

Digitisation in Agriculture in Tanzania: Farmers' Knowledge Systems, Digital Tools and Diverging Scripts



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Abstract

Sub-Saharan Africa has emerged as an epicentre for investment and deployment of digital tools primarily targeting small-scale farmers in the name of development. Through an ethnographically informed and qualitative case study of Tanzania, this research project contributes to the literature on digitisation in agriculture by unpacking the nuances of how global and regional trends play out in a country-specific context. Through a methodology that explores the national level digitisation in agriculture landscape, as well as rural farmers' lived experiences, this project unpacks the fits and misfits between agricultural knowledge systems and those presumed by digital application, as well as the consequences for the utility of digitisation in agriculture in Tanzania. Drawing on script theory, digital tools are understood as active in constructing (intended) users by suggesting, permitting and preventing different courses of action for farmers. In addition, by engaging with conceptualisations of choice, the study engaged with the choices that digitisation in agriculture aims to make *for* farmers and how farmers mediate these.

I critically examine the relationship between 108 identified digitisation in agriculture tools and the local knowledge systems they seek to enter and improve. Findings suggest a dissonance between the assumed and actual use and impact of digital tools for rural farmers, with mismatches between assumptions scripted into digital tools and farmers' lived realities. In addition, findings demonstrate how rural farming communities have developed innovative informal digitisation in agriculture practices, using (typically basic) mobile phone devices and functions to strengthen established agricultural knowledge networks, practices and situated needs and interests. The study suggests that further research should explore pathways to strengthen farmers' role as innovators, enabling continued farmer-led innovation in digitisation in agriculture. The study further indicates the need for further research to contribute towards agricultural futures that preserve farmers' sovereignty and choice.

Dedication

To my sons Leon, Noah, and Sami - my junior research assistant – who were all born during my PhD journey. You have taught me how to juggle fieldwork, coding data, and meeting deadlines with pregnancy complications, diaper changes, sleepless nights, and chasing after babies that grew into toddlers and, subsequently, the little boys you are today. It has been rewarding and challenging to grow into a mother of three and a researcher simultaneously.

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Figure 1: My two older sons, Leon and Noah, accompanying me during participant observations in Ubiri Ward, Lushoto.

Declaration

I, Hannah McCarrick, confirm that the Thesis is my own work. I am aware of the University's Guidance on the Use of Unfair Means (www.sheffield.ac.uk/ssid/unfair-means).

This work has not been previously been presented for an award at this, or any other, university.

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Introduction

Chapter 1

1.1. Introduction

Information and communication technologies (ICTs) have been recognised as potential tools to support small-scale farmers in an evolving agricultural context (GSMA, 2017). High hopes and expectations have been attached to the imagined potentials of digital technology-based tools, applications and services aiming to increase farmers' access to information, restructure agricultural value chains and foster 'improved' farming practices that, by extension, are assumed to increase farm productivity and profitability (Aker, 2011; Baumüller, 2012; FAO, 2015a; Krone et al., 2016; Okello et al., 2013). Private and public sector stakeholders have invested in digitisation in agriculture services that seek to reduce perceived information and knowledge asymmetries and improve service delivery to farmers by providing access to market prices, agricultural information and decision support via one or a combination of ICTs.

Over the past two decades, hundreds of digitisation in agriculture tools have been developed and implemented across Africa. For example, in 2015, at least 140 digitisation in agriculture tools were rolled out across the Majority World (Aker et al., 2016), which grew by 900% to reach 1,400 active services in 2023 (Beanstalk AgTech, 2023). Sub-Saharan Africa has emerged as an epicentre for digitisation in agriculture investment and deployment (Beanstalk AgTech, 2023; ITU & FAO, 2022; Tsan et al., 2019). A 2019 study identified 390 active digitisation in agriculture tools in Sub-Saharan Africa (Tsan et al., 2019). Quotes such as “nowhere is the potential of disruptive technologies in agriculture more promising than in Sub-Saharan Africa, where agriculture employs nearly 70 per cent of the region’s entire population” (Kim et al. 2020:xv) illustrate the narrative

that underpins the hype, the rationale and the assumptions embedded in discourses around the imagined impact of digitisation in agriculture in Sub-Saharan Africa. This study contributes to the growing contributions of critical voices in the ICT4D and digitisation of agriculture literature (see Chapter 2).

Despite the continued proliferation of digitisation in agriculture (Beanstalk AgTech, 2023), the literature presents limited evidence of its utility. The body of research suggests that the uptake and impact of digitisation in agriculture have been more limited than expected, with several literature reviews highlighting the need for more research to understand the relationship between digital technologies and small-scale agriculture in the Majority World (e.g. Aker et al. 2016; Baumüller, 2018; Kante et al., 2016; Krone et al., 2016; Nakasone et al., 2014). This study unpacks how global and regional trends in digitisation in agriculture play out at a country level through an ethnographically informed and qualitative case study set in Tanzania.

But this study is unusual. The proliferation of digitisation in agriculture service deployment continues despite limited and inconsistent evidence on use, impact and utility. This inherent paradox raises questions about the motives and interests that underpin the continued funding, implementation and promotion of digitisation in agriculture solutions in Sub-Saharan Africa. Technology is never neutral (Castells, 1996). This study recognises that the interests and assumptions of stakeholders in the sector intimately shape digitisation in agriculture services. By providing digitally enabled information, advice, and services, digitisation in agriculture implicitly and explicitly seeks to influence, shape, and incentivise farmers' behaviour and decisions. Drawing on Science and Technology Studies (STS) and script theory (Akrich, 1992), this project understands digitisation in agriculture tools as active in the construction of users by suggesting, permitting and preventing different courses of action for farmers. At the same time, farmers' interpretation, acceptance (or rejection) and appropriation can re-script digitisation in agriculture applications and services (Akrich, 1992; Rose et al., 2016; 2018).

By using choice as a conceptual lens (Kleine, 2013), the study engages with questions about the choices that digitisation in agriculture aims to make *for* farmers and how farmers mediate these. Through this approach, this project seeks to unpack the fits and misfits between rural Tanzanian farming communities' agricultural knowledge systems and digital realities, as well as the assumptions embedded in the design and content of digitisation in agriculture services. By

contrasting and comparing the demand (farming communities) and supply (digitisation in agriculture services and applications), the study is uniquely placed to analyse and discuss a country-specific expression of (mis)alignments as well as the consequences for the utility of digitisation in agriculture in Tanzania.

1.2. Research Objective, Aims and Questions

The objective of this research project is to critically examine the relationship between digitisation in agriculture tools and the digital realities and local knowledge systems they seek to enter and improve. The objective is to contribute to ongoing academic debates around digitisation in agriculture in the Majority World through an empirical case study set in Tanzania. The objective is operationalised as a three-fold research aim that seeks to answer five research questions, as outlined in Table 1.1.

Table 1.1: Research Aims and Questions		
Research Aim 1: Critically analyse the Tanzanian digitisation in agriculture landscape and digital tools designed for small-scale farmers.	Research Aim 2: Understand Tanzanian rural small-scale farmers' digital realities and local knowledge systems.	Research Aim 3: Understand the relationship between farmers' digital realities and local knowledge systems and digitisation in agriculture tools in Tanzania.
Research Question 1a: What past, current and planned digitisation in agriculture tools have been designed for and deployed in Tanzania?	Research Question 2a: How do small-scale farmers in Ubiri and Kikwe access, generate, transmit and act upon agricultural knowledge and information?	Research Question 3: (How) do digitisation in agriculture initiatives (mis)align with Tanzanian small-scale farmers' digital realities and local knowledge systems?
Research Question 1b: (How) do embedded ideologies, narratives and assumptions shape the choices digital tools present to Tanzanian farmers?	Research Question 2b: How do small-scale farmers in Ubiri and Kikwe use, negotiate, assimilate, mediate and re-script digital technologies to meet their needs and interests?	

1.3. Summary of Methodology

Through an in-depth case study of Tanzania, this study contrasts the country-level digitisation in agriculture landscape with the digital realities and local knowledge systems in two rural farming

communities. The study used a combination of desk research and key stakeholder interviews to compile a detailed inventory of past, current and planned digitisation in agriculture apps and services designed for and deployed in Tanzania. In addition, the study has employed a rich set of ethnographically informed qualitative methods to work with two rural farming communities and unpack farmers' perspectives, practices and experiences of local-level manifestations of digitisation of Tanzania's agriculture sector.

1.4. Summary of Key Findings

This study unpacks narratives, ideologies, and interests that shape digitisation in agricultural initiatives (Abdulai, 2022a; Benegiamo, 2023). The technological scripts of digitisation in agriculture tools are contrasted with the lived experiences, digital realities and knowledge systems of farmers in two wards in rural Tanzania. Findings illustrate how digital services and tools can be understood as instruments for behaviour change, aligning with the interests of various stakeholders in the ecosystem that have direct and indirect influence on the technology. I present findings that exemplify how ideologically charged design and content choices embedded in digital tools targeting Tanzanian small-scale farmers shape the choices that are (and are not) presented to the intended users (small-scale farmers). Against this background, I examine digital solutions for farmers as ideologically charged and recognise that they are well-positioned to act as (potential) instruments to shape a particular type of farmer who makes decisions and behaves in ways that align with the envisioned trajectory of a specific agricultural future that aligns with hegemonic discourses that dominate the development discourse.

The study reveals a crowded and fragmented digitisation in agriculture landscape, with 108 identified digitisation in agriculture tools in Tanzania. Among the identified tools in Tanzania, advisory services targeting small-scale farmers dominate, with many services requiring the user to access a smart device and internet connectivity. I analyse and compare findings about the macro-level landscape with micro-level data generated from ethnographically informed qualitative research with two rural farming communities.

Using ethnographically inspired and qualitative methods, this study has generated in-depth insights into the detailed intricacies that shape how farmers use mobile phones in two rural farming communities. The findings significantly contrast assumptions embedded in the scripts of identified digitisation in agriculture tools in Tanzania. In the case study communities, only a handful of

farmers knew of or had used digitisation in agriculture tools. The participants in the case study sites predominantly used and accessed basic mobile phone devices as part of complex, intentional and strategic digital practices navigating needs, interests and context-specific digital access-related challenges and opportunities. The study found that farmers who participated in the study used digitally-enabled practices - primarily using standard functionalities on basic mobile phone devices - to support their needs and interests, which are situated within their existing digital realities, knowledge systems, and contextual needs. These farmer-led *informal digitisation in agriculture practices* carry out many of the tasks and functions that the identified digitisation in agriculture tools imagine enabling for farmers. These innovative informal digitisation in agriculture practices are situated within farmers' existing digital realities, knowledge systems and contextual needs. Findings further illustrate that many digitisation in agriculture tools reproduce design-reality gaps (Ayoung & Abbott, 2021; Heeks, 2003; Masiero, 2016) and offer services that already exist more efficiently through informal digitisation in agriculture practices. The study looks at specific examples of how design-reality gaps play out in farmers' lives using the example of digitisation in agriculture tools focused on providing market price information by dissecting the reproduction of an information deficit model.

The study adds to current debates by unpacking mismatches between digital technology's imagined and actual roles in rural farmers' lives. Based on the findings, this study suggests that rural small-scale farmers need to be recognised as active knowledge creators and innovators rather than passive information recipients of advice and information. I contribute to a long line of academic contributions highlighting farmers' contributions as proactive, intentional innovators in the face of dynamic agricultural contexts (e.g. Feierman, 1990; Mortimore, 1989; Richards, 1985).

In the context of digitisation in agriculture in Tanzania, I illustrate how farmers - in their role as innovators - navigate, confirm, reject and rescript the script of digital technologies. By doing so, this dissertation contributes to existing debates around digitisation in agriculture by challenging assumptions about farmers' roles in utilising emerging technologies and innovation through agriculture practices - exploring nuance around the nexus between digital technologies (mobile phones) and farmers' practices, behaviour and choices. This study examines digitisation in agriculture from a perspective that seeks to contribute towards trajectories where farmers' agency and choice are enhanced, regardless of the "label" it operates under. I aim to support farming

futures that enable farmers to navigate the agricultural sector on their terms, where they can define their pathway and agrarian future.

1.5. Scope & Limitations

This study contributes to debates on the relationship between digitisation in agriculture and local knowledge systems, focusing on the uses and usefulness of digital technology for supporting farmer-centred understandings of development. I contribute to existing academic literature with a rich, detailed and insightful case study that analyses and compares national-level digitisation in agriculture landscape data and local-level findings from two rural farming communities.

The scope of the study is intentionally narrowed to focusing on high-level data about the broader landscape and an in-depth understanding of two selected rural communities - reflective of the aim to generate contextual richness. I do not claim this study is an exhaustive account of digitisation in agriculture in Tanzania; I contribute with a rich case study that serves as a foundation for further research, conceptualisation and academic inquiry. Findings speak to a specific temporal and spatial snapshot within the defined scope, which entails generalizability limitations within and beyond Tanzania as the digitisation in agriculture landscape and farmers' digital and epistemological realities continue to change and evolve. Findings from this study may translate between and within countries, but each context is unique. The beauty of qualitative research is that it is possible to present, discuss and analyse a web of interlinking narratives that co-exist, co-produce, and mutually reinforce each other.

I have made explicit efforts in the methodology design to acknowledge the complexity of the digitisation in agriculture landscape in Tanzania and the extensive body of heterogeneous cross-disciplinary digitisation in agriculture literature (Chapters 2 and 3). This study has captured (some of the) nuances and intricacies of digitisation in agriculture at the macro- and micro-level at a specific point in time, complementing and contributing to the existing academic debates about digitisation in agriculture in the Majority World.

1.6. Guide to the Dissertation

Following the introduction, Chapter 2 situates the study within existing literature and knowledge. Chapter 3 outlines the methodology used, and Chapter 4 provides insights into the case study context – Tanzania. The subsequent four chapters (5 – 8) share data about four perspectives of the

thesis: the digitisation in agriculture landscape, farmers' lived experiences, insights about farmers digitally enabled agricultural practices and the role of ideology in shaping technology. Chapter 9 discusses and analyses the significance of each data chapter individually and the combined contribution. Chapter 10 closes the thesis by summarising the findings, answering the research questions, reflecting on the contributions and suggesting areas for further research.

Literature Review

Chapter 2

2.1. Introduction

The literature on digitisation in agriculture illustrates a rapid proliferation of digital applications and services designed with small-scale farmers in the Majority World as the intended user group over the past two decades. As demonstrated in this chapter, the transdisciplinary literature on digitisation in agriculture is growing, but there are noticeable knowledge gaps. With this study, I aim to contribute to existing interdisciplinary literature through an in-depth case study of how digitisation in agriculture manifests itself at the macro and micro levels in a country-specific context: Tanzania.

In this chapter, I situate the study within existing knowledge and academic debates related to the research aims. In addition, the chapter identifies knowledge gaps and outlines the theoretical and conceptual approaches used to analyse and unpack the empirical findings. The first section introduces digitisation in agriculture and key academic debates. I connect the study's focus on digitisation in agriculture with the broader information and communication technologies for development (ICT4D) literature. Drawing on critical ICT4D scholarship, the discussion reviews the plurality of development discourses that shape ICT4D and digitisation in agriculture research and practice. I frame the study's aim by conceptualising development as the freedom to choose a life one has reason to value using a choice lens (Kleine, 2007; 2009; Sen, 1999). Next, the chapter connects the study to the literature on science and technology studies (STS). The section introduces script theory (Akrich, 1992) as the conceptual approach to unpacking ideologies, narratives,

politics, and discourses embedded in technology. The chapter then transitions to focus on the most central element of this people-centred study - farmers. This section reviews the literature on farmers' knowledge systems and, specifically, literature that recognises farmers as innovators. Finally, concluding remarks summarise the chapter's contributions and set the tone for the subsequent chapters.

2.2. Defining Digitisation in Agriculture

Before delving into the literature on digitisation in agriculture, I will first focus on motivating the use of this term by unpacking its meaning (see Sections 2.4.1 and 2.4.2 for discussions about the definitions of development and agriculture). Practice and research on the topic have been ongoing for decades, and the term digital agriculture dates back to 1987 (Meng et al., 2024). However, the field has not reached an academic consensus on a standard definition and terminology. The challenge of uniting behind shared vocabulary is unsurprising as academic scholarship on digitisation in agriculture is multi-disciplinary and extends into diverse academic fields, such as agricultural, social, environmental, and computer sciences. Examples of terminology that I frequently used interchangeably in the global development context include digital agriculture, information and communication technologies for agriculture (ICT4Ag), digitisation for agriculture (D4Ag), mobile agriculture (mAgri) and eAgriculture (e.g. Makini et al., 2020; Okediran et al., 2018; Tsan et al., 2019).

Other terms such as Agriculture 4.0, smart farming and precision agriculture are used to refer to agriculture-specific approaches to utilise and harness emerging digital technologies to meet complex and interrelated (agricultural) challenges in a dynamic global context in “smarter” and more efficient ways (Abbasi et al., 2022; Hilbeck et al., 2022; Klerkx et al., 2019; Meng et al., 2024). These latter terms are frequently linked to the concept of a fourth industrial revolution and - by extension - what is framed as a (digitally-enabled) fourth agricultural revolution.

In this study, I use the term digitisation in agriculture, drawing on Gow et al.'s (2024) suggested reframing of the more commonly used label, digital agriculture. The proposed terminological shift is rooted in the significance embedded in the semantic nuances between digital agriculture and digitisation in agriculture. Digitisation in agriculture represents a shift in focus to the process, thereby opening up space for pluralistic definitions and interpretations of the stand-alone terms digitisation and agriculture. The preposition (in) represents and manifests the relationship between

digitisation and agriculture and frames it as a (uneven, irregular, varied and dynamic) process.ⁱ Against this background, the label modification signifies a conceptual shift that creates space for multiple digitally-enabled agricultural futures and trajectories (Gow et al., 2024), including those that diverge from the dominant discourse. From now onwards, I broadly define digitisation in agriculture as the role of digitally-enabled practices, services, applications, platforms and tools to enhance, expand, support, innovate, improve or enable agricultural needs, interests and priorities. As I further discuss in Chapter 9, this process-focused conceptualisation opens up for recognising locally-driven digitisation in agriculture practices and innovation, going beyond a focus on digital services and applications designed *for* farmers.

2.3. Situating the Study's Contributions Within the Digitisation in Agriculture Literature

After defining digitisation in agriculture and motivating its broader significance, I now move on to review the literature. Many digitisation in agriculture services, tools and applications have been developed and deployed across Majority World (see definition in Section 2.4.1) contexts in the past two decades (Aker et al., 2016; Tsan et al., 2019). A decade ago, Aker et al. (2014) presented findings that revealed that at least 140 digital agriculture tools had been deployed across the Global South. More recent reports have witnessed a continued rapid increase in the deployment of digital agriculture tools in Sub-Saharan Africa (e.g. CCARDESA, 2022; FAO & ITU, 2022; Jadhavand & Kimaro, 2023). Sub-Saharan Africa is one of the geographies where digitisation in agriculture is rapidly expanding, with reports of increasing investment and a proliferating number of digital tools and services deployed across the continent (Tsan et al., 2019; GSMA, 2020). For example, Beanstalk AgTech (2023) identified 1,400 digitalisation in agriculture services active across the Majority World, of which 666 were in the Sub-Saharan African Region. Nearly half of the digital tools identified by Beanstalk AgTech (2023) had been launched within the previous five years. Drawing on the available data, it can be concluded that there is a rapid proliferation of digitisation in agriculture and that the African continent is emerging as a deployment hub for these imagined solutions.

The mainstream digitisation in agriculture literature is underpinned by recurring themes used to validate, justify and motivate the importance of investment in digitisation in agriculture. In the

following paragraphs, I engage with the most prominent elements that underpin the rationale and motivation behind digitisation in agriculture in the literature.

First, the literature frequently takes a starting point in population growth and global warming, which is argued to prompt calls for increased agricultural productivity and more sustainable agricultural practices (FAO, 2015a; World Bank, 2008). In this context, Africa is often pointed out as a “major hotspot for food insecurity” (Beltran-Peña, A., & D’Odorico, P., 2022:1), and the negative impacts of climate change on the agricultural sector globally are well documented (e.g. IPCC, 2023). The digitisation in agriculture literature frequently highlights growing populations and the need for a corresponding increase in food production in the light of climate change, often serving as the rationale behind a perceived need to transition from traditional agriculture towards digitally-enabled, smart farming (e.g. Abbasi et al., 2022).

Second, the literature recognises that smallholder farmers in the Majority World face several interrelated challenges related to the growing food demands, natural resource management and climate change-related vulnerabilities described above (Arndt et al., 2012; Giller et al., 2011; Mortimore, 1989; Schmidhuber & Tubiello, 2007; Thornton et al., 2011). Against this background, farmers need support – often framed as centred on increased access to information, advice and knowledge – to respond to the rapidly changing environments they farm within. Correspondingly, many imagined use cases for digitisation in agriculture solutions rest upon assumptions that rural farming communities in the Majority World are information-poor and that digital technologies can act as tools to close information asymmetries (Aker et al., 2016).

Third, the literature frames the penetration of digital technologies (predominantly mobile phones) among marginalised communities as an unprecedented opportunity to utilise digital technologies to support rural farmers in the Majority World to adapt to and improve current practices and to shape the future of agriculture (e.g. Steinke et al., 2024). While affordability is often highlighted as the main barrier to increased smartphone adoption in Sub-Saharan Africa (e.g. GSMA, 2022), optimism underpins contemporary approaches, actions and predictions for smartphone proliferation. For example, the GSMA has proclaimed that “smartphone owners are now the global majority” (GSMA, 2023a:n.p.). Forbes (2020) reported that the world reached 8.9 million mobile applications in 2020, and in 2023, the global population downloaded 257 billion mobile apps. Ericsson (2023) has predicted that 67% of Sub-Saharan African mobile subscriptions will be

smartphone subscriptions in 2029, and GSMA (2023b:5) anticipates an 88% smartphone adoption rate in Sub-Saharan Africa by 2030.

Against this background, digitisation in agriculture is underpinned by high hopes and expectations for impact in the form of “improving” agriculture as the sector faces multiple interrelated challenges. For example, Tsan et al. (2019:5) describe the potential of digitisation in agriculture as using “digital technologies, innovations, and data to transform business models and practices across the agricultural value chain and address bottlenecks in, inter alia, productivity, postharvest handling, market access, finance, and supply chain management to achieve a higher income for smallholder farmers, improve food and nutrition security, build climate resilience and expand inclusion of youth and women”.

In practice, many digitisation in agriculture tools seek to harness the potential of digital technologies to provide accurate and timely information (e.g. farming advice or market prices) to influence farmers to make “better” decisions (Aker et al., 2016; Ayim et al., 2022; Steinke et al., 2024; Porciello et al., 2022). Examples of the focus of services and applications developed and deployed in the diverse field of digitisation in agriculture include digitally enabled applications, services and tools that aim to link buyers and sellers, farmer-specific financial services, information dissemination services (expert-to-farmer or farmer-to-farmer) focusing on various themes (e.g. weather, specific crops, pests and diseases), agricultural data collection, and decision-support tools (Aker et al., 2016).

In summary, the literature contains a plethora of optimistic voices that emphasise the unprecedented opportunities presented by digital technologies in the agricultural sector and emphasise imagined development outcomes from these interventions (examples), but also critical perspectives that seek to engage with the underlying complexities and build a stronger evidence-based foundation of the sector moving forward (e.g., Abdulai, 2022b; Hilbeck et al., 2022; McCampbell, 2021).

Debates around the impact of digitisation in agriculture have been ongoing for the past 15 years (e.g. Aker, 2011; Aker et al., 2016; Aker & Mbiti, 2010; Nakasone et al., 2010). There is academic consensus that limited and mixed evidence has been produced demonstrating the impact of digitisation in agriculture - particularly at outcome and impact levels (e.g. Aker et al. 2016; Ayim

et al., 2022; Baumüller, 2018; Tsan et al., 2019; Duncombe, 2012; Kante et al., 2016; Krone et al., 2016; Mapiye et al., 2023; Nakasone et al., 2014; Walton & Heeks, 2011). The documented uptake, use and impact of digitisation in agriculture has remained more limited than expected (Beanstalk AgTech, 2023; FAO & ITU, 2022; Steinke et al., 2024; Tsan et al., 2019). Scattered data points towards digitisation in agriculture's impact on improving yields, economic income and farmers' resilience (Beanstalk AgTech, 2023; Fabregas et al., 2019; Porciello et al., 2022; Steinke et al., 2024), but the literature recognises the need for improved approaches to measuring outcomes and impact.

Only a fragment of digitisation in agriculture initiatives has been rigorously evaluated (Fabregas et al., 2024). Measuring the uptake, utility, and impact of digitisation in agriculture remains a critical area that requires more attention as the sector continues to struggle to demonstrate impact, often resorting to using the number of registered or active users as a proxy indicator for success (e.g. Tsan et al., 2019). It is common for success to be reported based on the number of registered or active users (which cannot be conflated with outcome and impact). However, challenges to accurately count active and registered users have been widely recognised due to the intricacies of mobile phone usage patterns in Sub-Saharan Africa, which often include frugal practices and innovation, multiple SIM cards, shared devices and fragile connectives (e.g., Bhatti et al., 2013; De Lanerolle et al., 2017; Khan, 2016). Yet, despite a track record of limited and mixed demonstrated impact, the enthusiasm around the digitisation in agriculture's potentially transformative impact in Sub-Saharan Africa remains widespread among stakeholders in the ecosystem (McC Campbell, 2021; Tsan et al., 2019). The low uptake and mixed evidence of digitisation in agriculture tools, tailored explicitly to (the imagined needs, interests and challenges of) farmers in the Majority World, continues to puzzle the digitisation in agriculture community. For example, Steinke et al. (2024:1) rhetorically ask, “What is holding back farmers from seizing the opportunities that come with mobile information services?” Against this background, the existing body of literature clearly expresses a need for further research on digitisation in agriculture (e.g., Aker et al., 2016; Baumüller, 2018; Duncombe, 2012; Kante et al., 2016; Krone et al., 2016; McC Campbell, 2021; Nakasone et al., 2014).

As mentioned, digitisation in agriculture is a multidisciplinary field. Notably, the growing body of literature on digitisation in agriculture from technical and natural science fields is more extensive.

In contrast, contributions from social sciences remain more limited and scattered (Klerx et al., 2019). One of the bodies of academic work it builds upon is the Information and Communication Technology for Development (ICT4D). As elaborated in the next section, the ICT4D literature has a long history of critically engaging with the intersection and complexities between digital technology and development, equally manifested within the sector-specific digitisation in agriculture.

2.4. Situating the Study Within the ICT4D Literature

In this chapter section, I introduce the field of ICT4D and define key terms. Building on critical strands of ICT4D, I discuss the significance of defining and engaging with the concept of development (the D in ICT4D), followed by a section that applies the same logic to the field of digitisation in agriculture, unpacking the concept of agriculture - and diverse perceptions of what it represents.

Digitisation in agriculture is a sub-strand of the multi-disciplinary academic and practical field of ICT4D, which seeks to utilise information and communication technologies (ICTs) for development purposes (Unwin, 2009). ICT4D encompasses sector-specific branches, such as health, education, governance, and agriculture, and has mainly focused on Majority World contexts. The terms information and communication technologies *for* development (ICT4D) and information and communication technologies and development (ICTD) are often used interchangeably in the literature (Dearden & Kleine, 2020). In addition, ICT4D is often used interchangeably with the term digital development, which has grown popular in practice and policy during the last decade (Heeks, 2016).

Kleine (2013) has highlighted the rapid pace at which digital technologies - and their intertwining with people and society - make it challenging for research and policy to keep up. ICT innovation has continued at a fast pace over the past decades, shaping patterns where “old” and “new” ICTs co-exist, overlap and are re-purposed to fit changing contexts and needs (Steve & Kwami, 2012). The practical implications of the dynamic technology development have played out in the ICT4D field through an initial focus on community radio and landline helplines, later shifted towards harnessing the potential of mobile phones and the Internet (Ayim et al., 2022; Steinke et al., 2024; GSMA, 2017). Over the years, the ICT4D field has adjusted its focus to leverage new technologies and trends as they have emerged - such as smartphones, big data, blockchain, robotics, drones and

artificial intelligence (GSMA, 2024). The literature recognises that digital technologies continue to develop and evolve, and what is considered an emerging technology and framed as “the next big thing” is bound to keep changing (Akbari & Masiero, 2025).

Against this background, this study deliberately does not use a strict definition of ICTs that includes or excludes specific digital technologies. Instead, I have been led by the empirical findings and explored what ICTs digitisation in agriculture services, tools and applications use and which digital technologies farmers in two rural farming communities use as part of their digital and epistemic realities.

Corresponding to research question 2b, and as discussed in greater detail in Chapter 8, this study aims to unpack if and how narratives, discourses, and ideologies are embedded in the design and content (see Chapter 1 and Section 2.6.2). Against this background, it is relevant to briefly synthesise the literature on how ICT4D has emerged and evolved as an academic field, as this provides insight into discourses underpinning the concept of development and the role of technology.

