee.
Lead and support actors	Syngenta foundation, ISEAL, and GFN can work together with local organizations and public extension service providers to develop training and communication about digital services.