Early academic work linking ICTs and development referenced in ICT4D literature dates back to the 1960s and the following decades (Avgerou, 2017; Heeks, 2014; Masiero, 2022; Walsham, 2017). Over time, ICT4D has grown into a multidisciplinary field with “its own conferences, journals, dedicated courses and textbooks” (Masiero 2022:1). ICT4D unites scholars from technology-focused fields such as computer science, information systems, data science and engineering as well as social science fields including human geography, development studies, ethnography and anthropology. As ICT4D has matured as a multi-disciplinary academic field, it now encapsulates a diversity of dominant and less dominant voices and narratives.

Notably, “despite being a relatively mature field, ICT4D research repeatedly witnessed the failure of ICT projects” (Ramadani et al., 2018:2424) and has struggled to demonstrate impact (Mthoko & Khene, 2018). The literature highlights factors such as reliance on donor funding with short funding cycles and overlooking the local context (e.g. ICT infrastructure, local needs and culture) are frequently highlighted as key challenges for ICT4D (e.g. Schelenz & Pawelec, 2022). Others have argued that ICT4D is failing marginalised groups and those living in poverty by not responding to their lived realities and needs (e.g. Harris, 2016) and risks creating or reproducing

harm and injustice (e.g. Akbari & Masiero, 2025). The concept of design-reality gaps has become a prominent and recurring theme in academic and grey literature on ICT4D (failure), including digital agriculture (e.g Akbari & Masiero, 2025; Ayoung & Abbott, 2021; Masiero, 2016; McCampbell et al., 2022; Steinke et al., 2021). In his seminal paper that coined the term, Heeks (2002:1) observed that *“most information systems – including current ICT projects – in developing countries fail either totally or partially. This paper develops a model which explains those high rates of failure. The model is based on the notion of design—reality gaps: the match or mismatch between IS designs and local user reality.”* As this quote illustrates, design-reality gaps were conceptualised as a response to observed mismatches between the intended design of ICT4D initiatives and the contexts and lived realities of the intended end-users of these digital tools.

The design-reality gap concept has since become a central analytical lens in ICT4D, due to its recognition of the multidimensional and interrelated factors that shape the fits and misfits between socio-technical systems and their intended users (Ayoung & Abbott, 2021; Heeks, 2006). Although, as noted above, the design-reality gap concept has been widely used to examine how disconnects between design and reality contribute to ICT4D failure, gaps remain in understanding how these discrepancies emerge and play out in practice – including specifically related to digital agriculture in Global Majority contexts (see e.g. Abdulai et al., 2023; McCampbell et al., 2022; Steinke et al., 2021).

The lack of demonstrated impact can also be framed as a relative failure to understand, measure and document ICT's ability to positively influence development, which is highly contingent on how the end goal - development - is conceptualised and measured. As ICT4D has evolved as an academic and practical field, there have been intentional efforts in the sector to learn from the past and shape future work around evidence-based best practices. Practical examples include the widely referenced Principles for Digital Development (n.d), which seek to unite ICT4D stakeholders in a commitment to adhere to a set of global best practices and the development of a set of minimum ethical standards for ICT4D research (Dearden & Kleine, 2018; Dearden & Kleine, 2019).

Less dominant voices in the ICT4D literature include critical ICT4D scholarship, which Akbari and Masiero (2025:2) define as “a vision that constructively problematises the core assumptions of ICT4D research” and practice. Schelenz and Pawelec (2022:165) have used an alternative definition of critical ICT4D, referring to the “cluster of work that engages critically with research

and practice in the field of Information and Communication Technologies for/and Development (ICT4D/ICTD)”. Critical ICT4D contributions have recognised and responded to changes that have occurred not only in ICT4D but in the thinking around development as a concept (see Section 2.4.1). Against that background, critical ICT4D calls for a paradigm shift “in the way we theorise, design, and execute ICT4D research” (Akbari & Masiero, 2025:2). Key themes that emerge from the critical ICT4D literature include debates on addressing concerns around fragmentation and lack of robustness in ICT4D theorisation and conceptualisation, as well as challenges around sustainability, scale and impact of ICT4D projects. Other central themes include fragmentation within the multi-disciplinary field, ethical implications of ICT4D research and practice, tendencies to reinforce existing (unequal) structures, failure to incorporate adequate intersectional gender analysis, techno-optimism and technological determinism and the influence of modernisation theory and eurocentrism and corresponding calls for greater inclusion of diverse voices in ICT4D (particularly marginalised and Indigenous groups) (see Schelenz & Pawelec, 2022:167 for a comprehensive summary).

The ICT4D literature also documents how the field has (attempted to) respond to (old and new) ICT4D critique, including intentional efforts to improve self-reflexivity in ICT4D research and deliberate attempts to include diverse perspectives, theories and conceptualisations (particularly Southern and indigenous) (Schelenz & Pawelec, 2022).

The scope of this thesis does not allow for a detailed analysis of the width and breadth of critical ICT4D; for further reading, see, e.g. Abbott et al., 2024; Akbari & Masiero, 2025; Heeks, 2006; Kleine, 2013; Leye, 2009; Robert, 2025; Schelenz & Pawelec, 2022; Walsham, 2017. However, in line with the study's aims, the next section further unpacks one of the core elements of critical ICT4D scholarship, which centres the definition of the concept of development and relates these debates to the aim of the study.

2.4.1. Unpacking the D in ICT4D

The literature includes various contributions that seek to conceptualise the development of ICT4D (see, e.g. Chipidza & Leidner, 2019; Kleine, 2013; Yheng et al., 2018). Critical ICT4D scholars have underscored the importance of focusing on and defining the D(evelopment) in ICT4D as notions of development - and how it may be achieved - are influenced by historical, political, ideological, colonial and economic factors (e.g., Escobar, 2011; Kleine, 2013; Kleine & Unwin,

2009; Krauss, 2013; Poveda & Roberts, 2017; Masiero, 2022). These voices argue that an intentional focus on development embodies a necessary shift from the historically dominant technocentric focus on the ICTs to the D(evelopment). Unwin (2009:1) argues that this is of broader significance as it “raises the question as to what we actually mean by development “. As I engage with term development within the boundaries of this research project, I focus on the concept of development and discourses around the imagined roles(s) of digital technologies within development processes (Akbari & Masiero, 2025).

Much of the initial ICT4D literature had a strong narrative centred around the imagined trajectory that ICTs can enable countries living in (financial) poverty to leapfrog and “catch up” with “developed countries” (Akbari, 2025; Davison et al., 2024; Masiero, 2022). This narrative aligns with the mainstream trajectory that has historically underpinned the concept of development aid from (so-called) “developed” countries to “developing” countries and dates back to the introduction of the Marshall Plan in the 1940s. Development as a term is closely aligned with historical conceptualisations of modernisation. For example, the Director of the UN’s Millennium Development Goals, Professor Jeffrey Sachs, frequently used a development ladder analogy where “developing” countries were positioned at the bottom and needed support to climb upwards towards a state of development (Greig & Turner, 2024; Zambakari, 2018).

In recent years, many academics and practitioners have moved away from using the binary developing versus developed vocabulary due to the outdated connotations it carries. Instead, the terminology Global South and Global North gained prominence. In this study, I use the vocabulary Majority and Minority World, which is terminology increasingly adopted by ICT4D and digitisation in agriculture scholars (e.g. Akbari & Masiero, 2025; Kreps & Bass, 2019; Roberts, 2025). The term Majority World recognises the geographical, cultural, social and financial heterogeneity of the contexts encapsulated in any term that seeks to jointly refer to diverse countries, communities, groups and peoples facing multiple inter-related forms of marginalisation. The terminology also acknowledges that these countries and people represent a *majority*, compared to the Global Minority that - from a contemporary and historical perspective - possesses greater financial wealth, political power and global influence.

Critics have highlighted that modernisation theory has influenced mainstream development aid at the expense of other dimensions of (human) development. Critical ICT4D and digitisation in

agriculture scholars have critiqued the mainstream ICT4D discourse for its modernisation bias, techno-optimism, the reproduction of neoliberal ideologies and unequal power hierarchies. Other areas where the mainstream discourse has been critiqued include overreliance on financial parameters in isolation from complementary factors to measure impact and success, and centring Western values and norms (e.g., Abdulai, 2022a; Díaz Andrade & Urquhart, 2012; Schelenz & Pawelec, 2021; Pieterse, 2010). The scope of this study does not allow for a full review of the modernisation and neoliberal influences on international development - and ICT4D (see Akbari, 2025, for a detailed review). More specifically, the literature acknowledges and - to various degrees problematises - the lingering legacy of modernisation theory in ICT4D, digitisation in agriculture and international development more broadly. These patterns include reproduced assumptions about a linear development process where technology is framed as an enabler, often mirroring experiences and trajectories in a Global Minority context (Abdulai, 2022a; Akbari, 2025; Schelenz & Pawelec, 2022). The literature also notes that ICT4D is implemented within the frames of neoliberal policy contexts (Leye, 2009; Murphy & Carmody, 2015), and Schelenz & Pawelec (2022:173) have referred to ICT4D's modernity bias as "one of the most frequently voiced points of criticism about the practice of ICT4D", and it is well-recognised and documented in the ICT4D literature (e.g. Akbari & Masiero, 2025; Kleine, 2013). Furthermore, the digitisation in agriculture and ICT4D literature discusses and engages with the concept of digital imperialism and data colonialism. However, due to the limitations of the scope of this chapter, interested readers are referred to further reading (e.g. Akbari & Masiero, 2025; Giles & Stead, 2022; Khene & Masiero, 2022; Kwet et al., 2019; Pieterse, 2010). However, these debates are relevant to the study, particularly in relation to the growing role of large-scale private sector players in funding and implementing digitisation in agriculture in the Majority World (see Section 2.4.2).

Beyond development conceptualisations and trajectories closely aligned with modernisation theory, there is a diverse literature that includes various conceptualisations of development. This research project grounds its conceptualisation of development on Amartya Sen's (1999) capabilities approach. Sen defines development as the expansion and freedom of choice to live a life one has reason to value. Drawing on the capabilities approach, the choice framework (Kleine, 2007, 2013, 2019) understands development as the expansion of a person's choice and is a people-centred conceptual framework that offers a counter-approach to technology-centred and techno-

deterministic strands of ICT4D. While I do not utilise the full-fledged choice framework, the concept of choice is used as a conceptual lens to unpack the choices digitisation in agriculture applications presents to farmers.

The choice framework differentiates between the existence of choice, use of choice, achievement of choice (Alsop & Heinsohn, 2005) and sense of choice (Kleine, 2007), giving rise to degrees of empowerment and leading to development outcomes. According to Kleine (2007; 2009), the *existence of choice* speaks to the choices that exist for an individual within the boundaries of resources and structures. *Sense of choice* refers to the choices that an individual is aware of and perceives to be attainable, given their socio-economic status and unique life situation. *Use of choice* draws attention to the extent to which a person actually makes those choices, and *achievement of choice* occurs when the outcome of a choice matches what the individual intended to choose. In practice, applying a choice lens to this research project enables analysis of whether a given digital technology, tool, practice, or service enables the users (farmers) to access (the existence, sense, use, and achievement of) choice.

Choice is recognised as the primary development outcome, and secondary development outcomes are defined as what people subjectively value doing and being (e.g. improved education, more free time, increased disposable income, less stress or better health). Agency and structure are recognised as important in co-constituting development processes as people use their agency to navigate the social contexts within which they live. Here, inter-personal characteristics may work as inclusive or excluding factors. From a conceptualisation of “development as freedom to choose” (Kleine, 2009:172), ICTs can provide individuals access to more (or fewer) choices, thereby contributing to (or restricting) development. Kleine (2009:174) argues that “in this logic, the contribution of ICTs and related policies to development can be determined by analysing whether they contribute to expanding choice. I elaborate further on how choice perspectives apply to the digitisation in agriculture field in Chapter 9.

2.4.2. Unpacking Digitisation in Agriculture

The previous section unpacked the D in ICT4D. I now shift from the concept of development to unpack the discourses embedded in the term agriculture and its significance in the context of digitisation in agriculture.

As mentioned in Section 2.2, digitisation in agriculture is often linked to the ideas of a fourth agricultural revolution driven by digital technology-enabled transformation. This framing is aligned with the linear modernisation conceptualisation of development (as described in Section 2.4.1), as agricultural development is categorised into consecutive phases. From this perspective, the first revolution entailed the transition from hunting to farming; the second revolution is framed as the move from manual to increasingly mechanised agriculture, and the third is synonymous with what is frequently referred to as the Green Revolution - representing the introduction of chemical and artificial inputs (Meng et al., 2024).

In the 1950s-60s, the Green Revolution propelled an agricultural intensification paradigm to its dominant and influential role today. Africa's - in comparison to other geographical areas - low use of industrial inputs is framed as a bottleneck to transforming and improving agricultural productivity and profitability as part of a "Second Green Revolution" or an "African Green Revolution" (see, e.g. AGRA, 2021; Diao et al., 2008). Advocates for this productivist intensification trajectory argue that "increasing adoption of modern inputs remains one of the best hopes for greater agricultural production in developing countries" (Minten et al., 2013:629). Consequently, countless policy- and project-level incentives have been implemented to incentivise farmers to use industrialised inputs in the name of improved agriculture and development (Hepelwa et al., 2013; Ickowitz et al., 2019). This is particularly relevant in line with this project's second research question, which seeks to examine if and how ideologies, narratives and interests are described in the design of digital tools targeting Tanzanian farmers.

Critics have accused the intensification discourse of coupling aims for increasing productivity and profitability with (performative) labels such as sustainable intensification and climate-smart agriculture (Bezner Kerr, 2024; Himmelstein et al., 2016; Mdee et al., 2019; Mdee et al. 2021; Struik & Kuyper, 2017). Through such a framing, the discourse seeks to secure a "triple win of higher agricultural productivity, increased resilience to climate change, and lower emissions" (World Bank, 2015). The sustainable intensification narrative has gained precedence from the push for sustainable, climate-resilient agricultural practices that stem from growing concern about climate change-related vulnerabilities and natural resource management (Arndt et al., 2012; FAO, 2015; Berners-Lee et al., 2018; Mortimore, 1989; World Bank, 2008). Stakeholders use different types of rhetoric to advocate for the necessity of ("sustainable") intensification, including to reach

global food security (scientists, experts, industry), to avoid expansion of cultivation into natural habitats that would threaten biodiversity (conservationists), and as a means to achieve rural development (NGOs, donors, policymakers) (Ickowitz et al., 2019; Abdulai, 2022a).

The mainstream narrative and dominant agricultural discourse have been referred to by Boogaard (2021:43) as the “hegemony of the agricultural modernization paradigm”. Adopting Boogaard’s vocabulary, this study defines the agricultural modernisation and intensification discourse as an agenda, trajectory and approach that seeks to mechanise, industrialise, improve and modernise agriculture. In addition, the agricultural modernisation paradigm aims to support the transition from small-scale farming to large-scale, commercial farming models that engage in the mass production of commodified crops (often through exports of cash crops). This process is associated with the broader commercialisation of food systems led by large corporations, and it often envisions digital technologies playing a role (Glenna et al., 2011). Digital technologies are frequently recognised in the literature as promising tools to support an imagined transformation of the agricultural sector from subsistence farming into profitable, intensified, high-input and industrialised agri-business models focused on generating revenue (Hilbeck et al., 2022; Mdee et al., 2021). This mirrors legacies from the development sector, which historically centred modernisation trajectories and technology transfer from Minority World to Majority World contexts as a core element of the imagined development trajectory (Akbari & Masiero, 2025).

Modernisation-aligned discourses are frequently reproduced in digitisation in agriculture - by donors, non-governmental organisations, industry reports, and government policies and programs (see, e.g. FAO & ITU, 2022) - as well as private sector actors. As the private sector has increasingly been recognised as an important ‘new’ development partner, new dimensions of (commercial) interests and incentives have entered development discourses (Jensen, 2010; Unwin, 2007).ⁱⁱ

Existing literature indicates that public-private partnerships or the private sector run a significant (and growing) portion of services through business models that aim to provide positive development impacts and make private profit (GSMA, 2017; Kuriyan et al., 2008; Kuriyan & Ray, 2009). Critical ICT4D scholars (e.g., Thompson & Walsham, 2010) have highlighted the financial incentives underpinning the digital development work of multinational technology companies. For example, the Digitalisation of African Agriculture Report (Tsan, 2019) mapped out the digital

agriculture funding streams in 2018, where approximately €175 million worth of development grant funding was earmarked for digital agriculture in Sub-Saharan Africa (as seen in Figure 2.1) and approximately €47 million was invested by private sector investments the same year. Critical voices in the literature have suggested that digital technology applications in the agricultural sector, such as big data models, may reduce farmers' decision-making power and instead feed into an increased control and power of private sector actors (Carbonell, 2016; Rose & Chilvers, 2018; Wolfert et al., 2017).

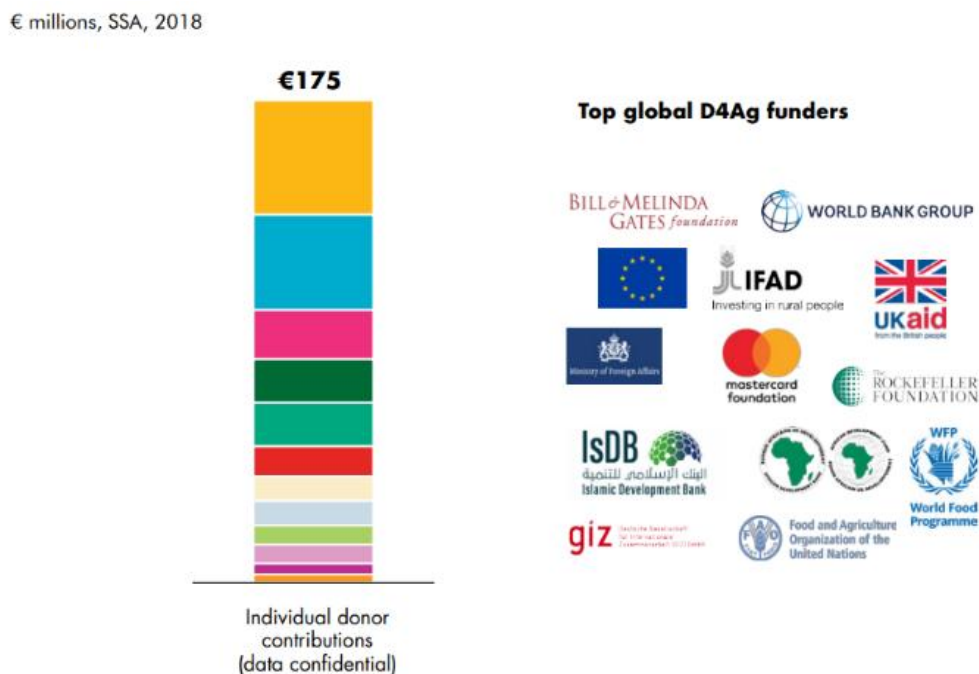


Figure 2.1: Screenshot from Tsan et al. (2019:13) outlining the top global funders in the digital agriculture landscape in Sub-Saharan Africa in 2018.

With the private sector as a prominent “development partner”, Africa's agricultural sector has increasingly been framed as a corporate opportunity to harness (e.g., Morris et al. 2009). Over the past decades, actors previously not involved in the African agricultural sector have identified business potentials related to seeds, fertilisers, pesticides, biotechnology, and - increasingly - digitisation of agriculture and food systems. The value proposition lies in new business models and markets for actors previously not involved in (African) agriculture, including the potential to

commodify and commercialise data collected through digitisation in agriculture services (Abdulai, 2022a; Hilbeck et al., 2022). The literature suggests that digital technology applications in the agricultural sector, such as big data models, may reduce farmers' decision-making power and instead feed into an increased control and power of large-scale and economically powerful private sector actors (Carbonell, 2016; Rose & Chilvers, 2018; Wolfert et al., 2017). Critical discussions around the prominent role of the private sector in funding and implementing digital solutions for African farmers have been limited in the digitisation in agriculture literature (for exceptions, see e.g. Abdulai, 2022a; Hilbeck et al., 2022).

While I have, so far, focused on dominant agricultural discourses, it is important to emphasise that a plurality of discourses and narratives exist. Whilst the hegemonic modernity discourse has a high level of influence, narratives around agricultural development are fluid, overlapping and continuously evolving. Less dominant voices, including proponents of regenerative agricultural trajectories, have critiqued the dominant discourse for co-opting a performative sustainability vocabulary, effectively engaging in green-washing and aligning with modernisation discourses (see, e.g., A Growing Culture & ETC Group, 2023b; Abdulai, 2022a; Hilbeck et al., 2022). Research has found that the modernisation and intensification discourse for agriculture has created, deepened and reproduced inequalities (e.g., Pingali, 2012; Vasco et al., 2022). For example, agricultural intensification has a track record of contributing towards a switch from independent farming on private, family, or community land towards a creation of a class of wage labourers without land subjected to multiple layers of marginalisation as small family farms are sold and commercialised (Bernstein, 2010; Ickovitz et al., 2019). In line with this, the digitisation in agriculture literature has engaged less with small-scale farmers' perceptions, priorities and visions, which may (or may not) align with broader and alternative agricultural development trajectories (Engel-Di Mauro, 2014; Fairhead & Scoones, 2005). However, there are also scholars in the field of digitisation in agriculture whose work aligns with alternative and less dominant agricultural approaches and whose work seeks to promote the intentional use of digitisation in agriculture to further an agroecological transition (e.g. Ajena et al., 2022; Bellon-Maurel et al., 2022; Hilbeck et al., 2022).

This study does not endorse a specific agricultural development discourse. As outlined in Section 2.2, I use the term digitisation in agriculture, with the explicit aim of recognising the diversity of

pathways and trajectories for agricultural futures. In Section 2.4.1, I situate this study within a choice-centred definition of development, which I discuss further in the next section.

2.4.3. Expanding Farmers' Choices

This thesis responds to calls for further research around what agricultural futures digitisation in agriculture tools seeks to amplify (e.g., Abdulai, 2022a; A Growing Culture & ETC Group, 2023a; Hilbeck et al., 2022), and in doing so, uses a choice lens (see Section 2.3.1) where success is defined as the expansion of farmers' choices.

This study defines an individual's ability to choose as the primary development outcome of any digitisation in agriculture intervention by applying a choice perspective to digitisation in agriculture. In a digital development context, *“placing human freedoms at the forefront of analysis forces ICT4D researchers to go beyond ICT provision to consider how ICT may, or may not, contribute to expanding people’s freedoms and abilities to determine their own development”* (Poveda & Roberts, 2017:120). This choice-based conceptualisation opens up for diverse and people-centred analysis of the potential roles of digital technologies to support farmers' choices, needs, priorities and envisioned agricultural futures. From this perspective, digitisation in agriculture can be understood as having the potential to support development by expanding farmers' individual and collective choices. By defining development as the expansion of choice using a choice perspective, I unpack the choices digitisation in agriculture applications envision offering the intended users (farmers).

Using choice as a lens to interpret digitisation in agriculture also relates to the concept of path dependency. Path dependency emphasises how specific choices or actions may result in a lock-in with a given self-reinforcing trajectory to the point where it may be difficult or impossible to change direction. The concept of path dependency emerged from debates by economic scholars in the 1990s (Arthur, 1994; David, 1994; 1997; Liebowitz & Margolis, 1995) and emphasises the importance of historical choices, events and conditions when explaining a given phenomenon's current state and trajectory.

In practice, path dependency and lock-in can dominate specific technologies, institutions, standards or discourses, marginalising alternative trajectories and limiting farmers' choices. Path dependency and lock-in have been widely applied across disciplines, for example, to conceptualise

contemporary lock-in in fossil fuel dependence (Goldstein et al., 2023), but also concerning farmers being locked into a pathway of agricultural modernisation (e.g. Clar & Pinilla, 2011) and digital transformation in the agricultural sector (e.g. Goodman, 2023; Hackfort, 2023). Applied to the digitisation in agriculture literature, some voices have raised concern that digitisation in agriculture reinforces the dominant agricultural discourse, further cementing a lock-in to industrialised, commercialised and modernised agricultural futures (Ingram & Maye, 2023).

2.5. A Script Theory Lens: Ideology, Interests and Assumptions Embedded in Technology

Complementing the choice conceptual lens, this study draws on science and technology studies (STS) literature to engage with the techno-social relationships in digitisation in agriculture (Pinch & Bijker, 1984). The STS field examines the relationship between science, technology and society and recognises that technology can never be neutral (Castells, 1996; Feenberg, 2012; Kleine, 2009).

In keeping with the STS literature's social constructivist perspectives, this project explores how social, cultural and historical factors shape technology. Technology is thereby understood not merely as a product of its technical functions but also as a function of social mediation (Hackett et al., 2007; Hughes, 1994). Technological determinism, on the other hand, sees technology as an autonomous agent that drives and causes historical and social change (Hughes, 1994; Sismondo, 2010; Smith & Marx, 1994; Wyatt, 2007). From a social constructivist perspective, technologies, including ICTs, amplify human intent (Toyama, 2015). This notion opens up the analysis of digitisation in agriculture as vessels that amplify human actors' implicit and explicit ideological, political, and economic interests expressed in the design, development and implementation of digitisation in agriculture tools. Funders, practitioners, academics, designers, and other stakeholders involved in designing and implementing digitisation in agriculture have subjective assumptions, convictions and interests which may be reproduced, amplified and manifested in the technology design (Hilbeck et al., 2022; Kleine, 2009). A technology design process involves multiple decisions, which, in the case of digitisation in agriculture, include design decisions related to what choices farmers are (implicitly or explicitly) permitted or prevented from making within the boundaries of the technology design. In addition, the ideologies and politics involved in the design process of a technology solution influence the framing of the intended end users, including

assumptions about imagined users' needs, wants and imagined futures (Monteiro, 2019; Terceiro, 2023). Within the digital development literature and practice (with exceptions, as it is a heterogeneous field), technology is frequently framed as the agent that is creating, leading and causing change and digital transformation, and the user - in this case, farmers - typically are framed as actors that need to adapt to the technology. Frequently, in the context of digitisation in agriculture, such logic assumes that farmers - and, by extension, farmers' knowledge, practices and behaviour - should adapt to the choices (implicitly and explicitly) presented through technology. Alternatively, digital technology may be framed as a tool that could contribute towards enabling, amplifying, expanding and sustaining farmers' choices (Bronson, 2021; Hilbeck & Tisselli, 2020).

Drawing on the STS literature (Pinch & Bijker, 1984), script theory (Akrich, 1992; 1994) has been selected as a theoretical lens to unpack ideologies, narratives and interests embedded in identified digitisation in agriculture tools in Tanzania. Script theory conceptualises technology as having a script - a predetermined set of actions - inscribed in its design and functions. A script is shaped by the politics, morals, narratives, and ideologies of a technology's co-constructors and permits, suggesting and preventing users from taking specific courses of action. However, users may act differently from what a script predicts, creating a dissonance between presumed and actual users. By adopting, mediating and appropriating a technology, users can re-script a technology's meaning and functions (Akrich, 1992; De Zoysa & Letch, 2013; Egmore, 2015; Latour, 1992, 1994; Lee et al., 2015; Oudshoorn & Pinch, 2003; Smith, 2014). Script theory highlights the mutually co-constituting roles between non-humans (e.g. digital technology) and humans (technology users).

From a script theory perspective, technology has embedded design intentions - a script - that outlines a specific string of actions and choices that align with the broader political and economic interests and ideologies underpinning the design process (Akrich, 1992; 1994). From this vantage point, designing a digital solution for farmers must be understood as an inherently political act. Drawing on script theory, this project understands digitisation in agriculture applications as active in the construction of users by suggesting, permitting and preventing different courses of action (and aligned choices) for farmers. At the same time, farmers' interpretation, acceptance (or rejection) and appropriation can re-script digitisation in agriculture services (Akrich, 1992; 1994; Rose et al., 2018). By engaging with questions around the choices that digitisation in agriculture services aims to make for farmers and how farmers mediate these, the study seeks to understand

fits and misfits between agricultural knowledge systems and those presumed by digitisation in agriculture tools, as well as the consequences this has for the utility of digitisation in agriculture in Tanzania.

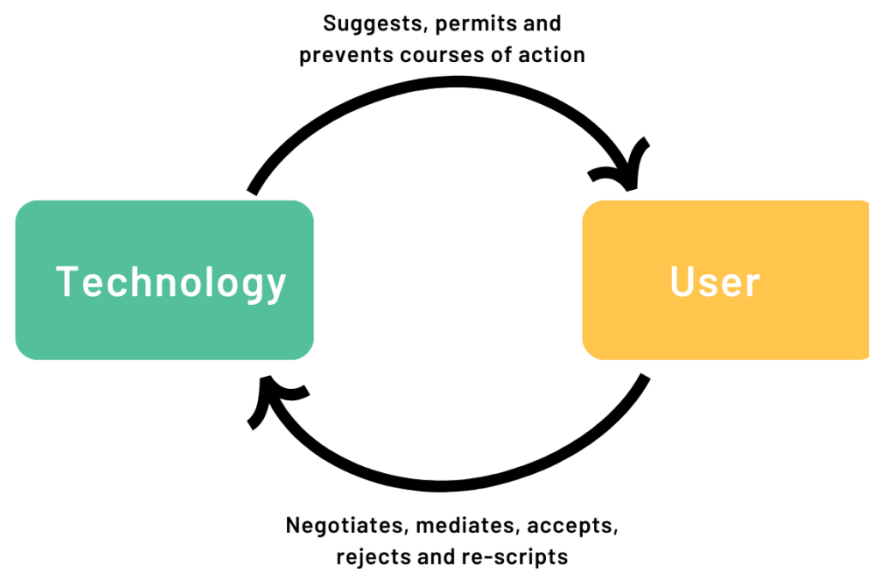


Figure 2.2: Visualisation of script theory. By Author.

2.6. The Complexity of Digital Access

One of the components of this dissertation's aim is to deepen the knowledge about rural farmers' digital realities. This study seeks to contribute to the body of work on digital access in the ICT4D literature through a detailed and nuanced case study of small-scale farmers' digital realities in the context of rural Tanzania (see Chapters 6 and 7). In this section, I review existing literature on digital access and position this study within existing knowledge and gaps using the 5 A's of the Technology Access framework (Roberts & Hernandez, 2019). One of the areas where I draw on the ICT4D literature is the existing body of work that has sought to complicate the often binary narrative about digital inclusion. In this sub-section, I review the literature and appropriate conceptual tools and terminology to better understand the fits and misfits between digitisation in agriculture tools and rural small-scale farmers' digital realities.

I briefly review how digital access conceptualisation has evolved in the literature. Digital divides have been an influential lens through which academic and grey ICT4D literature has engaged with

digital inclusion and refers to the divide(s) between digitally included and excluded individuals and groups. Early conceptualisations of the digital divide were initially framed as a digital access gap between those with and without physical access to digital infrastructure and devices, typically aligning with Majority and Minority World divides (Akbari & Masiero, 2025; Roberts, 2025; Warschauer, 2010). Initial debates around digital divides emphasised how rural and marginalised communities were excluded from digital development and emphasised physical access barriers (internet connectivity, connectivity and devices), referred to as the first-level digital divide (Van Deursen & Van Dijk, 2019).

Later work moved from a singular to a multidimensional conceptualisation of digital access, recognising that digital inequalities pertained even if people had physical access. The literature recognising second-level digital divides emphasised how socio-economic and interpersonal characteristics such as age, economic status, gender, literacy, digital literacy and educational background interrelate with a person's level of digital access. The move away towards multi-dimensional conceptualisation of digital access has partly been mainstreamed into practice and grey literature. For example, GSMA has been publishing an annual State of the Mobile Internet Connectivity Report, reporting on global statistics on mobile internet access and an annual Mobile Gender Gap Report focusing on gendered digital divides.

The ICT4D literature contains ample critique of lingering binary conceptualisations (e.g. access versus no access) and simplified conceptualisation of the practical realities of owning, using and accessing digital technologies in Global Majority contexts. Critical ICT4D scholars have contributed to digital access debates by conceptualising and reiterating the importance of understanding the complex and multifaceted layers of technology access and use, critiquing prevailing tendencies of binary framings of digital access (e.g. De Lanerolle et al. 2017; Kleine, 2007; 2010; 2013; Roberts & Hernandez, 2019). As mentioned, this thesis draws on the 5 A's of the Technology Access framework (Roberts & Hernandez, 2019), which provides a structured way to analyse different aspects of technology access. The framework provides an alternative to dichotomous and binary framings of ICT access, seeking a holistic approach to conceptualise and address digital inclusion. Technology access is broken down into five sub-categories that, just like access itself, are non-binary but, when used as a holistic framework, provide a useful tool to

identify and analyse barriers and enablers of users and non-users of technology in a given context. The following section briefly summarises the five categories that shape the 5 A's of the Technology Access framework, which may all intersect with interpersonal characteristics such as age, gender, disabilities, socio-economic status and geographical location.

First, *availability* refers to the availability of digital technology (e.g. devices), coverage reliability, speed, and strength of internet connectivity and value-added services (e.g. digitisation in agriculture apps, mobile money agents). Depending on the specific context, it may also include the availability of mobile money agents and kiosks selling airtime and possibilities to charge devices (e.g. electrified homes, solar charging options) as well as the availability of relevant content that aligns with the user's digital reality (e.g. language, format and device compatibility). Second, *affordability* refers to the ability to afford to use and connect to available technologies. For example, affordability may relate to the upfront cost of devices, airtime, data, device repairs and charging, disposable income, gendered patterns of intra-household monetary divisions, and control of household expenditure. Third, the *awareness* dimension of access includes awareness of specific technologies, services, apps and platforms and particular functions of a technology or service. In addition, awareness also encapsulates critical awareness and the ability to identify and recognise if and how a given technology could be used to support one's priorities and choices. Fourth, *abilities* refer to the individual-level abilities (and barriers which may inhibit the ability) to effectively use a specific technology or digital service (Gurstein, 2003). Factors that may shape, mediate, and determine a person's abilities include, but are not limited to, gender, age, educational level, socio-economic status, skills, and digital literacy. Marginalised individuals and groups may be inhibited by multiple intersecting components that inhibit their abilities to utilise technology. Lastly, *agency* refers to the extent to which a person feels able to act. Agency is typically conceptually tied to how people perceive themselves, their role in the world, and factors related to "intentionality, subjectivity and free will" (Sayes, 2014:141). Drawing on Chambers (1983), agency can be defined as the "extent to which a person feels able to act in the world to bring about change" (Roberts & Hernandez, 2019:5). However, human agency can also be enhanced or inhibited by structural factors. Complementary to the components embedded in the 5 A's of the Technology Access framework, Kleine (2007; 2010; 2013) has advocated for analysing digital access from a gender perspective. Gendered norms, values and practices shape how women and

men navigate time and space and, by extension, how people access and use (or do not use) digital technologies. The use of time and space, in turn, can shape the access and use of technology due to gendered patterns of physical movement, the socio-physical composition of public and private spheres and the socially and culturally shaped use of time. As outlined above, this thesis builds on and seeks to add nuance to existing work and conceptualisations of digital access that offer alternatives to binary and mutually exclusive framings of digital inclusion and exclusion.

In addition, the thesis draws on the conceptual work and terminology of De Lanerolle et al. (2017) that articulates nuances related to the digital realities of marginalised mobile users (also see, e.g. Steinke et al., 2024). This thesis has adopted this conceptual vocabulary to engage with and unpack the nuances of the social, economic, political and technical dimensions of digital inclusion (and exclusion) experiences of marginalised digital technology users. De Lanerolle (2017) has introduced the concept of being *less connected*, which is grounded in the contributions from Castell's concept of the *network society* (2000;2007), which is frequently used in ICT4D as a conceptual lens to understand the roles of digital technologies in society and Qui's (2009) concept of the *working class network society* highlights the grey areas between being and not being connected. Being less connected refers to individuals and groups who, despite being users of digital technologies, are de facto less connected due to various layers of social and economic marginalisation. Their status as less connected may be reflected in the type of device they use, how they use it, why they use it and if and how they benefit from their digital practices. The complementary concept of *network marginality* conceptualises the experience of being connected amongst individuals and groups who are less connected, typically characterised by digital realities characterised by factors such as limited and inconsistent connectivity, financial barriers to access airtime and data and the social practices around the use of digital technologies (De Lanerolle et al., 2017). Network marginality is typically partly caused by *fragile connections*, which refers to the inherent fragility of many less connected users' digital inclusion, where their connections can be disrupted or discontinued anytime for various reasons (De Lanerolle et al., 2017). Finally, *frugal practices* refer to the innovative methods and strategies that less connected users use to minimise costs and maximise use in contexts characterised by network marginality and fragile connections (Bhatti et al., 2013; De Lanerolle et al., 2017; Rai, 2015).

1	Accessibility	Access to the devices, connectivity, human and physical infrastructure needed to access and use digital agriculture tools.
2	Affordability	One-off and recurring costs related to handsets, airtime, data, value-added services, charging and repairs needed to be able to use digital agriculture tools
3	Awareness	Awareness of the existence of digital agriculture tools and where and how to access and them. Awareness of the functions of the devices available and how they can be appropriated to meet needs and interests.
4	Abilities	Marginalised individuals and groups may have multiple intersecting vulnerabilities that inhibit or enable the ability to fully utilise digital agriculture tools.
5	Agency	Structural and individual level factors may inhibit or enable farmers agency to interact with, use, mediate, appropriate and shape information, knowledge and services provided through digital agriculture tools.
6	Gendered Norms on the Use of Time and Space	Different groups of farmers navigate time and space differently due to gendered norms on the use of time and space, and this may be mirrored in their (non-)use of digital agriculture tools.

Figure 2.3: Conceptualisations of digital access components (Kleine, 2007; 2010; 2013; Roberts & Hernandez, 2019) applied to digitisation in agriculture.

The literature review found that despite a level of mainstreaming of nuanced frameworks to understand digital access, the academic and grey literature on digitisation in agriculture remains densely populated by binary ideas, vocabulary and conceptualisations of digital access, including framings that position farmers in mutually excluded categories, (e.g. included or excluded, users or non-users and connected or not connected). For example, the number of registered users of digitisation in agriculture services is often used to measure and report the success of digitisation in agriculture interventions (Morshed et al., 2020). Yet, such proxy indicators for actual use and impact conceal and obscure the nuances of digital access challenges that characterise many rural farmers' digital realities (Abdulai, 2024). It can be argued that reductive and simplified digital access conceptualisations are reproduced in discussions about farmers' digital use practices in the digitisation in agriculture literature. Given the identified gaps around digital access conceptualisation in the digitisation in agriculture literature, this study seeks to complement the existing literature on digitisation in agriculture by drawing on the work on digital access within

the ICT4D field applied to the case of digitisation in agriculture in Tanzania. In the context of this study, this entails utilising a multifaceted analytical lens when interpreting and analysing the empirical data, recognising that the digital inclusion of rural Tanzanian small-holder farmers is complex and aiming to contribute to further refining the nuances in which digitisation in agriculture interprets farmers' digital inclusion through contextual insights from this study.

The literature highlights that it is just as important to understand the digital realities of non-users as of users. Steinke et al. (2024) highlight that while digital technologies (potentially) offer promising tools, individuals and groups may be more efficiently reached and supported using non-digital pathways. Scholars in the digitisation in agriculture literature have presented data that recognise that many farmers in rural Global Majority contexts still predominantly use and access basic or feature phones (e.g. Steinke et al., 2024; Wyche et al., 2019). While there are still many research gaps related to understanding the access and use practices of rural farmers (and marginalised communities in general) in the Global South, the literature includes qualitative and ethnographic work that has explored the digital realities of communities at the digital margin (e.g. Blumenstock & Eagle, 2012; Blumenstock et al., 2016; De Lanerolle et al., 2017; Graham, 2019; Medhi, et al. 2011; Steinke et al., 2024; Wesolowski et al., 2012; Wyche & Steinfield, 2016; Wyche & Olson, 2018; Wyche et al., 2015; Wyche et al., 2019).

There are still many knowledge gaps related to rural African farmers' digital realities and practices about digitisation in agriculture. A recently published and first-of-its-kind article (Steinke et al., 2024:3-4) has summarised key evidence related to farmers' engagement with mobile phones that influences the trend of non-adoption of digitisation in agriculture applications and services. Seamlessly aligning with the aims of this study, the article by Steinke et al. (2024) seeks to document and unpack the demand side of digitisation in agriculture by synthesising existing research about farmers' digital realities and the implications for digitisation in agriculture research and practice. In Chapters 6, 7 and 8, I share and analyse data that adds to, complements and expands on this body of work, and I discuss the contributions from this study in Chapters 9 and 10.

There is a consensus in the academic literature that digital inclusion and access are particularly complex and challenging for marginalised groups, including women, exemplifying the necessity of an intersectional and gender-aware lens on any matter related to digital development. Within

the ICT4D literature, previous research has emphasised that gender analysis is frequently ignored or stops at ‘counting’ the number of women participating in or benefiting from digital technologies (McCarrick & Kleine, 2019). The digital agriculture literature (when acknowledging gender perspectives) frequently ignores the heterogeneity of rural women (Baumüller, 2018) and frames gender as an instrumental tool (Jackson, 2000) to improve agricultural productivity (GSMA, 2018) rather than recognising gender equality as a goal (and right) in itself (Buskens & Primo, 2010). Although the digital agriculture literature does highlight gender-differentiated information needs (e.g. FAO, 2018), there has been little engagement with questions around the potential for digital agriculture to not only support female farmers within unequal gender structures (conformist and reformist) but also to challenge the root causes of their inequalities (transformist) (Buskens, 2015). In the ICT4D literature, women's digital inclusion in the Global South is frequently framed as a commercial opportunity rather than a question of equality and rights. For example, the Mobile Gender Gap Report (GSMA, 2023a:n.p) claims that closing gender digital divides “could deliver an additional \$700 billion in GDP growth over five years”. This project complements the largely gender-blind literature on digital agriculture (Baumüller, 2018) by taking a gender-aware (recognising and being sensitive to the diverse roles of women and men) approach.

2.7. Farmers at the Centre

This research project takes an outspoken people-centred approach, recognising that any digital development project should centre the people, not the technology. Following this logic, the farmer is the most essential analytical element of the study. The phrase “nothing about us without us” originates from the disability rights movement and has been used to advocate for the need to include people living with disabilities in all processes related to disabilities. Nothing about us without us symbolises the need for any process to include the people impacted by the said process at all levels, assuring that their needs and interests are at the core (Charlton, 1988). Applied to digital agriculture, this perspective centres on the importance of ensuring the meaningful participation of farmers at all levels. Farmers should be at the centre when it comes to identifying the needs, the type of technology, the content, the implementation, the handling and ownership of the data, and the results and output (Hilbeck & Tisselli, 2020). This approach also aligns with participatory development scholarship (e.g. Chambers, 1997; Chambers & Ghildyal, 1985), which has presented counter-narratives to the development industries' top-down approaches and instead

advocated for bottom-up approaches that place marginalised groups, voices and needs at the centre of any development process - putting the last first.

This relative failure of digital agriculture is often attributed to various causes, but less consideration has been paid to potential mismatches with farmers' practical realities (Krone et al., 2016). This mirrors a history of marginalised groups with their priorities, needs, and interests identified for them in the name of development (Molyneux, 2000). The digital agriculture literature suggests that a lack of understanding of the practical realities of marginalised groups has led to ICT4D services more often being utilised by relatively more privileged individuals (e.g. Kuriyan et al. 2008; Kuriyan & Ray, 2009). Digital agriculture interventions frequently fail due to the inability to align with the intended user groups' social, cultural, economic and digital needs and practical realities (Emeana et al., 2020). This pattern mirrors a history of marginalised groups whose priorities, needs, and interests have often been overlooked in development processes (Molyneux, 2000). Concurrently, there is a growing recognition that user-centred design processes can address design-reality gaps (Heeks, 2001;2002; Smith, 2014) and the digital agriculture literature highlights the need for localised, needs-based and affordable (yet financially sustainable and scalable) services provided through trusted channels (Aker et al., 2016; FAO, 2015a; FAO, 2018; Murphy et al., 2014; Njelekela & Sanga, 2015; Vignare, 2013). As digital agriculture services are increasingly labelled as 'user-centred' and 'co-creative', there is a risk of performative use of concepts such as participation that is reduced to buzzwords.

This project seeks to complement existing literature by critically analysing how the diversity of farmers' informal, situated, tacit, Indigenous and local knowledge (Dea & Scoones, 2003; Rose et al., 2018) interrelates through processes of empowerment and disempowerment with digital agriculture service in Tanzania.

2.7.1. Farmers Doing and Knowing

This chapter section positions the study within current academic debates about conceptualisations of knowledge and knowing and introduces the information deficit model epistemic justice as a lens to unpack the systemic marginalisation of farmers and farmers' epistemologies and ontologies within digital agriculture and the broader development discourse. There are entire disciplines and academic debates that rigorously investigate and conceptualise knowledge and knowing (e.g. philosophy, sociology, psychology), how knowledge and technology interact with society (e.g.

science and technology studies) and local and Indigenous knowledge systems (e.g. development studies, ethnography, human geography, rural studies). This chapter section uses examples from broader academic debates to frame this study's contribution within existing literature about rural farmers' knowledge and knowing.

The 1998/1999 World Development Report (World Bank, 1998) carried the title Knowledge for Development. This report cemented the narrative that there is an information deficit in the Global South and a corresponding need to disseminate knowledge as a tool to facilitate development as an integrated part of the larger hegemonic development discourse (see Section 2.2.1). As emphasised by Narayanaswamy (2013:3), the “knowledge paradigm has sustained heavy criticism for its emphasis on market-driven, technical knowledge transfers from the ‘developed’ North to the ‘under-developed’ South as a panacea for failing markets and the promotion of development”. Influenced by the dominating development and knowledge discourse, digital agriculture as a practical and academic field is entrenched with notions of transfer of knowledge and technology to smallholder farmers in the Global South (Abdulai, 2022a).

Eurocentric discourses, where Western knowledge has been framed as superior to local knowledge, practices and epistemologies, have silenced, ignored and devalued the diverse set of local knowledge systems, epistemologies and knowledge within communities across the African continent (Boogaard, 2021). Colonial and racial discourses have formed deeply engraved and historically anchored perceptions that frame Western knowledge as superior to non-Western, local and indigenous knowledge and ways of knowing. The influential book *Orientalism* (Said, 1978) highlighted how, when the world is observed through a white gaze, it is not the reality that is being viewed but rather a manifestation of preconceived assumptions based on Western epistemologies and ontologies, as Western eyes would seek out only what would confirm - rather than challenge - their assumptions about the so-called exotic orient. Orientalism's (at the time radical) arguments called for the need to centre the places, people and knowledge typically placed at the margins. Said also made essential contributions around the racist and colonial discourses embedded not only in society and ideology but also in academia and the very foundations of how knowledge is perceived and valued. These patterns are visible in how scientific knowledge production processes are typically understood as unbiased, neutral, and representative of an objective truth discovered using scientific methods. It is the knowledge that the general public often does not have access to,

knowledge which is seen as detached from the less educated and less knowledgeable public. At the same time, scientific knowledge is perceived as knowledge that benefits the public—resting on assumptions that the public is not informed and not holders of (valuable) knowledge, such as the conceptualisation of science as something distinctly different and separated from society, the same information deficit logic is reproduced (Suldovsky, 2016).

These academic debates are relevant to this study, as information dissemination has been a core element of agrarian development interventions in sub-Saharan Africa over the past decades. Attributing farmers' challenges to an information and knowledge deficit is a widespread practice that extends beyond the digital sphere of agricultural development. Farm information and market prices in Tanzania have been distributed to farmers through notice boards at community centres, extension workers, print media and community radio dating to the inception of development aid (Njelekela & Sanga, 2015). In digital agriculture, high hopes are often centred around assumptions that ICTs will provide more effective channels to reach smallholder farmers, as traditional channels for agricultural information dissemination have been recognised as inefficient and insufficient to meet farmers' needs (Chilimo et al., 2011; Lwoga, 2010). However, such an approach reproduces assumptions that access to 'better' information (through modern technology) leads to 'improved' smallholder farming practices (Aker, 2011).

The information deficit model is a top-down conceptualisation of the imagined trajectory of scientific knowledge distribution and public acceptance that has been very influential in science communication and across various disciplines that emerged in the 1900s (Bauer, 1995; Bidwell, 2016; Irwin & Wynne, 1996; Ko, 2016; Simis et al., 2016). Existing literature has highlighted how information deficit model logic and its underlying assumptions influence agricultural projects, programs, and policy on a global scale (Rose et al., 2018). Disseminating information to farmers to influence farmers' farming practices and behaviour in the context of agricultural development has been a widely utilised method by international development agencies, national governments, and the private sector in both historical and contemporary Africa. An increased focus on collaboration, co-production, and relationship-building has been suggested to reduce the reliance on information deficit logic (Cook & Overpeck, 2018).

However, assumptions underpinning an information deficit model continue to influence the logic behind one-way, top-down approaches of information diffusion more broadly, but also influence many models of digital agriculture services that seek to address perceived information deficits despite widespread criticism of the approach. In the ICT4D literature, the widely recognised ICT4D research by Jensen (2007) suggested that fishermen in Kerala accessed market price information via mobile phones, shaping farmers' behaviour and decisions on where to sell and improving their bargaining power. Srinivasan and Burrell (2013) used an ethnographic case study of the same geography - Kerala – to discredit Jensen's study by demonstrating that fishermen were in fact not using mobile phones to choose the most profitable market, because the choice where to sell their fish was anchored in complex situated factors related to social norms, trust, local laws and existing social networks. As Srinivasan and Burrell unpacked the nuances around the fishermen's mobile phone practices, they discovered innovative mobile phone use, but not in alignment with the narrative Jensen had portrayed, which reproduced a simplified information deficit model logic.

In the case of digital agriculture, a reproduced information deficit logic may take the form of information dissemination of agricultural advice from experts through digital technologies targeting farming communities. In digital agriculture, the relative failure to demonstrate impact and utility (Kante et al., 2015) is commonly explained using information-deficit model logic, framing users' lack of awareness, interest and skills as the problem (Krone et al., 2015; Mercy Corps, 2016). There has been limited analysis applied to the relationship between (predominantly scientifically based and generalisable) agricultural information disseminated through digital agriculture tools and farmers' situated knowledge (Barrios et al. 2006; Dafoe et al. 2012; Rose et al. 2018; Vanlauwe et al. 2017). This can be contrasted with the high hopes around digital agriculture centred around assumptions that ICTs may provide more effective channels to reach smallholder farmers and also reproduce assumptions that access to 'better' (western) information (through modern technology) leads to 'improved' smallholder farming practices (Aker, 2011). This study contributes to the digital agriculture literature by critically analysing if and how the information deficit model logic and its fundamental assumptions are reproduced (or challenged) within digital agriculture services in Tanzania.

2.7.2. Recognising Farmers as Active Participants and Innovators in Development

As previous sections have illustrated, the literature illustrates that mainstream agricultural policies and programmes in Sub-Saharan Africa are characterised by modernisation and industrialisation discourses. The literature highlights that the hegemonic development paradigm neglects smallholder farmers' roles, needs, interests and knowledge despite their significant role in historical and contemporary agriculture in Sub-Saharan Africa (Birner & Resnick, 2010). Extractive and top-down practices have historically dominated practical and scientific development work, as opposed to approaches and methodologies centred around knowledge exchange with communities (Chambers, 1983; Said, 1978). This historical legacy is intimately connected to the conceptualisation of knowledge, knowledge production and how knowledge is valued and perceived, as rural Sub-Saharan African farmers are predominantly being invited to participate in digital agriculture as passive recipients of information and knowledge. At the same time, digital agriculture services are increasingly labelled as 'user-centred' and 'co-creative' this project seeks to complement existing literature by critically analysing how the diversity of farmers' informal, situated, tacit, Indigenous and local knowledge (Dea & Scoones, 2003; Rose et al., 2018) interrelates, through processes of empowerment and disempowerment, with digital agriculture service in Tanzania.

Critical ICT4D literature has problematised the tendency for ICT4D solutions, including digital agriculture tools, to focus on one-way communication that aims to disseminate information, advice and knowledge to end users. Through such an approach, end-users are framed as passive information recipients rather than as active users and contributors of knowledge and technology (Díaz Andrade & Urquhart, 2012; Masambuka-Kanchewa & Rodriguez, 2024). A growing body of literature on ICT4D has emphasised the need to recognise and include end-users. For example, Heeks (2008:33) wrote, "where ICT4D1.0—fortified by the 'bottom of the pyramid' concept—characterised the poor largely as passive consumers, ICT4D 2.0 sees them as active producers and innovators." In this study, the framing and inclusion of farmers in digital agriculture tools in Tanzania are analysed against this background.

The above-described portrayal of farmers is equally manifested in historical misconceptions and stereotypes that frame Global South small-scale farmers as irrational, unmotivated, unskilled, reactive and relying on outdated traditional knowledge and farming practices have been widely

critiqued (Chambers, 1983; Chambers & Ghildyal, 1985). An extensive body of work challenges this framing of farmers from disciplines such as development studies, human geography, anthropology, environmental studies, peasant studies, and political ecology. Mortimore's (1989) work, *Adapting to Drought: Farmers, Famines, and Desertification in West Africa*, challenged stereotypes about African smallholders by illustrating farmers' ingenuity, creativity and adaptability when adjusting to environmental changes. Watts (1983) used a case study of the political ecology of famine in northern Nigeria to illustrate how smallholder farmers have historically utilised their agency and knowledge to navigate and innovate in the face of drought and famine in changing environments. The title of Sara Berry's (1993) book "No Condition Is Permanent" resonates with the key contributions of her work, which highlights African farmers' agility, adaptability and innovativeness in adapting their farming practices and livelihood strategies in response to changes in Africa's agrarian sector. Her work also illustrated the dynamic nature of farmers' "traditional knowledge", contrary to popular portrayals of static and outdated knowledge among rural farming communities. Scott (1977) illustrates that the behaviour and choices of peasant communities are rational responses to the structural marginalisation experienced by rural Global Majority households. In the Tanzanian context, Steven Feierman (1990) and his book "Peasant Intellectuals" illustrated the active role of farmers in acting in their own interests through his research that interviewed hundreds of Tanzanians dating back to the 1960s. Feierman's influential work has illustrated that marginalised communities have relevant, useful, innovative and intellectual contributions and need to be recognised as active in shaping their situated futures.

This study situates its contribution within a long history of literature that has illustrated the strength and value of African smallholder farmers' evolving knowledge and abilities to adapt to changing environments, contributing towards reframing farmers from passive and reactive to innovative and intentional agents of change.

2.8. Conclusion

This chapter has positioned the study within existing literature connected to this research project's interdisciplinary focus. Against this background, this work seeks to contribute to the work of existing progressive ICT4D researchers, who centre their focus on people. By drawing on human-centred definitions and conceptualisations of development and using choice as a central concept,

this project seeks to complement existing literature by critically engaging with the interlinkages between digital agriculture, neoliberal agricultural policies and the impacts on smallholder farmers by using a people-centred definition of development where successful digital agriculture is defined based on the ability to expand farmers choices and enable them to live lives that they value as per their own definitions. In the next chapter, I outline the methodology that has been used to meet the study's objective.

Methodology

Chapter 3

3.1. Introduction

This chapter details the overall methodology and specific methods used to meet the project's objective of critically examining *the relationship between digital agriculture tools and the local knowledge systems it seeks to enter and improve*. The methodology was designed to meet the study's three project aims, answer the five research questions, and contribute to current digital agriculture debates through an empirical case study focused on Tanzania.

I start by motivating the relevance of Tanzania as a case study context, followed by a summary of the research project and timelines. I then provide insights about the data collection methods used to map the digitisation in agriculture landscape, followed by a section that outlines the methods used as part of the ethnographically-inspired qualitative fieldwork conducted in two rural farming communities.

3.2. Sampling of Tanzania as an Empirical Case Study

Tanzania is an interesting and relevant case study for several reasons. First, the agricultural sector is the primary sector of (self)employment amongst the Tanzanian population, which amounts to close to sixty-two million people, most of whom are rurally based farmers (Census, 2012; Census, 2022). Secondly, like the wider region and continent, Tanzania is experiencing the consequences of climate change, including within the agricultural sector, which is the backbone of the country's food security and economy (Arndt et al., 2012; Gebre et al., 2023; Kangalawe et al., 2017). Thirdly, Tanzania has experienced a rapid proliferation of mobile phone penetration (see Chapter 4). Fourthly, the government of Tanzania has identified digital technologies as a strategic tool in development and is framed as a key policy enabler (e.g. Ministry of Information, Communication and Information Technology, 2023). Lastly, Tanzania is a country where many traditional and new

stakeholders invest in digital development initiatives, services and tools (see Chapter 5). Based on these factors, Tanzania is a relevant and interesting case study to examine based on the aims and objectives of the study.

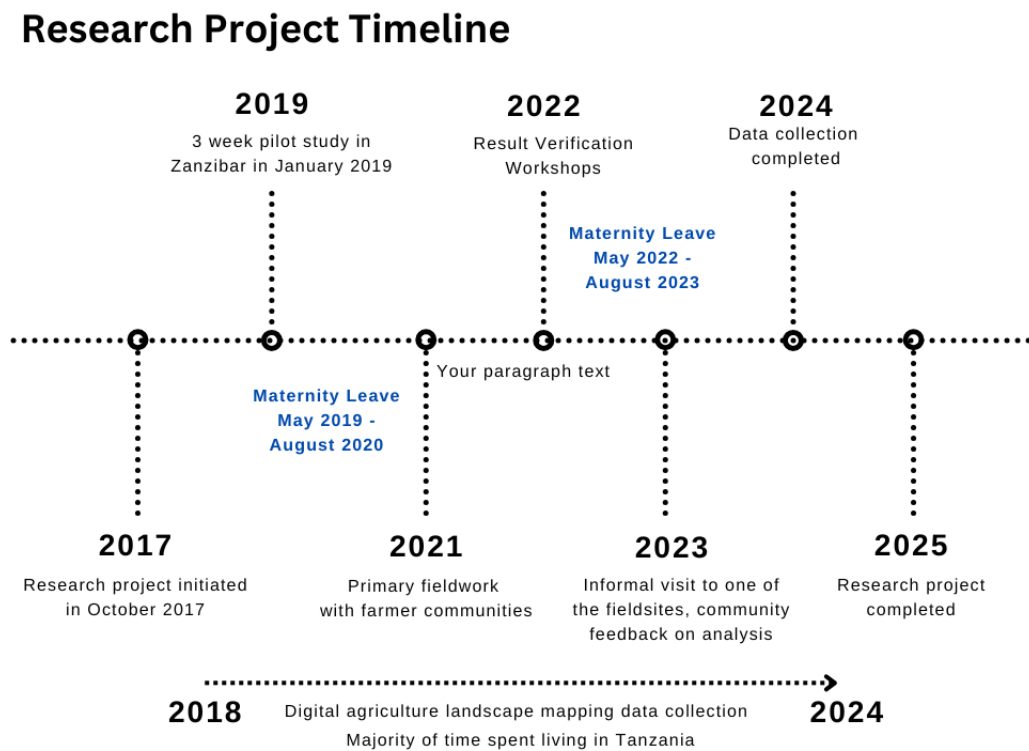


Figure 3.1: Research Project Timeline. By Author.

3.3. Research Project Overview and Timeline

This research project was initiated in October 2017, when the desk-based mapping of the digital agriculture landscape started. The mapping and testing of digital agriculture tools were ongoing until April 2024, and complementary qualitative interviews with practitioners took place between 2018 and 2022. Fieldwork with rural farming communities started with a three-week pilot study in Tazari Village in Northern Zanzibar in January 2019 (see Appendix 8). The primary fieldwork was conducted in Ubiri Ward, Lushoto District, between January and April 2021 and in Kikwe Ward, Meru District, from May to August 2021. I facilitated two weeks of result verification workshops in each field site during January and February 2022. In March 2023, an informal visit to Kikwe Ward offered an opportunity to get community feedback on the initial analysis and

outside of format data collection, I have been in contact with farmers from the fieldwork via phone calls and SMS to ask follow-up questions and clarification and get feedback on the initial analysis. During the project, I took two periods of maternity leave, which impacted the overall length of the research project in correlation with the births of my three children.

Table 3.1: Research Method Overview		
Methods	- Ethnographically informed methods/ Participatory Observations - In-depth Interviews - Focus Group Discussions - Participatory Mapping	- Desk Research - Site visits and Participatory Observations - In-depth Interviews - Testing digital agriculture tools
Research Participants	Farmers from the two selected sites (Ubiri Ward, Lushoto District and Kikwe Ward, Meru District)	Representatives from stakeholders running digital agriculture initiatives in Tanzania.

Table 3.2: Overview of Research Methods and Number of Instances	
Method	Frequency / Number of respondents
Semi-structured interviews with digital agriculture practitioners	21
Introductory informal interviews with farmers (not recorded and transcribed) – (Visit 1, see Section 3.6.1)	68
Semi-structured interviews with farmers (recorded and transcribed) – (Visit 2 and 3, see Section 3.6.1)	115
Focus Group Discussions	22
Result Verification Workshops	10
Baseline analysis and testing of digital agriculture apps	108
In-depth analysis and testing of digital agriculture apps	3
Participant observations in farming communities	A total of approximately 8 months

3.4. Methodology: Digital Agriculture Inventory

This chapter outlines the methodology and sampling methods used to collect data to compile Tanzania's comprehensive digital agriculture inventory. The inventory includes primary data collected through field observations, interviews, and desk-based reviews of secondary sources. Data was collected and compiled in an inventory (see Appendix 7) of past, current, and planned

digital agriculture tools. The inventory remained a living document until data collection was formally closed in April 2024. The digital agriculture landscape mapping methodology included four phases, as outlined in Table 3.3. Sampling criteria were designed to consolidate and aggregate primary and secondary data about Tanzania's digital agriculture landscape in a format that complements existing knowledge and that further research and practice can learn from and build upon. The final version represents a snapshot of Tanzania's digital agriculture landscape at a particular time but also a foundation for future research and practice to build on.

Table 3.3: Table of Digital Agriculture Mapping Methodology				
Phase	Phase 1	Phase 2	Phase 3	Phase 4
Aim of the phase	Identify digital agriculture tools (snowballing method).	Identify and document key data points about the identified digital agriculture tools	Basic user testing of the identified digital agriculture tools (where possible). Focus on determining status.	In-depth user testing and analysis of selected digital agriculture tools. Focus on design, functions and content.
Sample	All identified digital agriculture services		All digital agriculture tools that were possible to test	Three case studies representing a diversity of approaches
Methods used	Desk review: Literature reviews and search engines were used to identify reports, websites, academic articles, grey literature, social media, news articles, and other data sources. Interviews, participant observations, participation in sector-specific meetings and conferences in person in Tanzania and online		Testing.	

The criteria for inclusion in the inventory (see Table 3.4) contrast with the typical focus on *active* tools, as it contains digital agriculture tools that are planned, active, closed or have an unconfirmed status. This choice is motivated by three arguments. First, in many cases, the status of identified digital agricultural services could not be verified or confirmed due to insufficient data (as elaborated upon in Chapter 5). Second, the research spanned several years, during which the status of several digital services changed. Third, data about digital agriculture services that are no longer operational (or have an unconfirmed status) provide valuable individual case studies and are important data points when mapping the landscape. The methodological choice to use broad

sampling criteria aligns with the Principles for Digital Development that emphasise the importance of understanding the ecosystem and building on existing lessons learned and existing systems.ⁱⁱⁱ

Preliminary results guided the development of relevant data categories to code the data. Although draft data categories had been pre-defined, they were changed, adapted, and removed to fit the emerging data rather than fitting the data into predefined boxes (see Appendix 1 for data categories). The need for flexibility was critical as the body of knowledge about the digital agriculture landscape in Tanzania proved to be fragmented and incomplete (see Chapter 5).

Table 3.4: Criteria for Inclusion in the Digital Agriculture Tool Inventory	
The following criteria were used to determine the inclusion (or exclusion) of identified DA tools in the DA Tool Inventory.	
Type of digital agriculture tool	Projects, programmes, services, platforms, or applications.
Digital technology	The mapping remained open to identify what digital technologies' past, current, and planned initiatives used.
Agricultural focus	Digital agriculture tools with a primary or secondary focus connected to the agricultural sector, including tools with additional thematic focuses. For example, a digital agriculture tool focusing on financial access for farmers would be included, but a general mobile money service would be excluded.
Geographical focus.	A defined focus on Tanzania (a specific part of the country or nationally) either exclusively or with other countries.
Status	Previous, current, and planned.

3.4.1. Desk Research & Policy Analysis

Desk research and policy analysis were conducted to identify and critically analyse agriculture and ICT-related policies, projects, programs, and services. The desk research included reviewing the literature on historical and political economy perspectives related to Tanzania's agricultural sector (see Chapters 2 and 4). The desk research also involved mapping digital agriculture services in Tanzania, the details of which are outlined in the subsequent section.

3.4.2. Key Informant Interviews

Twenty-one key informant interviews were conducted during the data collection phase. Key informants were sampled through snowballing throughout the fieldwork period. Anonymised information about the participants is listed in Appendix 3 and includes representatives from the public sector, academia, development partners, and non-governmental organisations. Participants were interviewed for approximately one hour, and most interviews took place in the respondent's office. A smaller number of interviews were conducted via video call, as respondents were based in other parts of Tanzania or abroad.

Table 3.5: App Testing Methodologies			
Testing level	Inventory	Baseline	Comprehensive
Sample criteria	Identified digital agriculture tools without functional and accessible action points	Identified digital agriculture tools with an identified and functional access point. Digital agriculture tools identified in the study without an accessible and functional access point could not be tested.	Selected case studies
Number of apps	108	26	3
Testing components	Collection of baseline data as part of the inventory (see Section 3.4). No further testing was possible for 82 of the 108 identified tools due to a lack of a functional and accessible access point.	In addition to the inventory data collection, baseline user testing of the following components was done to answer the following questions: • Is the digital agriculture tool operational? • What is the main focus and function(s) of the digital agriculture tool? • Is the digital agriculture tool available to the general public or only to selected users (either specific stakeholders or behind a paywall)? • If the design positions the end user as a passive recipient of information/advice or an active contributor	In addition to the inventory data collection and baseline testing, in-depth analysis and documentation of the following components were done as applicable in each unique case: • Downloading the app (if required) • Registering (if required) • Logging in (if required) • User interface (text, colours, images, contrast) • Content analysis • Access cost analysis • Digital skills required • ICT and data required • Language skills required • Literacy skills required • What choices are end-users presented with? (content, design) • How does the digital agriculture tool conceptualise and frame farming? What is the

			narrative(s) embedded in the digital agriculture tool? • What problem(s) does the digital agriculture tool seek to address, and how? • What expectations are scripted into the digital agriculture tool? • What assumptions about end users are scripted into the tool? • Intersectional gender analysis • Graphic Narrative • Written Narrative
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3.4.3. App Testing Methodology

Testing identified digital apps and services was an integrated part of mapping Tanzania’s digital agriculture landscape. Out of the 108 identified digital agriculture tools, I identified a functional and accessible access point for 26. The remaining 82 digital agriculture tools, that lacked functional and accessible access points, were automatically excluded from testing.

The initial ambition was to test all identified digital agriculture tools using the comprehensive approach. However, the number of identified tools was higher than anticipated and even though only 26 had an accessible and functional access point, comprehensively testing them all was beyond the bandwidth of the project, not only due to the time resources required to test them, but also the workload of analysing and coding the data. Instead, I developed a methodology where all 26 were tested using a baseline methodology (see Table 3.5). After the inventory data collection had been completed and coded, three tools were sampled from the 26 and tested using a more comprehensive methodology with the aim of exemplifying how assumptions, ideologies, narratives, and discourses can be scripted into the design and content of digital tools designed for farmers (see Table 3.5). Table 3.7 outlines how key characteristics of the dataset influenced choices related to the sampling framework of the three digital agriculture tool case studies that were comprehensively tested, which aimed to sample a diverse rather than representative set of case studies. Each of the three case studies was tested in April 2024.^{iv}

The testing and analysis guide (see Table 3.6) was influenced by several concepts, including analysing each digital agriculture tool from a user interface (UI) and user experience (UX)

perspective. While UI and UX are often interconnected and can overlap, it is helpful to distinguish their differences. UI refers to the visual elements and includes aspects such as the layout and design. In contrast, UX refers to the overall user journey when interacting with a digital tool, including, e.g. ease of use and user content interpretation (Meirieta et al., 2024). Second, drawing on human- and user-centred design (HCD/UCD) principles, the user testing guidelines have aimed to facilitate an analysis that places the human user - in this case, the farmer - at the centre of the analysis. Finally, I have drawn on existing ICT4D research on digital access (e.g., Gerster & Zimmerman, 2003; Roberts & Hernandez, 2019; Kleine, 2009).

Table 3.6: App Testing Guide	
Thematic Guide (UX and UI)	Practical Guide
• Registration experience • Online/offline functionalities • User Interface (UI) accessibility - e.g. colour, fonts and font size, contrasts, visual design, navigation • Performance in fragile connectivity settings • Imagined role(s) of farmers, tasks assigned to farmer users, available options and choices (including their order and possible incentive structures) • Digital skills and literacy • Literacy and language • Cultural relevance of content and design • Content analysis: Ideologies, narratives and discourses • Assumptions embedded in design and content • Digital access analysis (Availability, affordability, awareness, abilities, agency and gendered social norms on the use of time and space) • Intersectional gender analysis	• Identify access point • Download (if necessary) • Register (if applicable) • Use and navigate all functions and content a minimum of two times (including in a context characterised by fragile connectivity) • Using the service on a minimum of two different device types (smartphone and feature/basic phone) • Analyse empirical findings from Kikwe and Ubiri

Table 3.7: Sampling Framework for Comprehensive App Testing	
Data set characteristic	Implication on sampling
The number of identified digital agriculture tools is large	Not all digital agriculture tools could be tested within the scope of the study. Three illustrative case studies were sampled for in-depth user testing.

The available data about many identified digital agriculture tools is limited.	Identified digital agriculture tools with insufficient available data were excluded from the sampling.
A large segment of identified digital agriculture tools used smartphone applications (see Chapter 5).	The case study sample should include digital agriculture tools using smartphone applications (stand-alone or combined with other technologies).
The access points of many identified digital agriculture tools are either not identified, not functional, or discontinued.	The case studies were selected among digital agriculture tools with identified and functional access points (a prerequisite for user testing). It must be possible to test the digital agriculture tools, either a publicly available tool or one I have been given access to that is usually only available to a specific registered user group.
The status of many digital agriculture tools is unconfirmed.	The case studies were sampled among digital agriculture tools with any status as long as they had identified functional and accessible access points.
The study participants (farmers, extension workers, government officials, and practitioners) had limited awareness of most digital agriculture tools.	The study could only collect limited data about farmer experiences and perspectives on using digital agriculture tools. I could not identify more than a handful of farmers across both communities who had used a formal digital agriculture tool (see Chapter 7).
A few farmers from Kikwe and Ubiri (the two field sites) had used a few DA tools.	The sampling prioritised digital agriculture tools that farmers in the study were aware of and had used, as the field data adds additional depth to the user testing and analysis.
During the fieldwork, the government rolled out one digital agriculture tool nationally, including in the two selected field sites.	The digital agriculture tool M-Kilimo was sampled as one of the case studies because the field data added value to the user testing analysis.
Stakeholder interviews were conducted with 21 key informants, some with knowledge about specific digital agriculture tools.	Digital agriculture tools with additional data (from stakeholder interviews) are preferred because the field data adds value to the user testing analysis.

3.5. Sampling in the Community-Based Research Components

This chapter covers the methodological aspects of the ethnographically informed qualitative research conducted with two rural communities.

3.5.1. Sampling of Case Studies Districts/Wards/Villages

The research project has used a comparative case study approach (George & Bennett, 2005; Mayor, 2006). Tanzania has 30 regions, and the research was conducted in two case study settings, Ubiri Ward in the Lushoto Region and Kikwe Village in the Meru Region.

The first (Ubiri) represents a “less likely” case, and the second describes a “more likely” (Kikwe) case concerning the likelihood of availability, accessibility, and use of digital agriculture services. A combination of variables was used to sample two case study sites, as outlined in Table 3.8. The locality of the selected field sites was used as a proxy to predict the level of ICT connectivity and the accessibility and availability of markets and services.

The data collection began with the “less likely” case and then moved to the “more likely” field site. As rain patterns and farming seasons impact farmers' daily lives and farming practices in various ways - e.g., farmers' workload, access to resources, health, and rural infrastructure (Binns, 2006) - the data collection was carried out for close to eight months and a revisit for two weeks several months later. The interaction with the communities over an extended period enabled me to engage with farming communities throughout different farming seasons, thereby improving the validity and reliability of the results.

After being informed about the sampling criteria, the regional agricultural offices in Tanga and Arusha helped select districts in their regions. The district agricultural offices in Lushoto and Meru assisted in choosing the Wards in their districts. The Ward Agricultural Extension Officers (WAEO) responsible for each of the selected wards introduced me to the communities and local leaders in the selected wards. To get as much diversity as possible represented within the sample population, the research sampled subsistence farmers, cash crop farmers, and mixed farmers in each research site.

Table 3.8: Case Study Site Variables		
Variables	Ubiri	Kikwe
Category	“Less likely”	“More likely”
Connection to infrastructure	Lower	Higher
Geographical position	Rural	Rural
ICT connectivity	Lower	Higher
Farming practices	Subsistence, cash crops, and mixed	
Crops	Mixed	
Gender equality	Constant	



Figure 3.2: Tanzania map highlighting the selected case study regions, Red: Ubiri Ward, Lushoto District, Tanga Region. Blue: Kikwe Ward, Meru District, Arusha Region. Picture: Creative Commons licence.^v

3.5.2. Less Likely Case Study: Ubiri Ward, Lushoto District

As outlined in the previous section, Ubiri Ward in Lushoto District, Tanga Region, represents the “less likely case” for digital agriculture to impact smallholder farmers' lives in this study. The district was selected with the support of the Regional Agricultural Office in Lushoto based on several criteria (see Table 3.8).

According to the 2022 census, Lushoto District had 350,958 inhabitants. Following Tanzania's administrative divisions, Lushoto District is divided into 44 wards (kata), divided into villages (vijiji) and hamlets (vitongoji). The initial research design was to sample one village at each case study site. However, upon arrival in Lushoto, the District Agriculture, Irrigation, and Cooperative Officer (DAICO) had already assigned two wards to participate in the research. The Ward Agricultural Extension Officers (WAEO), one male and one female, working in these two wards, had recently attended training as part of the national rollout of the government-led Mobile Kilimo service. As they were the only two representatives trained from the district, the DAICO deemed them the most knowledgeable about D4Ag in Lushoto. Only one of the two wards were selected due to the study's qualitative and ethnographically informed research design and the limited time

and scope of the project. The name of each ward was written on two pieces of paper, and one was randomly selected.

As the case study was carried out in a ward with an assigned WAEO that had (recently) been trained and sensitised on rolling out digitisation in agriculture service (M-Kilimo, see Chapter 8), the ward represents a “more likely” case within a “less likely setting.” In other words, other wards in the district were likely to be less sensitised to digital agriculture as their WAEOs had not attended the training on digital agriculture.

The district office insisted that all four villages in the ward of Ubiri (a total population of 6,750 according to the 2022 Census) should be included in the study. Therefore, Ubiri ward's four villages - Ubiri, Kizara, Handei, and Miego - were sampled despite the original aim of sampling only one village. This change led to both positive and negative consequences. On the positive side, the research captured the close interconnectedness between the villages and the nuances of differences related to infrastructure, digital access, and agricultural practices in the ward. The research design gained knowledge about the situatedness of each village and how intertwined and co-dependent life was between the neighbouring villages. On the negative side, the study may have obtained an even more in-depth understanding if the focus had been on only one village. However, that would have been at the expense of the knowledge about the other three villages. In summary, sampling all villages in the ward enabled the collection of an immensely diverse and insightful amount of data. The ward-level focus enabled the case study to capture more depth, width, and nuance.

3.5.3. More Likely Case: Kikwe Ward, Meru District

This study sampled Kikwe Village in Meru District, Arusha Region, as the “more likely case” for digital agriculture tools to impact smallholder farmers' lives. The district was selected with the support of the Regional Agricultural Office in Arusha based on several criteria (see Table 3.8).

According to the 2022 Census, Meru District had 331,603 inhabitants. The Regional Agricultural Office selected Meru District based on the sampling criteria. At the Meru District Agricultural Office, the DAICO identified Kikwe Ward, drawing on the same criteria. A highway was recently

built close to Kikwe, which now connects the ward to the nearby Tengeru and Usa markets and the large Kilombero and other markets in central Arusha. The choice was further motivated by the fact that the WAEO for Kikwe was a young, enthusiastic male extension worker trained in using M-Kilimo (see Chapter 8). Kikwe village is larger than the villages in Ubiri and includes four hamlets and a population of 10,965, according to the 2022 Census. During the sampling, participants and respondents from all the hamlets in the village were included to create a diverse sample, as in the least likely case.

3.5.4. Sampling of Research Participants

The WAEOs, local village and hamlet level leaders, and residents of Ubiri and Kikwe assisted in the snowball sampling of farmers and households, which fit the sampling framework throughout the fieldwork period (see Section 3.6). The sampling was designed to include diversity in age, gender and socio-economic status among participants. The operationalisation of the research design was continuously reviewed to avoid reproducing patterns of excluding marginalised voices in the villages where the research took place. This is particularly important as (male) village and hamlet leaders, farming group chairmen, and household representatives often do not represent the interests or priorities of a whole community or household, yet frequently have a high level of influence (Appentik & Parpart, 2006; Henshall Momsen, 2006).

3.6. Research Methods Utilised with Community-Based Participants

The study employed a qualitative mixed methods approach, combining qualitative, participatory, and ethnographically informed methods. In this sub-section, I share details about the research methods adopted in the research components that engaged with participants in Ubiri and Kikwe. The research methodology was guided by participatory research principles that aimed to put participants in the leading roles (Chambers, 1983; 1997).

3.6.1. Qualitative Interviews with Farmers

Qualitative interviews were used to engage with farmers in the two case study locations. The interview methodology was developed to gain a deep-seated understanding of farmers' lived realities, farming practices, knowledge systems, and their access to and use of digital technologies. The methodology involved interviewing each farmer three times to build trust and rapport through

repeated engagements. In total, 186 interviews were conducted with 68 farmers. Of these, 9 farmers participated only in the first step (Visit 1, described below). While their data was reviewed, analysed and included in the overall thesis, they are not counted in the tables of interviewed farmers (Tables 3.9 and 3.10), as these tables refer only to farmers who completed all three steps of the interview methodology.

The interviews, hereafter referred to as Visits 1, 2, and 3, were not carried out in that order for all participants. As outlined in Table 3.12, Visit 1 was an informal interaction, while Visit 2 and 3 used an interview guide with pre-identified themes and pre-scripted questions. The respondents were asked open-ended questions, following the lead of the respondent. In addition to these three visits, I also met with farmers on additional occasions as part of the general participatory observations. The aim was to space out the farmers' visits to engage with each respondent over a more extended period, observing their farming practices and knowledge systems at different times. The interviews took place at various intervals, ranging from a few days to a few weeks between each visit. The possibility to engage with each farmer over time increased the reliability and validity of results for six reasons. First, each meeting enabled new insights through the interview and participant observations. Second, multiple visits allowed observations that could validate information that farmers had self-reported during previous interviews. Data and insights that would have been unattainable through a stand-alone interview were gathered by observing and participating in multiple visits over time. Third, the research design enabled interaction with farmers during different stages of their farming practices. Fourth, a strong rapport was established with most respondents. Building ongoing relationships with a smaller number of farmers was deemed to be more valuable than brief interactions with a higher number of farmers. Fifth, the knowledge and observations from interacting with farmers in various spaces and places added valuable spatial and practical dimensions to the data analysis. Lastly, the research design opened up opportunities to ask follow-up or clarification questions from previous visits. Each of the three parts of the interview methodology is described in detail in the following sections.

The research project used a sampling framework (see Table 3.11) to guide the sampling of respondents, a vital component for the project's ability to understand different farmer groups' knowledge systems and *if, how, and why* they were (not) using digital technologies. The sampling

framework aimed to capture a diversity of voices. For example, early adopters of digital agriculture services (the real and imagined “darlings” of the digital agriculture narrative) and farmers who were more obviously excluded from these narratives (e.g., due to lack of connectivity or limited ICT skills). Roberts and Hernandez (2019) have argued that it is essential to understand the lived realities, perspectives, and aspirations of poorly connected or unconnected people for digitalisation and digital services to be inclusive. Their argument is highly relevant for digital agriculture research, making engaging with users and non-users of digital agriculture services equally important. Farmers were sampled through snowball sampling with the help of the WAEO and local contacts in the villages. Sampling criteria (see Table 3.11) were used to pre-select some respondents, while other farmers were coded retrospectively. Findings from initial focus group discussions (FGDs) were used to contextualise the sampling criteria variables and align with locally identified wealth and farmer categories. Contextualising the sampling framework was necessary as the study took place in two regions of Tanzania, and communities' definitions of what characterises a poor or rich household differed between and within Ubiri Ward and Kikwe Village.

Table 3.9: Farmer Interview Respondents - Gender			
Field Site	Male Respondents	Female Respondents	Total
Ubiri - “least likely”	17	14	31
Kikwe - “most likely”	12	16	28
Total:	29	30	59
Percentage:	49%	51%	100%

Table 3.10: Farmer Interview Respondents - Age			
Field Site	Age 18-35	Age 36 - 50	Age 50+
Ubiri - “least likely”	12	14	5
Kikwe - “most likely”	15	7	6
Total:	27	21	11
Percentage:	46%	35,5%	18,5%

Table 3.11: Sampling Variables - Interviews					
Interpersonal characteristics	Age		Gender		
Community-identified wealth categories.	“Rich”	“Average”	“Poor”	“Very poor”	
Community-identified farmer categories.	“Big farmers”	“Small-scale farmers”	“Modern farmers”	“Traditional farmers”	“Good farmers”
Sex & Gender	Women		Men		
Age	Mixed age groups, including youth				
Agricultural practices	Subsistence farmers		Cash Crop farmers		
Land status	Landowner		Land tenants		
Plot size	Varying plot sizes				
Mobile phone access and use	Smartphone owners	Basic phone owners	Mobile phone users that do not own a private device	Non-users	

Table 3.12: Summary of Interview Visits with Farmer Respondents			
Interview	Visit 1	Visit 2	Visit 3
Location	The respondent's home and/or farm environment (chosen by the respondent)		
Thematic focus (see Appendix E)	Agricultural practices, livelihoods, home environment, household composition and general life.	Knowledge systems and ICTs	The Role of Mobile Phones in Everyday Life

Purpose	Build report and trust, establish initial understanding about the respondent, his/her family situation and farming practices.	Build an understanding of the respondents digital reality and local knowledge system.	Collect in-depth data on the respondent's (non-)use of mobile phones and the internet. To understand <i>if</i> and <i>how</i> the access and use of ICTs fit into farmers' everyday lives, activities, agricultural practices and knowledge systems.
Additional components	Project information sheet and consent form.	Media Usage, Information & Communication Chart Mobile phone balance status	Jana Diary
Time Resources	Part of informal participant observations and home visit	25 - 50 min	15 - 30 min
Interview Guide	Themes (see Appendix E)	The interview was guided by pre-scripted questions based on the themes listed in Appendix E.	
Format	Informal	Semi-structured	
Documentation	Notes in research diary by researcher and research assistant	Recorded, transcribed in Swahili and translated to English	



Figure 3.3: The home and kitchen of one of the respondents in Handei Village, Ubiri Ward. Photograph taken in correlation to an interview.

3.6.2. Media Usage, Information & Communication Chart

The Visit 2 interview used a Media Usage Chart and an Information and Communication Chart (see Appendix 4, developed drawing on previous work by Kleine, 2013). The charts collected data to map farmers' complex knowledge systems by capturing patterns, linkages, and differences

within and between respondents' use of *different media channels* and *interaction with other human actors* for personal and agricultural purposes within their knowledge systems. The research assistant took notes during the interview and filled out the media usage chart based on the respondents' answers.

Kleine (2013) has emphasised that using media usage charts provides a valuable alternative to binary ideas around digital divides. It captures if and how respondents use, combine, substitute, complement and replace different media, communication and information channels for other purposes. The media options included in the chart were selected based on previous research, pilot study findings, and multiple data collection tool field tests (see Table 3.13). Drawing on communicative ecologies (Tacchi, 2006:1), the communication channels included in the chart were defined widely (including analogue, digital and physical) and consistently remained open to including new options. Communicative ecology recognises that any new form of communication - via a new type of ICT, analogue means, or face-to-face - must be understood about and as part of a person's broader communicative ecology. Various sources and mediums typically constitute a person's communicative ecology for communication, information, and knowledge that may have similar, different, and complementary roles (Tacchi, 2006; 2015).

To practically operationalise and implement the use of media usage charts in this particular research project, I introduced novel elements with the aim of making the method more participatory, engaging, and adapted to the specific context and respondents with whom I was conducting the research. I adapted my approach based on learnings from the pilot study, where I ran into methodological challenges when I took participants through each of the categories in the charts. The processes ended up being lengthy, and respondents often seemed bored, restless and lost interest during the exercise. After some experimentation, I landed on a revised approach where respondents did not engage directly with the chart. Instead I adopted a conversational approach to discuss each component of the chart with the respondent, and the research assistant listened in and filled out the chart based on the verbal interview.

I introduced an innovative approach to the practical data collection, as I fitted each chart onto two A4-sized pages (see Appendix 4), which were printed and laminated. The research assistant listened to the conversation and filled out the chart using two differently coloured pens, one

representing personal (non-agricultural) use and the other for agricultural use. The research assistant made a mark with a whiteboard pen on the chart based on their estimated frequency of use of different media channels for personal and agricultural purposes, respectively. After the interview, the laminated charts were marked with the respondent ID, photographed, and stored with additional data before the chart was wiped clean and reused. This approach was environmentally friendly as it eliminated the need to print separate copies of the same forms for each of the 59 farmers who participated in this part of the interview methodology. It was also practical in context: the laminated forms were durable and portable, whereas multiple printed copies would have been bulkier to carry and susceptible to damage from rain, dust and high humidity.

I also introduced a second innovation: printed and laminated, locally verified images representing each category on the charts. During the interview, I showed the respondent each image, prompting discussion about whether, why, where, when, and how often they used or interacted with that media channel, person or organisation. This approach generated richer and more meaningful data, facilitated smoother conversation, and likely improved reliability by ensuring that both I (as an outsider) and the farmers had clear, shared reference points. Respondent reacted positively to the images, which encouraged more engaged participation – many enjoyed engaging with the laminated pictures while speaking.

As described, the media chart collected data on the frequency of media use and ICTs for personal and agricultural purposes, respectively. A complementary information and communication chart was used to map the frequency of farmers' interaction with people, organisations, and institutions and the frequency at which farmers get and share information, advice, and help around agriculture with the same actors. The former discussed the nature and frequency of use with non-human actors, and the latter addressed the nature and frequency of interaction with human actors in farmers' knowledge systems. Understanding the frequency of interaction with non-media information channels for personal and agricultural purposes was valuable to holistically understanding farmers' knowledge systems.

Table 3.13: Overview of Content in Media Usage Charts
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Frequency of Use		Frequency of Interaction		
Radio	Internet	Family	Agrodealer	Local Government
SMS (mobile phone)	Newspaper	Neighbours	Buyers	National Government
Calls (mobile phone)	Information Board	Farming Friends	Sellers	NGO
Facebook	TV	Community Meetings	Extension Officers	Other
WhatsApp	Public Announcement	Farmer Groups	Mobile Money Agents	
Other Social Media	Other	Savings Groups (or other groups)	Agriculture Company	

3.6.3. Jana - Mobile Diary

As part of the Visit 3 interview, which had a strong focus on unpacking the role of mobile phones in farmers' everyday lives, farmers were asked to show their device (if they had one), report their current airtime balance, and verbally recall if and how they used mobile phones during the day before the interview. The method is designed to understand *if* and *how* the access and use of ICTs fit into farmers' everyday lives, activities, agricultural practices and knowledge systems. This segment of the study's methodology is referred to as the *Jana (Yesterday) method* and is based on De Lanerolle et al.'s (2017) *Reconstructed Mobile Diary Method* (RmDM). The method draws on psychology and media studies audience research and has repurposed aspects of the more established *Day Reconstruction Method (DRM)*, which “assesses how people spend their time and how they experience the various activities and settings of their lives” (Kahneman et al. 2004:1). In their study *Izolo* (which means yesterday in isiXhosa and isiZulu), De Lanerolle et al. (2017) worked together with South African mobile phone users to reconstruct the way each respondent had used their mobile phone the day before the interview. Building on their work, the development, use, scope, and focus of the *Jana* (which means yesterday in Swahili) method have been used to understand the role of mobile phones in smallholder farmers' lives. The *Jana* method collected rich narrative and contextual data on the practical realities of Tanzanian farmers and how their mobile phone use and non-use are manifested in their everyday lives.

This method did *not* aim to explicitly collect representative and generalisable data for farmers' typical ICT use. The method aimed to get detailed and contextualised snapshots of how digital technologies are embedded in small-scale farmers' everyday lives. Limited data exists on whether and how ICTs are embedded in farmers' context-specific everyday lives and practices. This study has used the *Jana* method to collect contextualised data about the practical digital realities of farmers in rural Tanzania. The *Jana* method particularly sought to understand how farmers' mobile phone use (and non-use) is embedded in their knowledge system, agricultural practices, and everyday life and practices. The method sought to explore how access and use of mobile phones are shaped through structural, social, cultural, infrastructural, and economic factors.

Different forms of diary-based research methods have been used across research disciplines. In traditional diary methods, respondents are typically instructed to record their actions and reflections in writing on terms and conditions agreed with the researcher(s) based on methodological choices and the research design grounded in the research question(s). De Lanerolle et al. (2017) noted that using diary-based methods to research people's access and use of ICTs has been associated with challenges related to respondents' ability and willingness to keep continuous notes throughout the day and the time-intensive nature of recording mobile phone use. In the context of this research project, asking small-holder farmers to keep a written diary would have come with additional context-specific challenges related to literacy, the time-intensive work of farming, and challenges associated with bringing and writing in a notebook in a farm environment. Therefore, farmers were asked to describe and discuss their previous day during an interview verbally. The method's design and implementation maximise the methodological strengths of diary methods, including exploring themes and concepts within their context. The methods allow contextualised details to emerge from the data without being a physical diary. Respondents were asked to, together with the researcher, narratively reconstruct the day before the interview. Respondents were asked to describe what they had done the day before the interview, from when they woke up until when they went to bed. The respondent was free to narrate their day as they pleased. The researcher asked open-ended questions around the themes in Table 3.14 but followed the respondents' lead. The themes were derived from the methodology of De Lanerolle et al. (2017) and were revised and adapted, drawing on insights from the literature review and the pilot study, to ensure their relevance to this study's context.

Table 3.14: Themes Guiding the Mobile Diary of Visit 3	
Use of time	Farming activities
Mobility & Use of Space	Use of ICTs
Care responsibilities	Emotions & Feelings

The Jana method has one very apparent limitation; it only accounts for one specific day in the respondent's life, bringing apparent limitations to the generalisability of results. The Jana method only accounts for a single day in a farmer's life and, as De Lanerolle et al. (2017:8) pointed out, “each person is different, and no day is the same.” The method offers a time- and context-specific and individual snapshot from the life of each participating farmer. However, the factors that constitute its methodological weakness are also its greatest strength. By collecting qualitative, in-depth, and contextualised data which is specific to a particular farmer at a certain time and place, the detailed insights into the everyday life of a farmer may be able to challenge some of the assumptions about small-scale farmers, their knowledge systems and how ICTs are (and are not) integrated into their lives that populate research, practice and literature on digital agriculture.

Respondents were asked to recollect events, activities, feelings, actions, and circumstances that were tied to a recent and specified date and time - *yesterday* - leading to contextualised and rich details that stood in stark contrast to the often general and vague nature of responses that were received from respondents during pilot interviews when farmers were instead asked to answer questions related to their “usual” or “normal” practices and activities. A nuanced and contextualised picture of a day in the life of farmers was captured instead of generalised accounts of the “usual.” The format also generated data on how, where, and with whom farmers spent their time, which is valuable information for understanding how knowledge systems manifest in everyday practice. Through triangulation of data from participatory observations, I was also able to observe patterns that farmers described in their Jana dairies during the everyday lives of farmers, which further strengthened the findings.

As the method relies on reported behaviour, which comes with data reliability problems as respondents may intentionally or unintentionally misreport, it has limitations related to recall bias (Kahneman et al., 2004). There is a risk that respondents' reconstructions are biased due to (knowingly or unknowingly) including and excluding certain information. This risk was managed by triangulating the data with data collected using other methods (including participant observations) and asking respondents to demonstrate what they reported. As the method asked respondents to recall very recent events (from the previous day), the risks related to recall bias due to time distortion of memories and selective memory can be argued to be lower than if respondents had been asked general and non-time-specific questions related to their mobile phone use. The oral recordings from the dialogue were later transcribed with additional notes, specifically highlighting conceptually interesting aspects that emerged from each “diary.”

3.6.4. Ethnographically Informed Participatory Observations with Farming Communities

Participant observations were conducted daily for approximately three months in each field site. Participant observations occurred before, during, and after interviews, as well as focus group discussions and participation in community activities. These included home visits (socially distanced and predominantly outdoors), farm visits, assisting with everyday work tasks at the farm (e.g., planting, weeding) or at home (e.g., sorting beans, removing maize kernels from the cob, cooking) of respondents, spending time at the village office, village centre—popular shops/kiosks and walking around in the communities.

3.6.5. Focus Group Discussions with Farmers

Focus Group Discussions (FGDs) are a method that uses facilitated group discussions to understand community dynamics. FGDs were used to explore further themes identified through interviews and participatory observations, as the approach is particularly useful for exposing norms and values that lead groups to act, think, and behave in specific ways (Bloor et al., 2001). Strengths of the approach include its ability to shine light onto shared and differing opinions, perspectives, attitudes and priorities, power- and gendered relations, as well as tensions, uncertainties, and conflicts of opinion (Barbour & Kitzinger, 1999; Bloor et al., 2000; Lloyd-Evans, 2006).

This study used FGDs to unpack and explore themes, as outlined in Table 3.15. A total of 22 focus

group discussions (FGDs) were conducted, 12 in Ubiri Ward and 10 in Kikwe Ward. The number of participants in each FGD varied, ranging from six to twenty-five participants. Most FGDs had between 8-12 participants. FGDs were audio recorded and transcribed to analyse group discussion and interactions, including the groups' power dynamics.

The sampling of participants considered aspects such as interpersonal characteristics and potential social, emotional or sensitive implications at individual, group or community levels for participants (Barbour & Kitzinger, 1999; Bloor et al., 2001). One of the most critical dimensions of the sampling strategy was ensuring a diverse sample population. The participatory wealth category data, together with other methods and variables, was used as a guide to continuously assure and counter-check if the sampling included different segments and groups of people in the ward and who - potentially - had been excluded. In addition, the participatory wealth category exercise data was used to understand potential differences between Kikwe and Ubiri Wards and, in the case of Ubiri, to contrast community definitions in the four villages in the ward. The community-defined wealth category, crop calendar and participatory community mapping exercises (see Table 3.15, Figure 3.4, and Appendix 5) were carried out at the beginning of the fieldwork period in each field site and helped me understand each of the two contexts. The information and knowledge gained were used to inform questions and understand answers during interviews and participant observations. As extension officers and local leaders participated in the FGD, in addition to farmers, the discussions also provided insights into the dominant narratives and perceptions around farming amongst people with community influence.

FGDs were carried out with pre-existing (e.g., farmers' cooperatives, women's groups) and purpose-constructed groups (Bloor et al., 2001) and mixed-gender, all-female, all-male, and youth-specific FGDs. The sampling for the FGDs was done in cooperation with either one of the village or Hamlet level chairperson (*mwenyekiti*), my local contact persons in the villages, or the WAEO, based on criteria I presented them with, such as gender and age categories. Sometimes, the composition of a planned FGD ended up being different than initially planned (e.g., more or fewer participants, different mix of gender and age). FGDs were held at a time and place suggested by the participants or a local leader, typically in a community or school building, under a tree, or in one of the farmers' homes or yards.

TAJIRI	- (CHF) Bina ya afya. - So lar .tv. Simu, taq.	WASTANI	(CHF) Bina ya afya.
- Ekari 5. - Nyumba - Ngombe wa Maziwa 2 - Simu Smartphone - TV - Redio - Pikipiki	- Milo Mitatu - Huduma kwa Jamii - Uuzaji ndani na nje - Ajira - Anakodi Masha	- Ekari (3) - Nyumba - Mifugo - kama mbuzi, kuku, kondoo bata - Milo (2) - Simu - TV - Redio - Baiskeli: ① - Solar - taq. tv. Kuchaji Simu.	
MASKINI	MASKINI SANA		
- Ekari 1 - 2 - Nyumba nologo - Mifugo - mbuzi, kuku, bata, kondoo. - Simu - kitochi simu nologo - Redio - Kibatazi - Mlo mmoja - mpaka 2 - Nguvu kazi - Kipato duni	- Ekari 1 - 1/4 nusu mpaka robo (Uitthi) - Kipanda (nyumba) - kibanda. - Nguvu kazi - Mlo mmoja - Kibatazi; kuni - Mavazi na malazi ni shida. - Elimu ni shida		

Figure 3.4: Visual created by participants during FGD 3, January 2021.



Figure 3.5: Women enjoying a tea break after an FGD in Kizara village, Ubiri Ward, April 2021.



Figure 3.6: Participants, after holding an FGD on mobile phone access and use in Ubiri Village, Ubiri Ward, April 2021.



Figure 3.7: Participants during FGD on resource portfolio mapping in Handei Village, Ubiri Ward, April 2021.



Figure 3.8: Young women from Handei Village, Ubiri Ward after participating in a focus group in March 2021.

Table 3.15: Participatory Methods Used During Focus Groups (see Appendix 5 for more details).	
Community-Defined Wealth Categories. Used in 6 FGDs.	Participants discussed and defined what four categories - <i>tajiri</i> (rich), <i>wastani</i> (average), <i>maskini</i> (poor) and <i>maskini sana</i> (very poor) - meant to them and in their specific context. The discussion was to be centred around the participants' village, and the goal was not that it would resonate with the whole ward, District, or Tanzania as a whole.
Crop Calendar. Used in 6 FGDs.	A participatory exercise that mapped and discussed farming practices and methods, crop types, planting, harvesting, climate, and weather patterns. The discussions centred around what farmers in that specific village grow, how the climate and weather usually affect farming during different times of the year, when the year farmers do different types of tasks (planting, weeding, harvesting, selling) and if and when during the year farmers usually experience economic hardship.
Participatory Community Mapping. Used in 6 FGDs.	Community based activity drawing maps of the community, prompting discussions about gendered structures, use of time and space, accessibility of services, farming practices, land management, and farmers' knowledge systems.

<i>Mobile Phones Access Mapping. Used in 6 FGDs.</i>	This method engaged with how multifaceted and non-binary dimensions and nuances of <i>technology access and use</i> - specifically mobile phones and the internet - were manifested in a specific farming context. First, participants were asked to discuss if, how, and why mobile phones and the internet were important to them. The second part of the FGDs explored how different dimensions of <i>access and use of ICTs</i> were manifested within a specific context.
<i>Resource Portfolio Mapping. Used in 6 FGDs.</i>	Participants discussed and defined what development meant to them. Secondly, FGD participants defined, visualised, and mapped their resource portfolios, drawing on the Choice Framework (CF) (Kleine 2013).
<i>Soil and Land Mapping. Used in 3 FGDs.</i>	Participants discussed and defined their area's different types of soil and land, including jointly creating a map where they visualised their community with a focus on soil and land. Discussions gained insights into farmers' perceptions of soil and land types, management and practices in the field sites.

3.6.6. Result Verification Workshops

Ten result verification workshops (RVWs) were held with participating communities in January 2022. The RVWs in Ubiri took place approximately nine months after the initial data collection, and the RVWs in Kikwe took place approximately five months after the initial fieldwork. During the two weeks I spent in each field site, as many households as possible were informally revisited. I held informal follow-up interviews, conducted ethnographically informed participatory observations, and had five formal RVWs. During the RVWs, I presented initial findings to the group using statements I had identified. Participants could either confirm, reject or add more local perspectives to the statements presented as the group discussed each theme (see Appendix 8). The result verification workshops enable research participants to give feedback, add additional information, dispute the conclusions and correct misinterpretations. Each participant received a certificate of appreciation and printed copies of photographs of them and their families during the fieldwork period.

3.7. Research Diary

Throughout active data collection, I maintained a detailed research diary to record field notes, reflections, and insights from participatory observations. While in Kikwe and Ubiri, I typically took notes on a notepad during the day and spent approximately an hour at the end of each day expanding these into a digital research diary. After the data collection concluded, the research diary as a whole was downloaded in PDF format and analysed and coded using NVivo alongside other data.

3.8. Data Processing and Analysis

In response to calls from scholars such as Baxter and Eyles (1997) for greater transparency in how data is interpreted and analysed, this section describes how the data has been managed and analysed.

Qualitative data in the study was collected both in English and Swahili. I transcribed part of the interviews, but Tanzanian research assistants transcribed most of the farmer interviews (Swahili to Swahili transcribing). This choice was made for two reasons. First, as Swahili is not my native language, transcribing was incredibly time-consuming. Due to the high volume of interviews and FGD conducted, I did not have the time resources to transcribe all the interviews, particularly as it took longer than usual to transcribe in a language that is not my first language. Second, the quality and accuracy of transcripts were improved when they were transcribed by native Swahili speakers who could pick up linguistic and culturally sensitive nuances I may have missed. Once the interviews and FGDs were transcribed, I read through them while listening to the audio recording, ensuring the transcription was accurate. This exercise also helped me to reconnect with the data, identify themes, and reflect as I moved into coding and analysis.

Transcribing was done by two young students and a group of translators affiliated with an NGO, and they were all financially compensated for their time. I translated the transcribed interviews with the support of research assistants, native Swahili speakers in my network, and online tools when necessary. When online tools supported translating words or parts I did not fully understand, the translation was always double-checked with a (human) native Swahili speaker. In addition to translating the text, I used research assistants and Tanzanians to help interpret findings culturally when necessary.

The collected data was coded and analysed using qualitative coding methods in NVivo (Crang, 2013). I used a coding framework with codes informed by the literature review and the study's conceptual framing, as well as inductive codes that emerged from the data and observations during the fieldwork. Coding was conducted iteratively in NVivo, with codes refined, merged and expanded as the analysis progressed, balancing inductive patterns and deductive insights.

Appendix 10 includes a table which summarises the main themes, related sub-themes and example codes.

During the coding, analysis and writing phases of my PhD, I used a method Nyqvist (2016) refers to as cross-writing or parallel writing. Cross-writing entails simultaneously writing academically and creatively based on the same data. Nyqvist highlighted how she found cross-writing to be an empowering and rewarding practice that strengthened her academic writing, helped her prevent writer's block, and maintained motivation. *“The difference in structure and outline of texts can, much like the language and style of different texts, fruitfully feed into each other and spark the joy and flow of writing”*, argues Nyqvist (2016:167). Similarly, Ingridsdotter (2017) highlights the analytical insights that can emerge when writing freely about your data and engaging with your findings outside of the boundaries of academic writing. It can enable the researcher to reflect on the meaning and significance of the data. In my case, using cross-writing as an integrated part of my data analysis was a similar experience that enabled me to reflect on and engage with and analyse my field data, experiences and observations. I had a parallel file to my dissertation - a document that I named Second File – where I freely wrote short stories about experiences during fieldwork, which helped me open up new perspectives and reflections about my data. Hemer (2016) recognises that writing in and of itself can be an eye-opening and liberating process that creates new insights. Learning and practising genre-transcending ethnographic writing, I found myself looking at my data from new perspectives, unpacking what my data meant, and, most of all - helping me identify and discover what stories I wanted to tell in this thesis and why. As Nyqvist eloquently describes it, *“working through the same empirical material with different lenses on—or perhaps looking at it with one eye first, then the other—opens up for alternative readings and interpretations and paves the way for new insights and ideas”* (Nyqvist 2016:166). Lykke (2013) similarly argues that genre-transcending ethnographic writing may open up new perspectives and angles of ethnographic data. Silow Kallenberg and Ingridsdotter (2017) recognise ethnographic fiction as a powerful tool for researchers to engage deeper in meaning-making and analysis. While the short stories that have emerged from my parallel creative writing are not part of my academic thesis, the process of writing these short stories has been part of the academic process and data analysis as one of several methods for me, as a researcher, to work with, interpret, and analyse my data. Beyond the dissertation, I may or may not find a context, avenue or purpose

where these stories can be used to communicate my research findings to a non-academic audience. All qualitative and ethnographic work is based on the ethnographer's interpretations and his or her subjective lens of a given phenomenon (Clifford and Marcus, 1986). You can, therefore, never claim to be writing the unfiltered truth. I want to clarify that my creative and academic writing has been done in parallel, yet has been strictly separate processes.

3.9. Data Management

The research project has followed a university-approved data management plan. All participants in the research were given a coded ID (a fictional name) in transcripts, and their data was stored in a separate password-protected file that linked each respondent to their ID. A third password-protected document lists the respondent's interpersonal data collected, such as age and gender. The key to re-combining the data has been kept in a separate, password-protected document. All collected data has been stored in individual files (coded with IDs for each respondent) in three separate locations: the university drive, on an external hard drive and in a password-protected file on my laptop. All personal data was anonymised and coded. Participants were informed of the data storage and security arrangements as part of informed consent procedures. All research participants were informed about how and why their data would be processed, stored, and used. As collected data included identifiable personal information about living individuals, the project complied with the General Data Protection Regulation (GDPR) requirements and the Common Law Duty of Confidentiality. All data was anonymised and stored securely (password protected), ensuring that none of the data could be traced back to a specific individual.

The data was accessible to me, and part of it was shared with the translator/research assistant (who signed a form aligning with this project's data management and ethics) and my supervisors. Metadata will be released to the University of Sheffield's data management for archiving (not including transcripts).

All personally identifiable data will be destroyed after the finalisation of the project. All remaining data will not be able to be tied to a specific individual, which (according to GDPR guidelines) means that it is no longer classified as personal data and can be reused for other research purposes

(which is outlined in the information sheet/consent form for this project that all research participants took part in).

Original audio recordings were transcribed, and audio recordings will be destroyed when the project is finalised, keeping only the transcripts. Possible future research using the data will draw on the transcribed data. In addition, a detailed research diary was password-protected in a digital form. The same procedures for data confidentiality were applied to the pilot, although not all interviews were transcribed, as the main focus was methodological.

3.10: Ethical Considerations

The fieldwork was conducted based on the University of Sheffield-approved ethics assessment. The initial approval of the ethics assessment and risk assessment for the research approved in 2018 needed to be amended, as the global coronavirus pandemic has created a situation where research needed to be adapted to the “new normal” of adhering to COVID-19 health and safety precautions, regulations and ethical considerations. The ethics assessment was updated and subsequently approved, assuring that the research did not put the researcher or participants at a greater risk than otherwise in their daily lives. Appendix 9 outlines the precautions taken to conduct research safely and ethically with low and/or manageable risks.

The project has been designed to assure participants' anonymity, privacy and confidentiality. The final thesis (or other data publications) has used pseudonyms or fabricated names. During this process, factors such as ‘insiders’ ability to identify locations and individuals through other information provided in a publication have been considered (Bryndon, 2006; Christians, 2011). When personally identifiable information, or information that may be potentially identifiable, has been disclosed, this has been done with the consent of the individual(s) involved and after making sure that they are fully aware of the consequences of this.

3.11. Reflections on Positionality and Reflexivity

As a study with a qualitative and ethnographically informed approach, it has been a priority to be aware of and reflect on the historical background and biases embedded in the themes and context the study engages with, including my positionality and reflexivity from an ICT4D perspective

(Abbott et al., 2024; Buskens, 2010; Jimenez et al., 2022). As a white, European (Swedish-Irish-Norwegian), university-educated female researcher with a positionality that set me apart from the respondents I worked with in this research project, I aimed to actively and continuously be reflexive and pay close attention to my positionality and cultural disposition throughout the research process.

I first came to Tanzania at 16 through a student exchange program, which led me to make a series of choices that led me to spend most of my adult life in Tanzania (primarily Zanzibar). I am married to a Tanzanian, and we have three children together. We live in Zanzibar, which I see as my home.

However, before starting this research project, I had just finished an assignment working for the Swedish International Development Agency's country office in Zambia for three years, in an environment where I was working with questions around digital development that aligned with the focus of this study. However, my environment was predominantly centred around expatriate international development professionals and urban, English-speaking and university-educated Zambian colleagues. The contrast between that environment and the rural communities I engaged with during my fieldwork pushed me to broaden my perspectives and to improve my Swahili. Although my husband is Tanzanian and I had lived in Tanzania for several years before this PhD, my Swahili was intermediate at the time. Although it got me around in day-to-day life, I did not feel confident enough to conduct my fieldwork without a translator. With the encouragement of my supervisor, Professor Dan Brockington, I consciously chose to work with a research assistant with minimal English proficiency to push my language skills to a new level during the fieldwork without relying on a translator. Speaking Swahili with research participants helped build rapport with respondents and the community. However, as I am not a native Swahili speaker and was (and still am) learning, this approach also came with challenges.

During several focus group discussions, particularly at the beginning of the fieldwork, I felt embarrassed as I made mistakes, and there were instances where the groups laughed at my attempts to express myself. However, the fact that I made continuous language mistakes was also helpful as it contributed to deconstructing socially constructed power imbalances between the local community and me. It is well documented that a researcher's linguistic abilities and fluency in the language spoken by respondents - in this case, Swahili, Kisambaa and Kimeru - impact the researcher's positionality and data (Tanu & Dales, 2015). As my confidence and skills grew,

participants and I could laugh together about my language mistakes, and I could ask them for advice and help. As I also do not speak the local languages in each of the field sites (Kisambaa in Ubiri and Kimeru in Kikwe), this opened up an opportunity for respondents to teach me some words in these languages – and to give me Kisambaa and Kimeru nicknames - but it also prohibited respondents from expressing themselves in their mother tongue.

At the start of my primary fieldwork, my twins were approximately 1,5 years old. My husband, sister-in-law, children and research assistant, who are all Tanzanian, travelled with me during my fieldwork, and they often accompanied me during interactions with respondents. When I was pregnant before the fieldwork, I foresaw challenges with conducting fieldwork whilst having small children and embarking on accompanied fieldwork (Ayeh, 2023). I was positively surprised by the experience and found that bringing my children during the fieldwork instead contributed to being able to collect better data and access new levels of insight into the culture, norms and structures of the villages where I worked.

The fact that I had a Tanzanian family and children helped me to build positive relationships with households in the community. In addition, the status of being a mother has been shown to shape how women perceive themselves and how they perceive other women (Frost & Holt, 2014; Phoenix et al., 1999). My status as a mother altered my positionality and opened doors for connecting with female respondents who were also mothers. As we cooked, bathed, and fed our children, we bonded over universal challenges and blessings related to motherhood and parenting. I participated in many situations and heard countless stories in these informal children-related situations, which helped me to form a deeper understanding of various topics. On the other hand, balancing the roles of reproductive work in the role of being a mother and productive work in the role of a researcher also presents challenges (Krause et al., 2022; Raddon, 2002) and “entangles our personal and professional selves” (Cupples & Kindon, 2003:3).

3.12. Conclusion

In this chapter, I have shared details about the methodology used to meet the aims and objectives of the study and answer the five research questions. The methodology includes desk-based research and qualitative semi-structured interviews with key respondents to map out the digitisation in the agricultural landscape. To understand the contrasting aspect of how digitisation in agriculture is manifested in rural farming communities at the margin, I have described the

ethnographically inspired qualitative methods I have used to capture farmers' experiences. Against this background, the following section explores the context for this research – Tanzania.

Context: Tanzania

Chapter 4

4.1. Introduction

In this chapter, I situate the study within the case study setting. I start by sharing a brief snapshot of Tanzania as a context. I then discuss the continued significance of smallholder farmers in Tanzania and move to present data about digital access statistics and how digital transformation is a core priority in Tanzanian policies. Following this, I discuss historical, political, and ideological influences that have shaped Tanzania's agriculture sector, specifically the imagined role of farmers within dominant trajectories. The chapter is wrapped up with concluding remarks.

4.2. Snapshot: Tanzania

Tanzania has a history characterised by colonisation, occupation, and exploitation. The borders and administrative structure of the nation rest on the post-World War I colonial division of "German East Africa." Present-day mainland Tanzania was re-named Tanganyika and given "artificial colonial boundaries" (Mmassy et al., 2022:99) that - on paper - unified "hundreds of independent clans, lineage groups, and chiefdoms" (Mmassy et al., 2022:99) and put under British colonial administration. During the colonial occupation by German and British settlers in mainland Tanzania, smallholder farmers were subjected to oppression, cruelty, marginalisation, and exploitation, and local resistance to the occupations was repressed (see, e.g., Mmassy et al., 2022; Mukembo & Edwards, 2016). The illegitimate colonial rulers enforced policies and politics that sought to exploit local labour and resources, many of which were intimately tied to the agricultural sector (Mmassy et al., 2022). Missionaries, settlers, the German and British colonial

administrations during the colonial era, and their politics and policies influenced Tanzanian small-scale farmers' agricultural practices, livelihoods, choices, and overall agricultural trajectory. Since 1964, the United Republic of Tanzania has been a union of Tanganyika (mainland Tanzania) and Zanzibar.^{vi}

The latest census reported a total population divided into 31 regions, 26 in mainland Tanzania and 5 in Zanzibar (Ministry of Finance and Planning, 2022). According to the National Bureau of Statistics, Tanzania has a population of 61,7 million, with 95 males per every 100 females. The national census in 2022 found a 3.2% population growth rate since 2012, and approximately half of the population (30,2 million) are between the ages 0 – 17 (PHC, 2022).

4.3. The Continued Relevance and Presence of Small-Scale Farmers in Tanzania

In 2020, Tanzania was recognised as a middle-income country, shifting from its previous label to a low-income country. This government milestone was met before the goal in Tanzania's Development Vision 2025 (Turuka, 2022). However, despite the semantics of economic labels representing the economic development status of a country, it is important to note that small-scale agriculture plays an important role in Tanzania and remains the primary source of employment, income and food for most of Tanzania's population. The National Sample Census of Agriculture (NSCA) of 2019/2020 was the fifth to be carried out since its inception in 1971/1972. The findings show that 65.3% of Tanzania's 12 million households engage in agricultural activities. Of households engaged in agriculture, 64.9% conduct crop farming alone, and 33% combine crop farming and livestock. The findings demonstrate a growing number of farming households in Tanzania, increasing from 5.8 million households in 2007/2008 to the 7.8 million identified in the most recent census. The dominant crops grown by Tanzanian farmers include maize, paddy rice, and sorghum, and they have all – mainly maize and paddy rice - experienced an exponential increase over the last two censuses. Over the past three censuses, the statistics on cash crops (e.g. coffee, cotton, cashew nuts) have shifted, showing uneven patterns. The same report found that 76% of cultivated land in Tanzania has local seeds, 20% uses hybrid seeds (in the report referred to as "improved seeds"), and 2.5% uses a mix of both (NSCA, 2021). This quick snapshot of agricultural statistics illustrates that Tanzania remains a thoroughly rural society and agricultural economy despite urbanisation and growth in other sectors.

In addition, Jerven's (2013a) work has highlighted the inherent flaws in African development statistics and pointed to structural challenges in how data is collected, analysed and presented, leading to inherently misleading statistics about African development. Looking at African agricultural development from this perspective calls for doubts about the reliability and validity of historical data sets that underpin how we measure the "progress" of African agriculture, particularly as the volume of data available today is greater than in the past (Jerven, 2013b). By extension, Jerven (and others, e.g. Carletto et al., 2015) have flagged the inherent dangers in developed policies based on misleading data. Thereby, we have to be careful with these data; nevertheless, while the detail may be uncertain, the bigger picture – the dominance of smallholder agriculture – is clear.

Brockington and Noe (2021) argue that this agriculture yields good dividends for many farmers. Their book, the result of a collaborative research project, demonstrates the nuances and complexities of how change has happened and continues to happen in rural Tanzania, which has not been captured in the macro-data indicators that dominantly characterise discussions about longitudinal development processes. Their book contributes to debates about rural development in Tanzania with three main arguments. First, assets are a key aspect of understanding the nuances of how rural Tanzanians benefit from economic development. Yes, assets are not included as a measure of conventional indicators for rural development. Second, rural Tanzanian households have experienced increased wealth over the past decades. As co-authors of the book revisit rural communities where they carried out research years back, the book demonstrates and exemplifies narratives of prosperity which challenge mainstream notions of rural African peasant life. Lastly, they emphasise that recognising the role of assets is not a panacea for understanding development processes. Instead, they highlight the multi-faceted and complex patterns that jointly shape rural development processes.

4.4. Digitisation in Tanzania

Tanzania has positioned itself as one of the "darlings" of ICT4D, with an affluent presence of stakeholders and investment aiming to harness the potential of Tanzania's digital transformation. According to the Tanzania Communications Regulatory Authority's (TCRA) communications statistics report for September 2024, Tanzania had 79.6 million active SIM card subscriptions at publication, a 5.4% increase from the previous quarter. The statistics illustrate a higher

subscription rate in urban areas, with Dar es Salaam, Mwanza and Arusha leading in the number of telecom subscriptions, and 14.8 million subscriptions alone are in Dar es Salaam (TCRA, 2024). If each of these SIM cards were registered to a unique user, this would translate to a mobile penetration rate of approximately of the population. However, measurements based on the number of subscriptions (active SIM cards as reported by the operators) compared to the size of the population are commonly used to overestimate the access and use of mobile phones. In Tanzania, as well as in the wider Sub-Saharan African region, the use of multiple SIM cards and shared mobile phone devices within households is well-documented, which further complicates measuring access and use of shared devices as each SIM card cannot be tied to one specific user (Tomitsch et al., 2010; RIA, 2017).

TCRA further reports an 84.8% mobile phone penetration for basic and feature phone devices, suggesting the presence of 55.2 million devices accross Tanzania. The smartphone statistics demonstrate a more modest penetration at 33.8%, with 22 million devices. Beyond mobile phones, the access and use of tablets (0.67%, 438,000 devices) and computers (0.02%, 12,000 devices) remains low. Mobile money subscriptions amount to 60.8 million; in September 2024 alone, 310,8 million mobile money transactions occurred accross Tanzania (TCRA, 2024).

Mobile and fixed internet subscriptions total 41.4 million, a 5% increase from the previous quarter. The data suggests a 9.8% annual growth rate for internet subscriptions over the past 5 years (25,8 million in 2019). Looking at mobile broadband coverage, the geographical coverage shows 73,6% 3G, 69% 4G and 2% 5G coverage. However, looking at the population percentage covered by network signal, 90.1% are covered by 3G, 84,9 by 4G and 18% by 5G.

Leading Tanzanian policy documents, such as the National ICT Policy (2023) and the National Five-Year Development Plan 2021/2022 – 2025/2026, have a tone that centres digital technologies as a key enabler for realising Tanzania's development goals. The Tanzania Digital Economy Strategic Framework for 2023 – 2033 has an opening statement by Her Excellency Dr. Samia Suluhu Hassan, President of the United Republic of Tanzania, where she writes the following:

”This framework symbolizes our unwavering dedication to the future, acting as a beacon, lighting our journey towards building an inclusive, resilient, and competitive digital Tanzania. We stand at the height of a new dawn, where the Fourth Industrial Revolution reshapes industries and redefines possibilities. We have witnessed digital technologies penetrate every aspect of our socioeconomic fabric, from agriculture and finance to governance and service delivery. As the rest of the world advances into the digital era, Tanzania, too, pledges to adapt, lead and innovate. The wind of change is upon us, and we must set sail, leveraging the strengths of our nation to reach new horizons.” (Ministry of Information, Communication and Information Technology, 2023:i).

Equally, external public and private actors have recognised the potential for digital development in Tanzania. As is further evidenced by the findings from this study (Chapter 5), the past years have witnessed considerable public and private investments into services and applications providing market price, market and weather information, farming advice, connections between producers and buyers and financial services that are targeted at smallholder farmers in Tanzania. GSMA highlights Tanzania as one of three African countries with more than 20 digital agriculture services (see Figure 4.1).

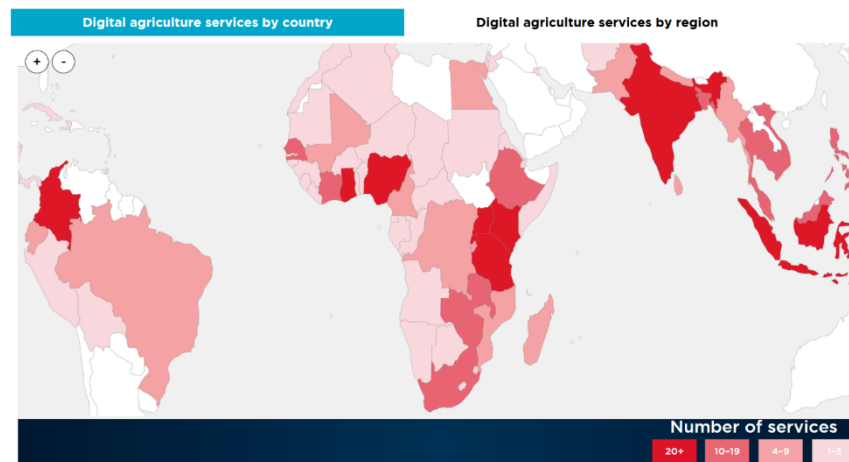


Figure 4.1: Screenshot from GSMA’s digital agriculture tracker on their website, which identified Tanzania as one of three African countries with more than 20 digitisation in agriculture services.^{vii}

4.5. Historical and Political Shaping of Tanzania’s Agriculture Sector

While the previous section briefly examined the tonality and trends around digital development in Tanzanian policy, this section turns the attention to the agriculture section.

The rhetoric and focus on transforming agriculture into agribusiness are central to agricultural policy and programs in contemporary and historical Tanzania. Under the rule of German and British colonial administrations, export-oriented cash crops were heavily promoted as part of a

colonial commodification of the agricultural sector built on the backs of the exploitation of local labour (Seimu & Zoppi, 2021). Post-independence, many colonial structures and policies were informally and formally kept in place - extending and reproducing structural patterns of marginalisation and exploitation. For example, the Co-operatives Ordinance, including section 36 (the “Chagga rule”), and the 1937 Native Coffee Ordinance significantly shaped and influenced the cash crop marketing policies for four decades, and colonial agricultural policies continued to be used in Tanzania until neoliberal reforms under structural adjustment programs (SAPs) (Seimu, 2016; Seimu & Zoppi, 2021). In the early years of Tanzania's independence, agricultural policies encouraged intensification through increased use of capital and industrial inputs and mechanisation, which was imagined to boost the economy (Meertens, 2000:335). The post-independence decades were characterised by increased state control of the food market under Tanzania's first president, Julius Nyerere. He pushed for African self-reliance and was a vocal critic of imperialism and capitalism (Shivji, 2017). Nyerere introduced a term referring to African socialism - Ujamaa - and emphasised strong values of African unity and solidarity, focusing on brotherhood and familyhood (Fouéré, 2014; Jacob & Pedersen, 2018). While implementing his Ujamaa principles, policies were often violently enforced without public consultation or consent. Examples include Opereshini Vijijini (Operation Villagisation), which entailed the forceful displacement of people to new villages; Opereshini Maduka (Operation Shops), which closed down privately owned shops; and Kilimo Cha Kufa na Kupona (agriculture is a matter of life and death), where people were required to participate in agricultural activities and forced the settlement of nomadic communities. Nyerere's Ujamaa impacted the agricultural sector in many ways, including forcefully displacing people, enforcing particular agricultural practices, restricting movement, and establishing new village structures (Mmassy et al., 2022).

Economic incentives and political motives (including pressure from donor countries, the private sector, and international organisations) have impacted the focus of agricultural policies. The most notable example is how Tanzania was pressured by the International Monetary Fund (IMF) and the World Bank to implement a structural adjustment package as a pre-requisite to accessing financial support packages in the late 1980s. The SAPs led to economic liberalisation and free market policies replacing socialist structures. The SAPs were the start of decades of policies and programs that have sought to commercialise and commodify agriculture through agribusiness with

the support and encouragement of international institutions, donors, and private sector partners (Meertens, 2000). In addition, international, Pan-African, and regional pressure, policies, and declarations have influenced the trajectory of agriculture in Tanzania towards industrialisation, commercialisation, and adoption of “improved” and “modern” farming agendas. Notable examples of such influence include the 2003 Maputo Declaration, the 2006 Abuja Declaration, the 2014 Malabo Declaration, the New Partnership for Africa’s Development (NEPAD), and the Comprehensive Africa Agricultural Development Programme (CAADP) (Adésinà, 2023; Minot & Benson, 2009; Tiri et al., 2020; Yovo & Ganiyou, 2022).

Tanzania's development, including the agricultural sector, has also been influenced by more recent presidents' priorities, policies, and leadership (Aikaeli et al., 2021; Mkonda & He, 2016; Nkobou & Ainslie, 2021; Sulle, 2020), see Table 4.1.

Table 4.1: Influence from Recent Presidents of Agricultural Policy	
President	Influence on Agricultural Policy
Jakaya Kikwete 2005 - 2015	Mobilising private sector investment into the agricultural sector to transform subsistence farming into commercial and profitable enterprises. His policies and politics translated into programs such as Kilimo Kwanza (Agriculture First) and Southern Agricultural Growth Corridor of Tanzania (SAGCOT). Kikwete’s vision imagined a central role for the private sector in agricultural development. One result of Kilimo Kwanza was the Agricultural Sector Development Program (ASDP), which utilised public-private partnership (PPP) models.
John Pombe Magufuli 2015 - 2021	Magufuli re-emphasized the state's presence in the agricultural sector within an overarching political agenda that sought to redefine Tanzania's relationship with donors and foreign investors and enable local investment.
Samia Suluhu Hassan 2021 - Present	The policy framework guiding Tanzania's overall development consists of key policies and programs such as the third National Five-Year Development Plan (FYDP III), Pathways for Sustainable Food Systems 2030, Agenda 10/30, and the Agriculture Sector Development Programme (ASDP II), and Building a Better Tomorrow - A Youth Initiative for Agribusiness (BBT-YIA). These essentially reproduce key elements from the dominant neoliberal development discourse and a productivist intensification narrative that centres on increased productivity, transitions to agri-business, supporting entrepreneurs, and reducing poverty reduction to mainly economic parameters. President Hassan has had a stronger rhetorical focus on sustainability and the environment compared to her predecessors.

In contemporary Tanzania, the dominant intensification discourse - entrenched with the above-mentioned historical legacies - is evident in, for example, the Government's "Kilimo Biashara" (Agricultural Business) - Agenda 10/30 that "aims at transforming agriculture into business enterprises" (African Union, 2023:1). The Ministry of Agriculture's flagship national program Building a Better Tomorrow - A Youth Initiative for Agribusiness (BBT-YIA)^{viii} focuses on inspiring, motivating, coordinating, engaging, and enabling young Tanzanians to become successful agribusiness entrepreneurs. These initiatives feed into larger goals and aims around commercialising the agricultural sector and using economic growth as a tool for poverty reduction, which are emphasised in other government policies and programs (e.g., the Agricultural Sector Development Program Phase II (ASDP II) and the Five-Year Development Plan 2021/22-2025/26) (African Union, 2023).

The agribusiness narrative - echoed throughout Tanzania's agricultural policies and programs - builds upon an assumption that arable land should be transitioned from small-scale "inefficient" farmers to larger, commercialised models and farming methods. Regardless of whether this transition happens through illegitimate (land grabbing) or legitimate (voluntary sales) transfers of land titles or through smallholder farmers reinventing themselves as commercial agro-entrepreneurs, it is clear that this narrative perceives smallholder farmers as strategic tools in the process of making the smallholder farmer obsolete (Bezner Kerr, 2023). In Tanzania, examples include the Southern Agricultural Growth Corridor of Tanzania (SAGCOT), which has been widely recognised as a top-down initiative that has further marginalised and excluded local small-scale farmers through land grabbing for commercial purposes (Sulle, 2020). Initiatives like SAGCOT, driven by an agenda to transition small-scale agriculture to larger-scale agribusiness, offer small-holder farmers two roles to participate in commercialised models of farming they present: either as entrepreneurs or paid labourers (Sulle, 2020). This can be argued to be an example of how contemporary agricultural politics and policies are reproducing plantation logic through structures designed to keep small-scale farmers in marginalisation and exploitation, as their roles and positions serve the interests of others (Bezner Kerr, 2023). One way that colonial legacies are lingering in Tanzania's contemporary agricultural sector is through the (global, pan-African, regional and national) agricultural policies, programs and politics in sub-Saharan Africa frequently support and encourage the acquisition of land by private companies or the state, who

are imagined to “more effectively realise the production potential of the land to meet national and global food objectives” (Mdee et al. 2020:1264). This mirrors the colonial history of land grabbing. “It is in the interest of local and national elites to welcome large-scale initiatives promoted by foreign and national capital because they create opportunities for rent-seeking and direct benefits through lease agreements and/or directly accumulating land.” (Sulle, 2020:347). In other words, many agricultural projects and policies carried out in the name of development, have had adverse and indirect or directly harmful consequences for farmers in Tanzania. For example, SAGCOT, which seeks to commercialize and modernize agriculture through investment in Tanzania's central zone has enabled elite capture, landgrabbing and displacement, further marginalizing smallholder groups (Mdee et al. 2020; Sulle, 2020)

Contemporary Tanzanian agricultural policies, priorities, and programs have been centred around a development trajectory focused on modernisation, commercialisation, industrialisation, and mechanisation of the agricultural sector, enabling a Tanzanian green revolution. Previous research in the Tanzanian context has pointed out the inefficiency in agricultural policy implementation (Kawishe & Mallya, 2022) and the gap between policy and practice (Mdee et al. 2021).

However, it is important to point out that Tanzania's agricultural sector includes various competing and intersecting narratives and discourses. While the dominant narrative is aligned with an industrialised, commercialised and modernised trajectory, there are alternative narratives at play. In Tanzania, proponents and stakeholders advocating for alternative agricultural futures are formally represented by the national umbrella organization Tanzania Organic Agriculture Movement (TOAM). With various stakeholders and sponsors, TOAM has organized three National Ecological Organic Agriculture Conference (NEOAC) editions. In November 2023, the country's first National Ecological Organic Agriculture Strategy was officially launched in collaboration with the Ministry of Agriculture. Launching this strategy and appointing Dr Mwatima Juma, Chairperson of TOAM, to Tanzania's Presidential Food and Agriculture Delivery Council represents significant steps for counter-discourses in the Tanzanian agricultural policy space.

Within larger discourses of agricultural development, examining how farmers are being positioned, framed and imagined in the implicit messaging and tonality of agricultural policy in Tanzania is interesting. Mirroring historical and contemporary framings of peasants as lazy and

unproductive (Bryceson, 2000; Handy, 2009; Whitehead, 2000), the implicit message in Tanzanian policy rhetorics implies that to achieve development a *transformation* is necessary rather than embracing trajectories that centre farmer-driven change from within.

4.6. Conclusion

In this chapter, I have presented data that illustrates that although Tanzania is a country undergoing change, it remains centred around smallholder agriculture, the main occupation and livelihood of many Tanzanians. I have shared national statistics about digital access, which sets a backdrop to the qualitative findings about farmers' digital realities that I present in Chapters 6 and 7. I have also reflected on the historical, colonial, political and ideological influences that have shaped Tanzania's agricultural sector and how farmers are being framed in these discourses. I have examined policy rhetorics that focus on shifts towards commercialised models and agri-business and exemplified policy rhetorics that emphasise the need to transform Tanzanian farmers and the agricultural sector they operate within.

Tanzanias Digitisation in Agriculture Landscape

Chapter 5

5.1. Introduction

This chapter presents findings about the digitisation in agriculture landscape in Tanzania based on primary and secondary data collected between October 2017 and April 2024. The complete data set has been compiled into an inventory of past, current, and planned digitisation in agriculture applications and services in Tanzania (see Table 5.1; Appendix 7). Building on the foundation at the national level, succeeding chapters (6 and 7) present complementary data reflecting the lived digital- and epistemic realities of rural farming communities in Tanzania.

Following the introduction, this chapter shares key findings about Tanzania's digitisation in agriculture ecosystem, including data about the focus, intended user groups, access requirements, funding landscape, and use and impact of identified tools. The second part unpacks qualitative insights from the data collection process. The concluding section summarises the main contributions to the literature about digitisation in agriculture that this chapter has made and forms the backdrop for upcoming analysis chapters.

5.2. Tanzanias Digitisation in Agriculture Landscape

A notable finding from mapping Tanzania's digitisation in agriculture landscape is the number of digital tools identified. While there are earlier grey and academic studies (see Section 5.3.1.) that have identified deployed digitisation in agriculture tools in Tanzania, this study adds additional depth and nuance in an extensive inventory that maps out 108 past, current, and planned

digitisation in agriculture services^{ix} (see Figure 1.1 and Table 1.1). No other country-specific mapping that has captured these many tools has been identified in the desk research. Of the identified digitisation in agriculture tools, 52% are exclusively designed for a Tanzanian user base (either on a national scale or targeting a specific region, district or group). Other identified digitisation in agriculture tools have been developed with a target group that includes Tanzania but spans multiple countries (see Figure 5.2).

Table 5.1: List of identified past, current and planned digitisation in agriculture initiatives in Tanzania.^x

1. AfriFARM 2. AfriScout 3. Afya ya Mnyama Digital Limited 4. Agriculture Dashboard System/ Kilimo Dashboard 5. Agriculture Trade Management Information System (ATMIS) 6. AgriManagr 7. AgriPath Project (Farmbetter App) 8. AgriTechs 9. Agricultural Innovation Pilot Project 10. AgroBot 11. Alternative Exchange (trading platform) in Eastern and Southern Africa 12. Anzia Sokoni 13. Agricultural Routine Data System (ARDS) 14. Arifu 15. COSITA/ FARM Africa 16. Dairy Farmers Information System (DFIS) 17. Digital Inputs Financing Toolkit (DIFT) 18. Digital Mobile Africa 19. Doctor Kilimo App 20. East Africa Fruits 21. E- License application for Exporters of Agri-products and Agricultural ERP 22. eHakiki 23. eKilimo Startup Acceleration Program 24. EMA-i 25. Esoko 26. Farm Clinic 27. Farmer Registration System (FRS) 28. Fertiliser app 29. Fertilizer Optimizer Application 30. FIT Insights Limited 31. Food Processing Software 32. The Guiding Acid Soil Management Investments in Africa (GAIA) project 33. GeoFarmer 34. Green Fingers Mobile 35. iCow	55. LandPKS 56. Linda Mbegu 57. Livestock Information Network Knowledge System (LINKS) 58. MAMIS (Mviwata Agriculture Market Information System) 59. Metajua 60. Mobile Agricultural Extension Tool 61. Mobile Application to Secure Tenure (MAST) 62. Mobile Holistic Climate Service 63. M-Kilimo 64. Mobis 65. More than Cashews 66. mFarming (mKilimo) 67. mKulima 68. Mkulima Hub 69. MyAgro 70. MyPhoneExplorer 71. NAAT APP (Netherlands Alumni Association of Tanzania App) 72. Nuru Infocomm / One2Two 73. Ninayo 74. Obus 75. Phema Agri - Lunga App 76. Plantix 77. Plantvillage Nuru App 78. Relationship Information Tracking System (RITS) 79. Robotech Lab 80. SAGCOT Integrated Knowledge and Information for Agriculture (SIKIA) 81. Seaweed Farmer Project 82. Seed Tracker 83. Shamba Konnect 84. Smart Village Agri Hubs 85. SmartFarmer 86. Sokoni Sasa 87. Starfish Mobile 88. TAHA Information System (TIS) 89. TAHA Kilimo App
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36. Illovo Sugar 37. Integrated Kilimo System 38. iProcure 39. Iringa – Mitigation, Adaptation, Productivity for Climate Smart Agriculture (IMAP4CSA) 40. Jambo Maisha 41. Jembe 42. JembeKilimo 43. Keep an eye on Poultry Business 44. Kilimo Fasta 45. Kilimo Fresh Foods Africa Ltd. 46. Kilimo Klub 47. Kilimo Smart 48. Kilimo Taarifa 49. Kilimo Tanzania 50. Kilimo Guide 51. Kilimo Utabiri 52. Kilimo Biashara 53. Kuza One 54. Knowledge Plus (K+) App	90. Tanzania Kilimo Digital TV 91. Tigo Kilimo 92. Tanzania National Livestock Identification and Traceability System (TANLITS) 93. Tigo Korosho 94. Tumaini App 95. Ubia Soko 96. Ugani Kiganjani 97. UPTAKE (Upscaling Technologies in Agriculture through Knowledge Extension) 98. Ushauri 99. Ushauri Kilimo 100. Ugunduzi 101. UZA EAC, 102. Viamo Platform 103. WeFarm 104. weightCAPTURE 105. YaraConnect 106. Yara CheckIt 107. Yara USSD Service 108. Z Kilimo.
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Table 5.2: Intended User-Groups Among the Identified Digitisation in Agriculture Tools.				
Farmers	Extension Workers	Pastoralists	Traders, Retailers, Buyers and Middle-Men	Agribusinesses and Start-Ups
76%	13%	1%	15%	3%
Agro-Input Dealers, Companies and Producers	Actors working with or selling to farmers. ^{xi}	Financial Institutions	Consumers	Government and Policy Makers
6%	13%	2%	4%	6%
Regulators	Researchers	Investors	Landowners and Land managers	Insufficient Data
1%	4%	1%	2%	6%

5.2.1. Intended Users

The data reveals that a majority of identified digitisation in agriculture tools have farmers as (one of) their intended user group(s). Although farmers are not a homogenous group, the available data set does not allow further disaggregation of the data into more specific farmer categories. Table 5.2 presents the data across categories. Many digitisation in agriculture services have multiple imagined end-users (e.g., farmers submitting questions and extension officers answering questions), which is reflected in end-user categories that are not mutually exclusive.

5.2.2. Digital Technologies

Of the identified digitisation in agriculture tools, 47% are smartphone and web-based applications, which require users to use a smart- and internet-enabled device as a minimum requirement to access the tool. Of the 108 identified tools, 24 (22%) are designed to be fully accessible without access to a smart device or the internet, typically using solutions such as interactive voice response (IVR), SMS and USSD. In addition, 10 (9%) are designed in a hybrid manner (e.g. including an Android app but also an SMS service). However, when interpreting the data, it was noted that 22% of the identified digitisation in agriculture tools did not have enough available data to be coded.

The data illustrates that the most common design among identified digital tools requires the intended user to access an internet-enabled smart device as a minimum access requirement. This finding is particularly interesting when compared and contrasted with Tanzanian farmers' digital realities. Chapter 4 summarises recent statistics about mobile access in Tanzania, which indicates approximately 33% smartphone penetration compared to 84.8% for basic and feature phones (TCRA 2024). However, the literature suggests that smartphone access and ownership tend to be skewed towards urban- and higher socioeconomic-status populations in Sub-Saharan Africa (Lwoga, 2010; Melephane, 2022). Findings from this study strengthen this assumption as data found that farmers in two rural communities in Tanzania predominantly accessed and used basic mobile phones, with many having no or limited smartphone access.

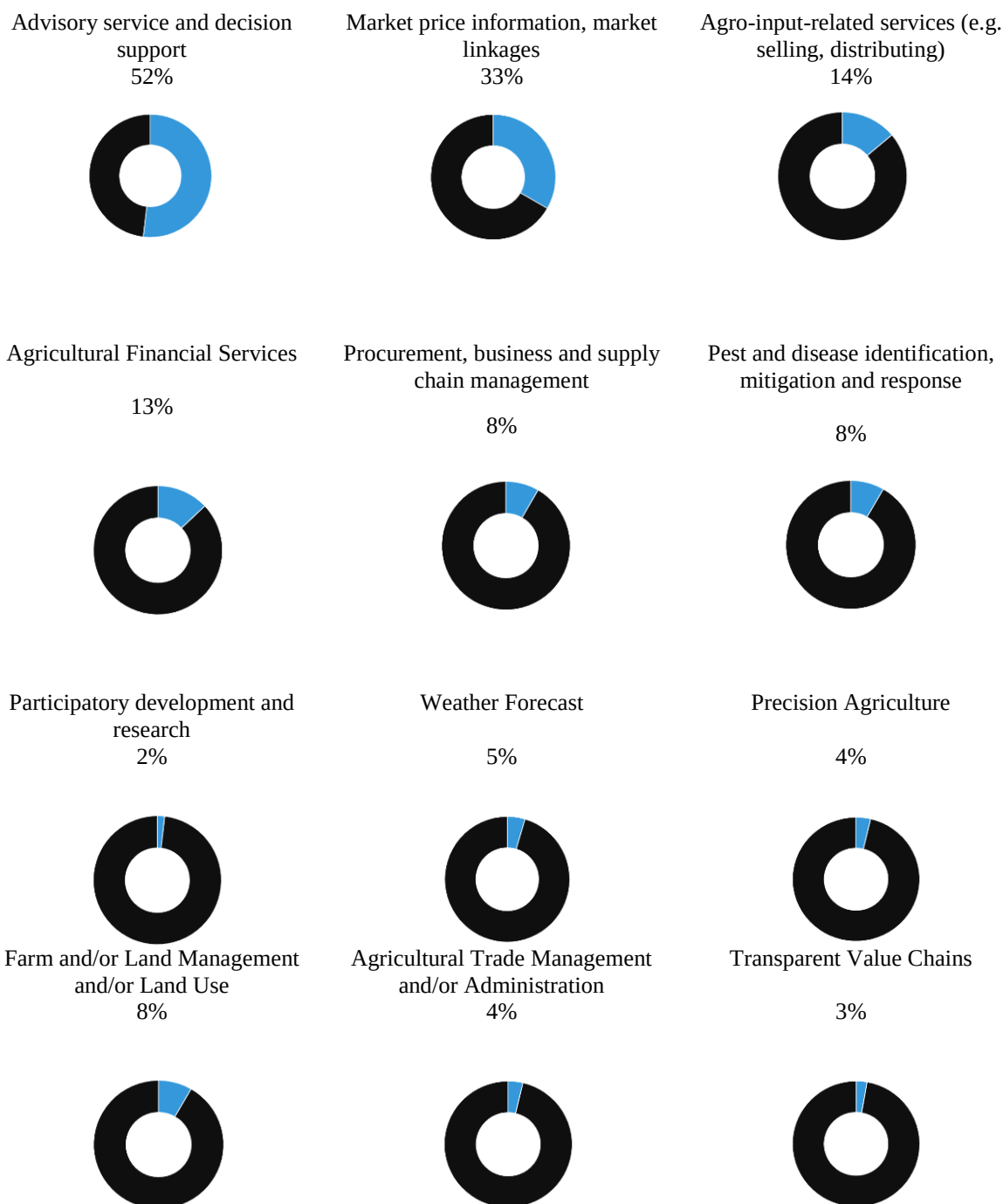


Figure 5.3: Key Focus Areas of Identified Digitisation in Agriculture Tools in Tanzania. Illustrating the percentage of the total number of digitisation in agriculture tools that focus on each category, a digital tool can have multiple focus areas. (By Author).

However, it is essential to highlight the diversity encapsulated in the broad category of smartphone and web-based applications.^{xii} Of particular relevance is recognising the non-binary relationship between online and offline accessibility, including the diversity in smartphone applications where some are designed to require constant internet access while others have offline functionalities. Smartphone applications may function partly or wholly offline once downloaded. Therefore, the conclusions that can be drawn about the online and offline functionalities of the identified digitisation in agriculture tools are limited (see Chapters 6 and 7 for detailed findings about rural digital realities).

5.2.3. Thematic Focus Areas

The data demonstrates that approximately half of the identified digitisation in agriculture tools are designed to provide advisory services and decision support, and a third focus on market price information and market linkages (see Figure 5.3). The data categories capture the multipurpose design of segments of the identified digitisation in agriculture tools by coding multiple focuses where applicable—which may include more than one category - reflecting the complexity of digitisation in agriculture on the ground.

The dominant focus on utilising technology to facilitate the dissemination of information and advice suggests that Tanzania's digitisation in agriculture discourse closely aligns with information deficit model logic assumptions (see Chapter 2). According to an information deficit logic, digital technologies offer an opportunity to address historical information asymmetries of rural, information-poor and hard-to-reach farming communities through digitally-enabled dissemination of information and advice. In Chapter 9 (Table 9.2), I synthesise and give concrete examples of how information deficit model logic is embedded in the focus and scripts of digital agriculture tools in Tanzania based on analysis and user testing of identified digital tools.

5.2.4. Stakeholder Snapshot

Furthermore, the collected data offers a snapshot of the key players in Tanzania's multi-faceted digitisation in agriculture funding ecosystem.^{xiii} The inventory mapped out funders ranging from public development cooperation agencies (e.g. USAID, GIZ, JICA, Finnish Funding Agency for Technology and Innovation), non-governmental organisations (e.g., Norwegian Church Aid, One Acre Fund, Tanzania Horticulture Association), UN agencies (e.g. UNCDF, UNDP, FAO), private sector technology players (Nokia, Google, Vodacom, Tigo, MasterCard Foundation), agricultural

private sector (e.g. Yara), foundations (e.g. Skoll Foundation), academic research grants, venture capitalists (e.g. Acumen Fund) and challenge funds (e.g. The Africa Enterprise Challenge Fund). Mirroring regional trends (see Chapter 2), the findings from this study illustrate the growing presence of private sector actors from both the technology industry (e.g., Microsoft, Google) and the agricultural private sector - including corporate philanthropic arms of multinational agricultural corporations (e.g., Syngenta, Bayer, Yara) - has been noted in the literature on digitisation in agriculture in the Majority World (e.g., Birner et al., 2021; Tsan et al., 2019; Hilbeck et al., 2022; McCampbell, 2021).



Figure 5.4: Logos and posters from identified digitisation in agriculture tools in Tanzania. Compiled by the author.

5.2.5. Demonstrated Utility and Impact of Digitisation in Agriculture in Tanzania

The data also reveals findings related to the (limited) availability of use- and impact data for the identified digitisation in agriculture services. Out of the 108 identified digitisation in agriculture tools, the desk review identified data referring to either use, outcome or impact for 38%. Notably, this also corresponds to the fact that no use, outcome, or impact data were obtained for 62% of the identified digitisation in agriculture tools.^{xiv}

Only two of the 41 digitisation in agricultural tools with available data report on outcomes (an annual income increase reported by MyAgro and improved milk quality for dairy milk reported by MyPhoneExplorer), and no data at the impact level was identified. Apart from these examples, 59% of the available data reports on the number of registered and/or active users. An additional 20% reported the number of people connected, reached or served, which leaves room for subjective

interpretations of what that means in practice. In addition, 29% of the data measures success based on the number of times a function of the tool had been used (e.g., the number of SMS sent), and 7% reported how many times the app had been downloaded. In other words, the value of digitisation in agriculture tools is frequently articulated using vague language referring to the number of users, the number of people reached, and people registered to a service. Still, evidence of the outcomes and impacts remains scarce. Additional identified data on the use and impact of individual digitisation in agriculture tools captured in the inventory is summarised in Appendix 2. These findings illustrate that much of Tanzania's digitisation in agriculture landscape remains a black box, and - as I explore in the next section - it is challenging to obtain information and evidence about the usage and impact of individual tools and the sector as a whole.

Table 5.3: Challenges Encountered When Mapping Tanzania's Digitisation in Agriculture Landscape	
Challenges	Underlying Cause(s)
It is difficult to identify digitisation in agriculture services and applications.	There is no standardised database, coordination, tracker or similar mechanism for digitisation in agriculture initiatives.
It is challenging to identify and access information about identified digitisation in agriculture tools (e.g. user statistics, impact evaluations, implementation details and key functions).	The identified documentation is scattered and has many gaps. Many identified digitisation in agriculture applications lacks a formal source of information. In addition, institutional memory is limited within the sector, as well as individual implementing partners and funders.
Determining the status of identified digitisation in agriculture services is complex and, in many cases, impossible.	Limited updated, detailed and available information about individual digitisation in agriculture tools exists.
Using identified digitisation in agriculture services is challenging.	Information about where and how to access and use many digitisation in agriculture services is often unavailable, not communicated or challenging to obtain (e.g. information about where to download a smartphone app or what USSD code to use).

5.3. What the Data Collection Process Teaches Us About Tanzania's Digitisation in Agriculture Landscape

The experiences and observations gathered during the six-and-a-half-year data collection process add a layer of qualitative insights about the digitisation in agriculture landscape in Tanzania. The following subsections discuss three key themes from the data collection process and final dataset, allowing for a more nuanced interpretation of the landscape (see Table 5.3).

5.3.1. Laying a Puzzle with Fragmented Data Pieces

The data collection process proved that the fragmented nature of Tanzania's digitisation in agriculture sector translates into high time- and resource investments to identify, learn about and test (when possible) digitisation in agriculture tools. Lessons learned from the data collection process illustrate that verifying and building upon existing data is difficult. The desk research identified twelve resources published between 2017 and 2024 that directly or indirectly map or list digitisation in agriculture services in Tanzania. Each resource identified between two and sixty services, as outlined in Table 5.4, including preliminary data from this study published in 2022 (Hilbeck et al., 2022) and the final number (108) of identified tools presented in this dissertation.

The mapping identifies three initiatives that seek to track or coordinate digitisation in agriculture tools. First, the Integrated Kilimo Systems (IKS)^{xv} is a digital platform launched by the government of Tanzania in 2020. IKS aims to support interoperability and data sharing by acting as a united interface for digitisation in agriculture systems owned and operated by the Ministry of Agriculture. Therefore, IKS does not include other digital tools. The website contains information about nine tools but has not been updated since 2022 (as of March 2024).

Second, a research project (Mushi et al. 2022; 2023; 2024) has been developing a proposed government-owned E-government service that is envisioned to serve as a one-stop-shop for all government digital tools under the name Farmers Digital Information System (FDIS). However, beyond published research papers, no additional information has been identified about FDIS.

Table 5.4: Summary of Findings from Recent Mappings of Tanzania's Digitisation in Agriculture Landscape (see Appendix 6 for more details)		
Number of identified tools	Resource	Year of Publication
10	CABI	2017
28	GSMA	2020
2	Ndimbwa et al.	2021
20	CCARDESA	2022
8	Mushi et al.	2022
60	Gatsby Africa	2022
9	Integrated Kilimo System	2022
50	Jadhav & Kimaro (USAID/DAI)	2023
6	FAO	2023
37	IFC	2024
20	GIZ	2024
28	GSMA	2024
95	Hilbeck et al. (preliminary results from this study)	2022
108	McCarrick (this study)	2024

Figure 1: Availability of digital applications for the livestock sector across Africa

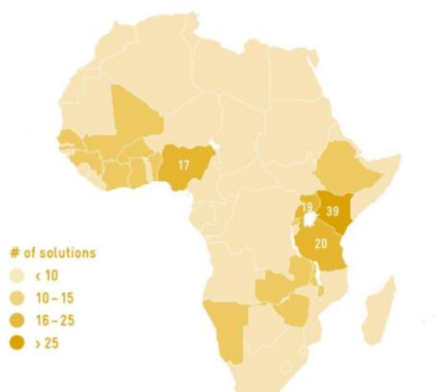


Figure 5.5: Screenshots from GIZ's (2021) report on digitising the livestock sector in Africa identifies twenty digitisation in agriculture tools in Tanzania, and GSMA AgriTech's Digital Agriculture Maps report (Accessed 20/2/2024) identifies twenty-eight digitisation in agriculture tools in Tanzania.

Lastly, GSMA's online tracking tool AgriTech Deployment Tracker^{xvi} has collected and tracked digitisation in agriculture across various geographies since 2009, including Tanzania. However, the AgriTech Deployment Tracker is currently unavailable, and the only available data on Tanzania's digitisation in agriculture landscape on the GSMA website is the data from a 2020 mapping (see Figure 5.5). In summary, no comprehensive and updated coordination mechanisms or database for documenting and sharing information, best practices, or lessons learned about digitisation in agriculture tools in Tanzania has been identified.

A lesson learned from the research process is that it is challenging to cross-fertilise different resources and build upon knowledge generated by existing resources that have attempted to map the digitisation in agricultural landscape in Tanzania.

For example, IFC (2023) identifies 217 digitisation in agriculture tools across seven countries, of which 37 were listed as operational in Tanzania. Yet, the report does not list or provide details or references about the digitisation in agriculture tools (beyond basic information about five tools with headquarters in Tanzania). Similarly, a USAID-commissioned report (Jadhavand & Kimaro, 2023), a report by Gatsby Africa (2022), and an academic paper (Mushi et al., 2022) identified 50, 60, and 8 digitisation in agriculture tools, respectively. Yet, none of the publications provide information about specific digitisation in agriculture tools and do not include traceable references

to more detailed resources. Other reports have documented data such as the names, implementing stakeholder(s), and a short description of each digitisation in agriculture tool. However, in others (e.g. CCARDESA, 2022), the report does not include any information on where to find more information, including the access points to digitisation in agriculture tools.

Interviews with practitioners and farmers re-inforces and validates the framing of Tanzania's digitisation in agriculture ecosystem as a scattered and fragmented sector. The findings suggest that the landscape is difficult to comprehend not only for outsiders (such as myself) but also for “insiders” in the digital agriculture sector, such as donors, government officials, digitisation in agriculture practitioners, Tanzanian researchers and, most importantly, the aimed-at end-users groups - farmers. Most farmers who participated informally and formally in the study had never heard about any digitisation in agriculture tools despite the crowded landscape (see Section 7.1).

Similarly, out of 21 key stakeholder interviews with digital agriculture practitioners, many could not name a single digital agriculture tool (apart from the one(s) they were working on). No interviewee (including key informants and farmers) in the study could give more than three examples of digital agriculture services. An employee responsible for the agricultural portfolio of a bilateral donor based in Tanzania was unaware of the digital components of the projects and programmes supported by the donor he represented. During the interview, he shared the following;

“So sometimes things are done by the discretion of the partner. Yeah. And we always meet during the annual review meeting, and then we hear probably what they are doing. We need to report. Okay, so there are a lot of things which are done in digital.” (A4)

Similarly, a key respondent representing an organisation implementing a new (at the time) digitisation in agriculture tool focused on market price information was unaware of any other previous or currently active digitisation in agriculture tools focused on market price information. This is notable considering that 33% of this study's 108 digitisation in agriculture tools focus on market price information and/or market linkages (see Section 5.2).

5.3.2. Fumbling in the Dark: Mapping a Landscape with Insufficient Data

Another finding emerging from the data collection process was the difficulty of accessing and obtaining data about identified services and applications. Some of the identified services have available data (to various extents) on websites, academic articles, grey literature, and industry reports (e.g., GeoFarmer, Ugunduzi, LandPKS). However, the study obtained little or no available information for many identified digitisation in agriculture applications and services. For example, the only identified information about one tool - the Seaweed Farmer Project - is one news article and a single web publication. Similarly, the only information identified about another tool - Yara USSD service - is a short profile in an industry report.



Figure 5.6: Screenshot of an article from 2016, the only (identified) evidence that a mobile app existed.^{xvii}

The lack of (detailed) information about many identified digitisation in agriculture tools leaves substantial knowledge gaps related to the concept, design, content, funding, implementation, and impact of much of the previous and contemporary work, limiting the ability to re-use and improve by building on an understanding of the existing ecosystem - which aligns with best practices outlined in digital development best practice (e.g. Principles for Digital Development, n.d.).

The leading source where data about digitisation in agriculture tools was identified was on the websites of implementing partners (57%), followed by other websites (44%), industry reports (35%), social media (29%), news or blog articles (19%), project reports (12%), academic articles (11%), stakeholder interviews (10%) and government websites or statements (7%).^{xviii}

5.3.3. Looking for the Access Point: Challenges to Find and Use Digitisation in Agriculture Services

As emphasised earlier in the chapter, the lived experience of conducting the data collection illustrates the substantial effort and grit required to access basic information about digitisation in agriculture services in Tanzania. This extends to obtaining information about the access point of individual services, e.g., the correct USSD code, website address, or smartphone application needed to access and use a tool. Notably, I could not obtain information about where and how to access and use 43% of the identified digitisation in agriculture tools. In addition, 21% had at least one access point identified, but the access point was non-functional. Of the 108 tools, 21% had at least one access point identified and were available to use by the public. In comparison, 7% was identified but could only be used by people provided with login details or by purchasing access to a commercial solution. The final inventory, therefore, has gaps as these services could not be tested or fully analysed (see Table 5.1 and Appendix 7).

Table 5.5: Status of Identified Digitisation in Agriculture Tools		
Number of identified tools	108	
Active/Operational Status	31	29%
Unconfirmed Status (“Zombie”)	69	65%
Closed/Discontinued Status	7	6%
Planned Status	1	1%

5.3.4. Determining the Status: Dead, Alive or a “Zombie”?

Early in the data collection process, it became clear that it was no easy task to determine the status of the large number of tools that emerged as the mapping of the landscape unfolded. Out of the

108 identified digital initiatives, 31 were confirmed active, seven were confirmed as formally closed, completed, or discontinued, and one was confirmed to be in the planning stage. I did not identify adequate available data to determine the status of 69 tools. I refer to these services as having an unconfirmed status (see Table 5.5).

For example, the AgriPath farmbetter app has an updated and functional website,^{xix} but the link to the mobile application is non-functional.^{xx} In this particular case, several possible scenarios may explain these circumstances. For example, there may be an error with the link, the application may be undergoing updates and, therefore, has been temporarily removed, or the initiative may be permanently discontinued. However, without access to more information, it is impossible to determine the status of this particular digitisation in agriculture tools.

Another illustrative example is the TAHA Kilimo App and TAHA Information System (TIS). In 2021 and 2022, I conducted stakeholder interviews with two TAHA (Tanzania Horticulture Association) employees from the Arusha and Zanzibar offices. The interviews provided detailed information about the multi-year processes of developing TAHA's two digitisation in agriculture tools. At the time of the interview in Arusha, there was a sizeable roll-up advertising the TAHA Kilimo App in the office lobby. However, when reconnecting with the respondents in 2024, both had ended their employment at TAHA and were unaware of the status of digitisation in agriculture tools. TAHA's website and social media do not contain any information or reference to either of the tools. Despite clear evidence (from two independent stakeholder interviews) that these two digital services existed, no proof of their existence has been identified online.

These examples illustrate a trend in the dataset, indicating a significant disconnect between digitisation in agriculture practice on the ground and the documented and available information (e.g., in reports, articles, websites, and social media). Therefore, inactivity or lack of presence in online spaces does not necessarily indicate that a digital application is discontinued. Similarly, online presence does not necessarily reflect a digital service's practical implementation and use. For example, the Fertilizer Optimizer App has an available and functional service point (a smartphone app)^{xxi} and detailed information available online.^{xxii} Based on this data alone, it would be logical to categorise the digital service as active. However, stakeholder interviews with the local implementing partner, Tanzania Agricultural Research Institute (TARI), revealed additional dimensions, the main one being that there was no funding to conduct training after the app had

been developed (a process that TARI participated in). Subsequently, the app was not used (see Chapter 8). Like “zombies”^{xxiii} of the digitisation in agriculture landscape, the Farmbetter app, TAHA Kilimo app and Fertilizer Optimizer App are all illustrative examples of digitisation in agriculture tools that are neither alive nor dead.

5.4. Conclusion

This chapter has presented findings from an extensive mapping of past, current, and planned digital services designed for and deployed in Tanzania's agricultural sector. The data illustrates a crowded digitisation in agriculture landscape populated by digital tools, services and applications with a dominant focus on information and advice dissemination targeting farmers as their intended and imagined users. While the data shows diversity in the technology required for (potential) users to access identified digital tools, many require users to have access to a smart device, connectivity and data. Information dissemination, advisory services and decision support tools are the dominant focus areas among the identified digitisation in agriculture tools, indicating a lingering information deficit model logic in the larger discourse. The findings also illustrate that, despite the continued proliferation of digitisation in agriculture initiatives, the evidence of outcomes, impact and utility of individual or collective digital applications remains scarce.

The chapter also lends perspective into intricate challenges that emerged from the process of data collection, illustrating structural adversities related to how digitisation in agriculture as a sector operates. This study exemplifies how structural challenges related to coordination, transparency, documentation and openness form an interlinked web of practical challenges to map, study and learn from the crowded Tanzanian ecosystem.

This chapter corresponds to the study's first research aim, which seeks to critically analyse the Tanzanian digitisation in agriculture ecosystem and digital tools designed for small-scale farmers. The foundation laid out in this chapter through a high-level overview of the digitisation in agriculture landscape in Tanzania informs subsequent chapters that present additional findings about farmers' knowledge systems, situated digital realities and unpacks if and how ideology is embedded in the design of digital applications.

Farmer's Situated Knowledge Systems and Digital Realities

Chapter 6

6.1. Introduction

The interplay between the envisioned role(s) of digitisation in agriculture and the practical realities experienced in rural farming communities is a core theme underpinning this study (see RA3; RQ3). Following Chapter 5's presentation of findings from the national level digitisation in agriculture landscape, this chapter delves into the latter part of this relationship by focusing on unpacking farmers' digital realities and local knowledge systems based on qualitative and ethnographically informed research conducted with two rural farming communities.

This chapter presents key themes from triangulated data from ethnographically inspired participant observations, focus group discussions, and qualitative interviews with farmers from two rural communities in Tanzania. As part of this study's multi-method qualitative approach, I mapped the frequency of use of *different media channels* and *interaction with different human actors* for personal and agricultural purposes within the knowledge systems of 54 farmers (see Section 3.6.2). These findings are used to frame the chapter's two thematic segments.

The first section presents key findings about farmers' knowledge systems and perceptions about knowledge and knowing. The second section shares insights about the role of digital technologies within farmers' knowledge systems. The chapter ends with a conclusion that summarises key points and connects the chapter to the study's research aims and questions.

Table 6.1: Key Findings – Frequency of Communication with (Human) Actors in Farmers Knowledge Systems Synthesised key findings from Knowledge and Information System Mapping with 54 farmers from Ubiri and Kikwe (see Chapter 3 and Appendix 9).			
Actor(s)	Frequency of Interaction	Personal (non-agricultural) Communication	Agriculture-Related Communication
Family and household members	Once or multiple times daily	94%	55%
Neighbours	One or multiple times daily	91%	52%
	At least once per week	100%	77%
Peers outside of the direct community	At least once per week	45%	43%
	At least once monthly	75%	79%
Peers at savings groups meeting(s)	At least once weekly	42%	27%
Peers at farmer group meeting(s)	At least once weekly	25%	26%
Agricultural extension officers	No communication	81%	26%
	At least once per month	15%	32%
Agro-dealers and Input Suppliers	One – three times annually	19%	57%
Buyers	No communication	69%	14%
Middle-men	No communication	70%	23%
	One – three times annually	11%	45%
	At least once weekly	17%	25%
Agri-companies	No communication	70%	23%
	One – three times annually	18%	18%
Non-governmental organisations (NGOs)	No communication	98%	81%
	Once per year	2%	13%
Local government	No communication	59%	66%
	One – three times annually	19%	17%
National government	No communication	89%	91%

6.2. Farmers' Local Knowledge Systems

Aligning with the study's objective to critically examine the relationship between digitisation in agriculture tools and the digital realities and local knowledge systems they seek to enter and improve, the following sub-section unpacks qualitative findings about the nuances of farmers' knowledge systems.

I start by examining key insights about the frequency (daily, weekly, monthly, annually) at which farmers in the study communicate with various (human) actors about personal and agricultural matters (see Table 6.1 for a summary).^{xxiv} The synthesised data suggest that farmers in Kikwe and Ubiri primarily rely on community-based epistemic resources, such as family, household

members, neighbours, and community groups. In addition, many respondents have frequent interactions with established contacts in their social networks located in other geographical locations (e.g., friends, family, acquaintances or a subject-specific trusted contact).

Contrarily, the data suggest that farmers in Ubiri and Kikwe have less frequent interactions with people and institutions outside their immediate local community and pre-existing social networks. Actors such as extension workers, agro-dealers, buyers and middlemen played a less frequent role in most of the participating farmers' agricultural knowledge systems. These findings echo previous research that has emphasised the importance of community-based knowledge sharing and production in farming communities in Tanzania and other Global Majority contexts (e.g. Chen et al., 2015; Conley & Udry, 2010; Krishnan & Patnam, 2014; Lwoga et al., 2011; Meribe, 2014).

6.2.1. Farming as an Embodied and Lived Experience

As described in the previous section, the data illustrate the prominence of community-based actors and existing social networks in farmers' knowledge systems. Adding further nuanced insights about farmers' knowledge systems and practices, the triangulated findings from the study illustrate that respondents experience and conceptualise agricultural learning as an embodied, practical process in the field.

The research indicates that farmers in Kikwe and Ubiri observe, learn and co-produce agrarian practices, techniques, and knowledge from family members, neighbours and community groups. Accounts from farmers and direct observations illustrate that the farmer's experience of agriculture often rests on a foundation of agricultural knowledge that starts to be built early in life. Young children are typically indirectly introduced to agriculture by family members and are gradually more and more practically involved as they grow up, moving from an observer role to an active farming role. Wrapped up with a *kitenge*,^{xxv} children typically indirectly participate in agricultural activities from the backs of their mothers, aunties, siblings, and grandmothers, partaking in the everyday life of their caretakers. Slightly older children start to help with agricultural activities at the farm (e.g., planting, weeding) and at home (e.g., post-harvest crop care and feeding animals). When reaching school age, many children contribute to household and farm work during evenings, weekends and school holidays. Children in secondary school who are close to graduating sometimes work independently on one of the family plots as a complement to attending school.

Farmer respondents reported learning to farm by participating in and observing farming activities from their parents, extended family and neighbours.

Respondents also reported that they learn agricultural knowledge, methods and practices through other channels and from other people, including at school or university, from extension officers, seminars, or through advice from radio or TV, which are typically complementary to the dominant pathways for sharing, producing and applying agricultural knowledge in Kikwe and Ubiri centre around practices of informal self-education, intergenerational knowledge transfer, practical learning-by-doing and field-based experimentation.

“We farm like our grandparents, parents, and mothers because they are our teachers, and we have learned from them”, shared twenty-year-old Marangu from Kikwe, suggesting intergenerational learning patterns that position farming as a matri-linear heritage. However, farmers' cross-generational, peer-centred and mutual knowledge exchange practices and community-based experimental learning do not necessarily equate to reliance on historically dominating “traditional” and Indigenous agricultural knowledge and practices. Building upon this observation, it is relevant to echo previous research that has emphasised the importance of recognising the plurality and non-static nature of Indigenous and local knowledge (ILK) and that farmers' practices continue to evolve, adapt and change over time (Berkes et al., 2000; Mortimore, 1989; Richards, 1985). External networks influence ILK, and in the field study location, industrialised and input-heavy approaches to farming are widespread in the communities and influence the knowledge and practices that younger farmers learn from their families and communities. In Chapter 7, I further unpack findings that similarly illustrate the complex intricacies of farmers' (digitally enabled) knowledge systems, including farmers' resourcefulness in adapting (local) knowledge and practices to changing agricultural contexts and needs.

6.2.2. The Dynamics of Community-Centred Knowledge Practices

As the chapter continues to explore the nuances of farmers' knowledge systems, the findings illustrate how farmers' agricultural knowledge and practices are intertwined with their broader cultural, social and economic lives. The data indicate that actors with a frequent presence in farmers' knowledge systems often play a role that transcends into the realms of both agricultural and personal life. For example, many female respondents are members of one or several savings

groups,^{xxvi} which they typically meet with weekly. Other members of the savings groups are examples of actors that respondents in the study reported recurrently communicating with about personal matters (for example, a child-related topic) and agricultural topics (discussing, sharing or seeking advice explicitly related to farming) and formed safe spaces for women to connect and collaborate.

The multi-dimensional nature of the role of community-based actors in farmers' knowledge systems reflects the dimensions of trust that are typically embedded in community-based farmer-to-farmer relationships, such as the relationships between female members in savings groups. Findings and observations, thereby, suggest that farmers often ascribe epistemic authority to trusted community-based sources.

However, the insights from this study are multifaceted, and findings equally suggest that farmers' perceptions of and relationship to “external” actors - such as extension officers - represent a different dimension of how farmers ascribe trust and epistemic authority to actors in their knowledge systems. The data reveal heterogeneity within local perspectives on how knowledge and expertise are valued and perceived by farmers. Farmers in the study ascribe epistemic authority to actors they identify as *experts* (typically using the word *mtalaam* in Swahili). Still, the perception of who was deemed to be an expert was not uniform. The gathered data provides insight into two divergent strands of opinion among farmers. This mirrors existing research that has suggested that the reasons for ascribing epistemic authority to a specific source of information can be many, for example, due to an expert or authority status, previous positive experiences, approval-seeking behaviour or a wish to mirror one's existing beliefs (Suldovsky 2016).

One perspective associates expertise and valuable knowledge with people with formal titles and education, such as extension officers, often due to their formal educational background. Farmers aligned with this position reported valuing and trusting formal knowledge over situated, practical, and informal knowledge provided by knowledge channels in their communities. I exemplify this by sharing three quotes from farmers in the study;

“Because in farming, there are always changes in weather and climate and even seeds have variations, so I need more expertise and guidance. It is from an agricultural officer. For the fertiliser, I need advice on how to use this manure and how to use the one from the store. It will enable me to get good and plentiful harvests. I needed advice, but even the agricultural officers don't come to our homes. I believe this because those agricultural officers will have studied what they advise on”, Male Farmer, Ubiri (F26)

“The diseases are many. I do not know if the seeds cause diseases or the weather... You grow maize, you see it withers, now the wilt... If you do not get an expert, you will never know what is wilt or what the cure is, so you still need information”, Female farmer, Kikwe (F44)

“We have little education and a lot of things are going modern. And that is why we are here for advice”, farmer Kikwe (RD).

The study found that actors with a less prominent and frequent role in farmers' knowledge systems usually have a relationship where information and knowledge exchanges are focused on a specific life sphere (e.g. purchasing inputs from an agro-dealer). Only a few respondents engaged with non-community-based stakeholders (e.g. extension workers, agro-dealers, buyers) about non-agricultural matters. For example, 74% of respondents reported communicating with an extension officer at least once yearly about farming, but only 19% said the same for personal matters. This indicates relationships that do not contain the deeper personal connection that characterises the relationships with many community-based actors in farmers' knowledge systems. I want to note that building deeper relationships is not necessarily connected to or correlated with sharing and interacting about personal lives. However, in Kikwe and Ubiri, many farmers perceived trust and personal relationships to be important aspects when building relationships within their knowledge systems. For example, a minority of respondents had cultivated deeper relationships with extension workers and middlemen that had transcended into their personal spheres of life. The data further indicates that some actors (particularly NGOs, agri-companies, and local and national governments) have limited or no roles in many farmers' knowledge systems (regarding the frequency of interaction and communication) across personal and agricultural spheres.

Notably, although the study identified a strong demand for agricultural advice from external experts (typically extension officers), most farmers could not specify what advice they perceived themselves to need (see Chapter 9, which further unpacks this finding). Instead, farmers described a perception that there was expert knowledge out there that—if they could only access it—would help them by providing informed advice.

While most respondents mirrored the viewpoints above, the data also identified minority positions that acknowledged and recognised farmers as experts and holders of valuable agricultural knowledge that (partly or wholly) transcends that of formally educated experts. Nassor, a male farmer from Kikwe (F67), shared his perspective:

“The farmer has more knowledge than maybe that agricultural extension officer because the officer doesn’t stay at the farm all the time. Currently, the farmer is on the farm, but the agricultural extension officer is in the office, waiting for the season to come and listening to seminars before coming to the farm”.

A similar narrative was shared by male farmer John: *“Extension workers study in school, farmers study in the field”*. He emphasised that extension officers are *not farmers* and lack the practical, lived, everyday experience required to give sound, context-specific, practically applicable advice. John emphasised that small-scale farmers are *experts* in their local environments and hold extensive knowledge passed through generations. He reflected on his learning journey;

“I learned about farming from my parents and also from school. In primary school we were encouraged to farm. We would go and farm on the school’s land, and I learned from that and enjoyed it. To be honest, I have never been anywhere to learn about farming except through trial and error and learning from what I do on the farm. I keep learning while at the farm.” (F56).

However, farmers in the study that recognised farmers' knowledge as valid and important still typically attributed less relevance and epistemic authority to farmers' knowledge compared to formal, official knowledge from external experts with formal forms of knowledge. For example, a female farmer from Kizara, Ubiri (RVW2) said;

“Even the extension officers come and ask you [the farmer]. Instead of us asking them... We know that I can use this soil for these crops. Yes, we know everything here. Because we cultivate in a practical way. Unless they are educated and know a lot that we do not know... That advice we desperately need! They have gone to school” (F62).

In addition, an intersectional gendered analysis of the collected data reveals that female and male farmers often ascribed epistemic authority to men on matters related to agriculture in general, particularly business-related matters and issues about industrial inputs, where they were positioned as local experts. This trend in the data is exemplified below by a quote from Mansa, a female farmer in Kikwe in her mid-forties, who avoids going to the agricultural input shop. Instead, she prefers to send her 25-year-old son.

“Because they (young men) have more extensive knowledge than me. Just by looking at a disease, they rush to the agro-dealer and say; This is the problem, and this is the pesticide. They go and bring it back. I don't know, I might think it's a pest when it's actually a disease. So... young men have extensive knowledge, which is why we rely on them. When they go to the agro-dealer, I might be told that a certain pesticide is not available, but there's another one that doesn't work, and I get deceived and buy it. But when they go and ask for a specific pesticide, they get it, and if they don't find it, they leave because they know that medicine treats that particular disease. So, we women are deceived.” (F62).

As illustrated by the quote below, local perceptions about knowledge and knowing shape and are shaped by gendered social norms that influence who is seen as knowledgeable and whose knowledge is valued. While women in the study reported relying on other women, men were considered experts to a greater extent by both male and female respondents.

In Ubiri and Kikwe, many respondents stated that they trust advice when they can observe if the advice results in the intended outcome. For example, male farmer Masudi recalled when he knew that a specific community member was a trusted advisor: *“There was a time when I was told something and I did it, and I planted and the seeds grew well and I harvested. It was four years ago.”* Another female farmer from Kikwe recalled how she knew she could trust the advice of a former extension officer;

“They said - your farm needs some fertiliser - and really, when I used that fertiliser, I succeeded. For example, if he gave me successful instructions, I knew his instructions were good. For example, in 1989 he just went to test the soil. Yes he did and he returned it to me and I used the directed seed and managed to get twenty sacks, so I knew his advice was good”, Ngakisali, Kikwe (F44).

The above quotes illustrate the interconnectedness between information, observation and trust that farmers utilise when navigating complex knowledge landscapes, and make decisions about their farming lives.

6.2.3. Farmers' Choices and Decision-Making

Building on previous sections, the discussion now turns to findings about farmers' choices and decision-making. Farmers in the study did not identify a lack of information and knowledge as one of their primary challenges. On the contrary, farmers who participated in the study often had clear plans for the practices and inputs they wanted to apply. However, structural problems - such as limited financial resources and infrastructural marginalisation - frequently meant that they could not act on the knowledge and information they already had (or new information that they got),

such as using the inputs they wanted to use, planting when they tried to plant, and selling when and where they wanted to sell.

Many farmers in Kikwe and Ubiri shared stories of receiving agricultural information and advice from extension officers and other sources, which they could not act on due to a lack of (typically financial) resources. Most farmers in both Ubiri and Kikwe perceived industrial inputs as a prerequisite for them to secure a harvest and, therefore, identified the cost of industrial inputs as a considerable challenge. *“Most farmers we cultivate, but basically we have no capital, we do not have the ability to buy the best fertiliser, we don’t. We go backwards”*, shared a man from Handei, Ubiri (RVW3). The stories and opinions of farmers from both fieldsites echoed the same core - which a young male farmer from Ubiri expressed (RVW5);

“There are money problems you can't solve with advice, and there are inputs you can't solve with advice, only by making money.”

A woman from Kikwe (RVW7) and a male farmer from Miego village in Ubiri (RVW4) both expressed frustration with not having the financial means to act on advice (that typically involved purchasing inputs);

“You can get advice, but you are not capable, and you can just ignore it” (RVW7).

“I could get advice, and I receive it. But I fail because of money” (RVW4).

These quotes illustrate that even in cases where a farmer decides that she would like to adopt and act in accordance with information or advice she has obtained, she may not have the resources, abilities and agency to do so. In these situations, farmers described their choices as limited to options aligned with their available resources. In practice, this often meant leaving one or several plots uncultivated or changing their planned farming activities and practices as they could not use the inputs they perceived they needed or wanted to use (specific seeds, manure, fertilisers, or pesticides).

Farmers in the study used different strategic methods that involved planning to save income from different sources - such as sales from previous harvests - to finance the inputs for the next season. In practice, however, farmers in the study reported facing significant challenges in adhering to savings targets due to regular and unexpected expenses. For example, Subira (F19) - a middle-

aged female farmer - explained that she always has things to pay for and never enough money. Beyond costs related to her household, dependents, and farm, she was also regularly expected to contribute financially to weddings, funerals, sick relatives, or school-related costs for grandchildren. Interpreting Subira's response from a gender perspective sheds light on the gendered nature of farmers' financial lives, as women in Ubiri and Kikwe typically shoulder the financial responsibility for reproductive, household and care expenditures.

The findings from Kikwe and Ubiri also illustrate the high level of uncertainty and risk embedded in the contexts where farmers make decisions, which many market price information apps do not consider. Some farmers farm for business purposes, others for subsistence purposes, and most farmers in the study farmed for a combination of reasons. Unexpected situations often alter the reasoning and the available choices along the way. Due to unexpected expenditures, farmers may need to sell all or parts of the crops they intended to store for the low season. Other farmers may have to make a quick sale in response to a financial emergency, which does not allow for a market price comparison.

In addition, several respondents highlighted a problem with counterfeit inputs, locally referred to as *mbegu mbovu* (rotten seeds).^{xxvii} After receiving advice from an extension officer, married couple Subira (F18) and Yassin (F19) saved up to buy a specific hybrid seed at the agro dealer shop. They purchased and planted the hybrid seeds, but nothing ever grew despite following all the instructions. They suspected that the seeds were expired or fake (counterfeit). In their experience, cabbage and tomato seeds had been especially problematic, specifically Chinese brands, so they tried to choose other brands. In other cases, they had planted hybrid vegetable seeds only to have crops other than what was pictured and described on the seed package. They explained that they often were not happy with the quantity and quality of the crops compared to what the agro dealer had explained when they bought the seeds. As they had experienced so many problems with seeds they bought from the agro dealer shops, they were now worried each time they bought a new bag for their hard-earned money. They felt that purchasing seeds included and involved a lot of uncertainty and insecurity on the part of the farmer. At each purchase, they were concerned about whether they would get the seeds they wanted or if they were investing their saving in a bag containing *mbegu mbovu*.

In the past, they had personally gone to complain at the shop but never got any money or useful advice. *“The normal price for 2 kilos of maize seeds is 12,000. This is a lot of money, and I don't want to waste it on rotten seeds”*, Subira explained. Subira and Yassin's experiences illustrate the complicated and uncertain environments in which farmers make decisions related to their farms. It also illustrates how structural challenges (in this case, counterfeit seeds) undermine farmers' agency, decisions and actions (in this case, in the shape of deciding to buy and use a particular seed type).

Almost all farmers in the study highlighted market access as a challenge. Yet, farmers did not perceive the problem as access to information. Instead, the problem they identified was the market price and the unfavourable and unpredictable market structures. *“Getting the products I need easily is a challenge for my business because prices are unpredictable and transportation costs are high,”* shared a farmer from Kikwe (FGD16). The high cost of industrial inputs presented a significant cost burden and financial stress factor for farming households in the study. The problem definition echoed by farmers throughout both communities was identified as having too low market prices and too high expenditures, making it difficult for farmers to profit even when seeking out the best market to sell their produce. Many farmers in Kikwe and Ubiri felt discouraged by the structural challenges, as exemplified by the below quote from Nassor, a male farmer from Kikwe (F67V2V3);

“A majority of farmers worldwide face challenges in agriculture, such as inadequate agricultural inputs and low prices for their crops. This low pricing is a major challenge for farmers. So, we request that this issue be addressed because when a farmer cultivates, and their crops lose value, and the inputs become more expensive, the farmer becomes unable to continue.”

The practical realities of farmers in Ubiri and Kikwe suggest a complex reality where market price information is only one of many factors influencing farmers' behaviour and choices^{xxviii} on the market.

Unexpected shocks, such as loss of harvest due to extreme weather or sudden health expenses, can cause long-standing challenges for local households and severely impact the behaviour and choices of individuals and households (Béné 2020). Sometimes, decisions are (directly or indirectly) involuntary - farmers may be forced to make certain decisions due to a perceived lack of other choices. Farmers in the study typically knew that the market price was better in larger cities, but

selling at a distant location did not make logistical and financial sense. Shabani (F23), who farmed maize, tomatoes, cassava, bananas, and beans with his wife in Miego, Ubiri, typically sold any surplus in the village or, if it was a larger quantity, in Lushoto town. Shabani knew he could get a better price for his produce in Dar es Salaam or other larger markets, but he did not perceive that as an option due to logistics and attached costs. “*What am I supposed to do? Go to Dar es Salaam with 10 kilos of bananas?*” he said during a farm visit and chuckled at the thought of it.

To illustrate the complex interplay that underpins farmers' rationale and decision-making I will share an observation from Kikwe. Ngakisali, a 67-year-old female farmer, had a high status and respect in her community, which she earned by participating in countless trainings, seminars, and projects. During a re-visit to Kikwe in May 2023, Ngakisali had been recruited by an NGO to lead a women's group in a project where the women would use improved methods and modern technologies to model to the community how tomatoes could be grown more profitably. Ngakisali recruited the women and allocated a plot, and the organisation came and installed a drip irrigation system, including an electric pump. However, at the time of my visit, almost all of the women in the project had dropped out.

The reasons were twofold. First, the electric pump was expensive to keep running, so the group could not afford it and had to water the tomatoes by hand. Secondly, the frequent watering of the tomatoes was time-consuming, and the women did not perceive themselves to have the required time. Consequently, Ngakisali predominantly tended to the plot by herself through manual irrigation, and the electric pump was not used. This story exemplifies how farmers' practical realities often alter what is rational and logical to do in various situations. An expert unfamiliar with the specific context may outline an imagined scenario and, based on that, predict how farmers may act. However, the parameters and factors farmers must navigate are often more complex. In the case of Ngakisali's tomato project, the project was based on best practices and modern approaches, and all the participants were informed and trained. Yet, the reason people dropped out had nothing to do with information.

6.2.4. Imaginaries of Farming Futures from Farmers Perspectives

Earlier parts of this chapter have illustrated the community-centred nature of farmers' knowledge systems. In this section, I unpack additional nuances around the interplay between farmers' perceptions of farming and knowledge. This chapter segment explores farmers' voices,

perceptions, and interpretations of farmers, farming, and - by extension - agricultural futures, which are presented and analysed. In five focus group discussions, farmers from Kikwe and Ubiri were asked to describe and discuss four categories of farmers: *big*, *modern*, *good*, and *traditional*. Condensed key findings are summarised in Table 6.2 and are described in more detail in below sections.

Table 6.2: Farmers' Definitions of Farmer Categories Summary of data collected with farmers from Ubiri and Kikwe	
Big Farmers (Large-scale farmers)	Modern Farmers
- Big plot - Employing day workers - Hybrid seeds - Using machine equipment (tractor, irrigation pump etc.) - Utilising expert advice - Selling in Tanzania and abroad - Has economic resources - Machine irrigation - Transporting produce/owns a vehicle to transport produce - Takes care of his farm - Uses chemical fertilisers - Has access to storage - Sells produce to a permanent market or client	- Has (formal) agricultural education - Irrigated farming - Uses a plant nursery - Employs day workers - Uses hybrid seeds - Permanent market (inside and outside the country) - Transport of produce available - Innovative and modern - Growing what the market needs - Uses chemical fertilisers - Uses fertile soil - Has storage for produce - Uses expert advice - Farms for subsistence and business
Good Farmers	Traditional Farmers
- Plants on time - Uses hybrid seeds - Relies on expert advice - Farms for subsistence and business - Has enough food and is food secure - Selling at the internal market - Uses manure and chemical fertilisers - Takes care of the farm	- Do not take advice from experts - Uses local seeds/farmer seeds - Uses natural methods - Does not have a seasonal approach to farming - Low yields - Uses manure - Does not plant on time - Suffers from food insecurity - Intercropping/growing multiple crops on one plot - Subsistence farming - Uses unfavourable soil types - Does not have a permanent market or client base

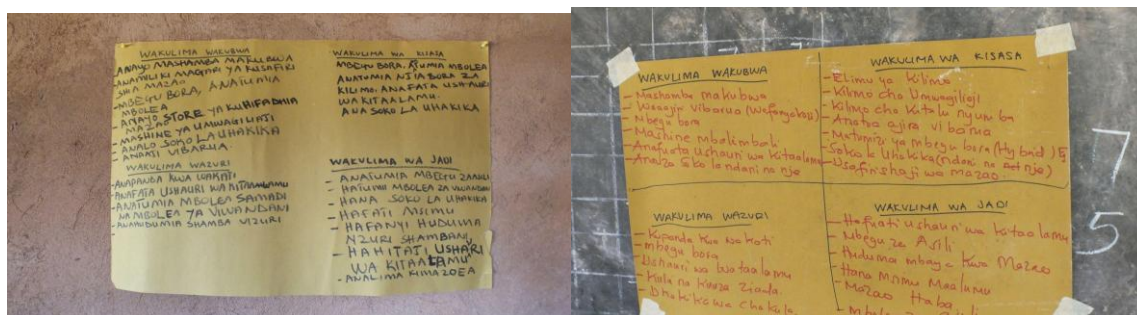


Figure 6.1: Example of FGD outputs where farmers defined how they viewed different types of farmers.

The findings lend insight into local interpretations of farming and farmers and reveal the influence of larger discourses and narratives. Farmers in the study associate *traditional farmers* with farming practices, approaches, and seed varieties that have historically been dominant in their communities. Traditional approaches were described as and equated with inefficiency, low yields, outdated practices, low status, food insecurity, bad fortune, and poor prospects. Participants identified two reasons for the continued use of traditional farming practices and methods in their communities. First, they described local resistance to change among some farmers perceived as unwilling to listen to and follow *expert* advice promoting alternatives to traditional farming. Second, other farmers were perceived to continue to rely on traditional methods and practices due to challenges to access alternative information or advice and financial constraints that left them unable to afford and adopt the practices, inputs and approaches associated with modern (industrial and commercial) farming. It is interesting to observe that sustainable practices such as manure, intercropping and natural fertilisers are maligned in these farmers narratives and perceptions.

A different narrative emerged from farmers' perceptions of the other farming categories. *Big farmers* (large-scale farmers), *good farmers*, and *modern farmers* were all associated with characteristics that farmers defined as positive. Key factors that farmers highlighted included formal education, success, mechanisation, market access, commercialisation, business-oriented farming, following expert advice, and adopting the use of hybrid seeds, synthetic fertilisers and chemical pesticides (see Table 6.2). No focus group participants under either category mentioned organic options other than as part of traditional farming, which (as mentioned) had low status and generally negative connotations.

Similar narratives were echoed in informal conversations and qualitative interviews with individual farmers. An example is young male farmer Marangu from Kikwe, who said, “*Modern farming is better than traditional farming because traditional farming is not as successful. Because traditional farming does not yield as much as modern farming*”. Female farmer Ngakisali, a well-known senior community member in the same village, expressed similar views:

“Right now, we are coming out of ignorance. Right now, if someone brings me knowledge of old farming, I don't want it at all! I like modern farming and using seeds and fertilisers according to the measures I was directed to use. Modern agriculture is innovative, brought in by the experts for professional farming and sowing the seeds in time and with space.../... We do not despise her [the traditional farmer], but we cannot receive her instructions because they are useless. But modern agriculture can do business. In the past, we used to cultivate only for food. You cannot cultivate current agriculture without chemicals, and pests have become so numerous that if you do not use pesticides, you will not reap.” (F44)

Ngakisali’s quote illustrates the complex challenges smallholder farmers in rural Tanzania are faced with, and that will continue to become more challenging with practices that contribute to ecosystem imbalances. The findings shared lend insights into how ideology, narratives and discourses shape and are shaped by farmers' perceptions of knowledge and farming. Other parts of the thesis (Chapter 8) engage with the narratives, ideologies and politics that influence the design and content of digital tools designed for Tanzanian farmers.

6.3. The Role of Digital Technologies in Farmers’ Knowledge Systems

Adding to the chapter's first section, which has focused on findings about the role of various human actors in farmers' knowledge systems, this section explores and presents findings about the role and frequency of digital technologies and analogue information and communication channels in shaping how farmers communicate and access information as part of their situated knowledge systems. Data from the Media Usage Chart and Information & Communication Chart (see Section 3.6.2), conducted with 54 farmers, provides insights into the roles and frequency farmers use various digital and analogue media and communication channels for agricultural and personal purposes. In the following sections, I elaborate on the relevance of key insights summarised in Table 6.3 (see Chapter 3 for methodological insights and Appendix 4 to review the data collection tool).

Table 6.3: Findings from the Knowledge and Information Mapping (Highlights)		
Category of ICTs and frequency of use	Personal (non-agricultural) information	Agriculture related information
Listens to radio at least once per week	91%	76%
Never listens to radio	9%	20%
Watches TV at least once weekly	49%	32%
Never watches TV	40%	62%
Makes or receives phone calls at least once daily	67%	20%
Makes or receives phone calls at least once weekly	91%	48%
Never uses phone calls	6%	24%
Sends or receives SMS at least once daily	6%	24%
Sends or receives SMS at least once weekly	69%	33%
Never uses SMS	24%	44%
Uses Facebook at least once weekly	11%	9%
Never uses Facebook	87%	91%
Uses WhatsApp at least once weekly	7%	6%
Never uses WhatsApp	93%	94%
Uses the Internet (not including Facebook or WhatsApp) at least once weekly	6%	2%
Never use the Internet (not including Facebook or WhatsApp)	96%	96%

The data suggest that radio is the most commonly and frequently used ICT function on a radio device or via a mobile phone. Notably, almost all respondents (91%) listened to the radio for personal (non-agricultural) purposes at least once daily, and 76% listened to agricultural content on the radio weekly. However, although radio use was nearly universal, a fifth of respondents (20%) reported never listening to the radio for agricultural purposes. Phone calls were the second most common communication channel among farmers in the study, with 91% of respondents reporting making or receiving calls weekly for non-agricultural reasons. Findings show that 48% of respondents made or received phone calls weekly for agricultural reasons and 20% daily. The data also found that 15% of respondents used SMS daily to communicate about farming, and 33% used it weekly. TV similarly played a role in many farmers' knowledge systems, as 32% reported watching agricultural TV content at least once weekly.

On the contrary, only a minority of respondents use social media and Internet-based channels. 91% of respondents had never used Facebook for agricultural purposes, with similar figures for WhatsApp (94%) or internet-based services (96%). For non-agricultural purposes, the internet-

based ICT channel findings were similar (see Table 6.2). These latter findings are particularly interesting to contrast with data from the landscape mapping of Tanzania's digital agriculture landscape, of which 47% require users to use the internet and a smart device (see Chapter 5).

6.3.1. The Roles of Mobile Phones in the Lives of Farmers

A device is a prerequisite and entry point for farmers' participation in mobile phone-based digitisation in agriculture. This section presents and unpacks data that provides novel insights into whether and how farmers access, own, and use different mobile phone devices. I also share data on how farmers conceptualise, prioritise and perceive different types of devices and their (potential) value and contextual relevance.

The study identified four categories of devices farmers access and use (see Tables 6.4 and 6.5). First, the dominating device category was basic mobile phones (not internet-enabled), locally referred to as *kiswaswadu* or *simu ndogo* (small phone). Second, many farmers owned, accessed and used feature phones - typically referred to as *simu smart kitochi* (smart flashlight phone). Feature phones typically have additional features such as a slightly larger colour screen, pre-installed applications, or Internet-enabled functions. Farmers in the study often conflated basic and feature phones, mainly due to low awareness of all the device(s) functionalities, particularly related to internet-enabled functions and features.

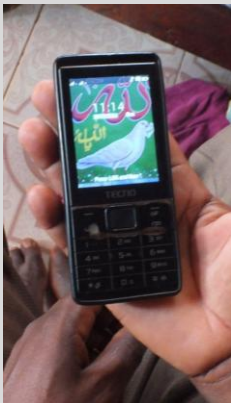
The third category is a robust phone model - or *Simu ya Mnara* (phone with antenna) - typically water and dust-repellant, with long battery life (up to three months) and one or several strong flashlights. Although it was the least common type of device in the communities,^{xxix} these types of devices were used by farmers in the study, observed on display in local shops and promoted at an agricultural conference. However, at the time of the fieldwork, the robust device category was not (yet) widespread to the point that it had a well-known and standardised (nick)name (as the other three categories have).

Lastly, my empirical findings indicate low ownership, access and use of smartphones - typically referred to as *simu kubwa* (big phone). Local residents and leaders were asked to estimate the smartphone penetration rate in their communities, and their estimates ranged from one to five per cent. Although these anecdotal approximations are subjective guesses (and do not represent formal access and ownership statistics), they represent the lived experience of residents in these two rural

Tanzanian communities. Triangulating this data with participatory observations, it is clear that the level of smartphone penetration at the time of the fieldwork was very low in both settings. For example, well-connected community members failed to be able to identify and recruit interview and FGD participants who owned, used, or accessed smartphones. For example, in Kizara village, Ubiri, my local contact spent a few days looking for smartphone users in his community but could not identify anyone. Similarly, the youth chairman of Ubiri was asked to support organising an FGD exclusively for smartphone users. He struggled to identify participants; of the final participants, only a fraction owned, used or had access to a smartphone. In addition, during ten separate result verification workshops across both field sites, all participants agreed with a statement concluding that owning, using, or having access to smartphones and the Internet is rare in their community.

Moreover, insights from the study also reflect the expanded presence and dominance of Chinese low-end phone brands in the African market. Among the farmers I encountered who owned or otherwise accessed smartphones, the Chinese low-cost brands dominated. Farmers reported that these brands are associated with challenges related to the quality and lifetime of devices. The increase in entry-level and refurbished smartphones shipped to Africa has been recognised as a driving force behind increasingly affordable options for entry-level devices on the continent. In recent years, cheap Chinese smartphone brands - e.g., Tecno, Infinix and iTel (all owned by Transsion Holdings) - have entered the African market and reached a dominant market position (Avle, 2022; Lu, 2021; Olaleye et al., 2019; Oluwole, 2024).

Table 6.4: Table of handset costs (TZS and USD)^{xxx} based on farmers' estimations and field observations	
Basic phone	15,000 – 35,000 TZS (\$5.74 - \$13.21)
Feature phone	35,000 – 50,000 TZS (\$13.41 - \$19.15)
Robust Phone	50,000 – 100,000 TSZ (\$19.15 - \$38.31)
Smartphone	80,000 – upwards TSZ (\$30.65 – upwards)

Table 6.5: Categorisation of Mobile Phone Devices Used by Rural Farmers			
Basic Phone <i>Simu ndogo or Kiswaswadu</i>	Feature Phone <i>Smart Kitochi</i>	Robust Phone <i>Simu ya Mnara</i>	Smartphone <i>Simu Kubwa</i>
			
Basic phones typically have functions such as calling, SMS, calculator, calendar, radio, and torch. This phone model sometimes has a basic camera, Bluetooth, pre-installed games, and additional functions. Basic mobile phones were the most common phone in both Kikwe and Ubiri.	Feature phones typically have the same functions as a basic phone but with additional functions such as Internet connectivity (often pre-installed Facebook and WhatsApp), Bluetooth, camera, and games. Feature phones were common in Kikwe and Ubiri, but users typically did not utilise the Internet-enabled function.	Robust mobile phone, typically water and dust repellent, has extended battery life (up to 4 months), power bank functions, strong flashlights, and radio, and sometimes has an antenna and multiple SIM card slots. Typically, Internet-enabled with pre-installed WhatsApp and Internet browsing capabilities, camera, and radio functions.	Smartphones typically have all the functions of basic and feature phones but in more advanced versions. Depending on the type of device, the smartphone comes with a different set of pre-installed applications, which can be modified and customised by the user. It was rare for farmers to use and access smartphones in both Ubiri and Kikwe.

6.3.2. Reimagining a “Good Phone” From Farmers’ Perspective

In this section, I present findings related to locally anchored yet diverse farmer definitions and perceptions of what constitutes a “good phone”.

Farmers’ heterogeneity is reflected in the data as individual farmers’ values and ranks mobile phone types and functionalities. Findings similarly suggest that striving to own, access and use a smartphone is not universally applicable to all farmers.

Some farmers value mobile phone models according to a linear hierarchy, ranging from basic to smartphones. These individuals typically explicitly desire to own and use a smartphone (if they are not already) and acknowledge the (potential) benefits of smartphones. Still, respondents -

including those with a positive perception of smartphones - recognise and perceive smartphones as impractical due to factors such as short battery life and a perceived high risk of damage or breakage. Therefore, farmers in the study frequently argued that smartphones are less suitable for their communities' practical realities than other types of devices (see Section 6.2.3). Farmer-defined characteristics of a good phone illustrate parameters identified as most critical, practical, and valued by farmers in the study, as well as centre qualities such as durability, resistance to water and dust, long battery life, and affordability (see Table 6.6).

Table 6.6: Farmer-Defined Characteristics of a Good Phone	
Long battery life	Able to be used during an extended period (preferably a minimum of a few days)
Robust and durable	Able to withstand daily use in a farm environment (occasional falls, rough environments, and weather) without easily being broken.
Water-resistant	Able to function in an environment where the phone is occasionally exposed to water due to weather or during irrigation.
Dust and dirt-resistant	Able to be used with dirty hands while working on the farm, buttons, and a screen that is not too sensitive to dust, dirt, and soil exposure.
Affordable	Available at a price that farmers with low disposable income can afford.
Easy to repair	Local repairers are familiar with the mobile phone model and know how to repair common problems.



Figure 6.2: Robust mobile phone owned by a farmer that meets many of the farmers' criteria for a good farm phone.



Figure 6.3: Examples of typical mobile phones owned and used by farmers in Ubiri and Kikwe.

For example, Abasi (F3) was widely recognised in his community (and by the extension officer) as one of the ward's most innovative farmers in Ubiri. During fieldwork, he owned a robust, water-resistant, dust-repellant mobile phone with two large, strong flashlights (see Figure 6.3). Abasi explained that this phone matches his needs and context; he can use it at his plots regardless of the weather and does not have to worry about using it with dirty, muddy or wet hands. In addition, he appreciated the strong flashlights, which are particularly useful as he often walks to and from his plots during early or late hours when it is dark outside. He shared that he is not interested in replacing his robust device with a smartphone, which, using Abasi's parameters for a good phone, would be significantly less helpful to him and his situated context, needs and interests.

6.3.3. Rural Mobile Phone Ownership

Building on the insights shared in the previous section, I now delve deeper into findings illustrating how device ownership dynamics shape individual farmers' digital realities and experiences. First, some farmers own the mobile phone(s) they use (they are the only or primary users of that specific device). Second, some farmers own a mobile phone but primarily use other people's devices. For example, Mayasa (F7) owned a basic mobile phone and three SIM cards, but the battery was dysfunctional and did not charge properly. Therefore, Mayasa reported frequently using her husband's or neighbours' phones. This example illustrates that owning a device does not

necessarily translate into that device being the primary handset used by the individual. I observed widespread shared access strategies to complement privately owned devices (Table 6.7). The observed periods for borrowing other people's devices ranged from a few minutes to make a phone call to more extended periods (hours or days). Third, in some cases, farmers with a basic or feature phone sporadically or frequently use other people's smartphones. For example, Agnes (F40) has adult children who have moved to other parts of the country. One of them owns a smartphone, and whenever he visits, she enjoys using (with his assistance) his device to take photographs, communicate with people via WhatsApp, and send pictures of her family and farm to relatives and friends in other locations.

Table 6.7: Conceptualisation of Farmer - Mobile Phone Relationship Categories	
Individual ownership and use	Farmers that owned one or several mobile devices, which were the only or primary devices used by that individual
Individual ownership and use, complemented by shared use practices	Farmers that owned one or several mobile devices but, due to various constraints, frequently complimented the individual use with shared use practices
Shared use within households	One or several devices are shared with other household members. Male household members typically owned and controlled devices.
No device ownership, reliance on shared use practices	Farmers in households with no mobile phones relied on shared use practices involving devices in the community.
No device ownership, but individually owned SIM card used through shared use devices	Farmers who did not own a mobile phone used innovative methods, such as a SIM card that could be inserted temporarily or semi-permanently into someone else's device. This enabled increased autonomy despite the shared use (individual phone number).

In multiple-device households (where multiple household members owned a device), observations suggest that men typically owned more high-end phone models, aligning with existing evidence around patterns of gendered digital divides at all levels of society (GSMA, 2023; Tran et al., 2015). Participant observations from both communities further suggested that women used faulty and old devices more often and were more prone to depend on male household members to complement the restricted use of their sub-optimal devices. Many farmers had handsets with problems that

impacted the functionalities and user experience to different degrees, e.g., a missing back piece and the battery tied on with a string, buttons where the numbers had been rubbed off, and screens were partly or entirely broken (see Figure 6.4).



Figure 6.4: A mobile phone owned by Masudi (F26), a farmer in the study. Yanga (F32), a 25-year-old man from Miego, attempts to repair his mobile phone at home after being exposed to water and soil while farming.

Fourth, some households shared a device (typically owned by a male family member). For example, Masudi (F26) lived with his wife and children, and his mobile phone was the only handset in the household. Masudi's wife also used the same device to make calls, but Masudi decided who could use it and took it when leaving the house. His wife's digital access depended on Masudi's location and willingness to share. In some households, a younger family member owned the household device rather than the head of the household. For example, widow Mwendwa (F45) lived with her adult daughter Grace (F49), Grace's four children and additional grandchildren. At the time of the fieldwork, Grace was the only household member who owned a device (a basic phone, and she later purchased a smartphone) and was, thereby, both the gateway and gatekeeper to her mother's access to a device.

Fifth, some farmers did not own a mobile phone but used other community members' phones based on needs or opportunities. For example, Aziza (F11) is a single mother living in a household without a mobile phone (with her elderly mother and teenage child). If she wants to make a phone

call, she typically walks over to her neighbour or sister and uses their phone (if they have airtime). Her then eighteen-year-old son, Iddi (F34), frequently uses a neighbour's smartphone to read the news on the BBC Swahili website and browse the neighbours' Facebook feed (Iddi did not have a profile). Johari (F33), a 19-year-old female, did not own a mobile phone at the time of the fieldwork. However, she reported enjoying visiting her aunt in Lushoto and using her TV and smartphone.

Lastly, some farmers do not own a mobile phone handset but still own a SIM card. For example, Nasra (F35), a 30-year-old female farmer, had a broken basic phone during the fieldwork. To enable continued phone use, she had permanently inserted her SIM card into her next-door neighbour's phone, as her device had two SIM card slots. When someone called, the neighbour answered and took a message, and Nasra regularly checked the SMS messages when she visited. Nasra is an example of a person using innovative strategies to practise a somewhat personal mobile phone use without owning a device. Compared to using someone else's device *and* SIM card, Nasra's approach allows for slightly more autonomy as the phone number remains personal, and messages and phone numbers can be stored on the SIM card.

In addition, the findings illustrate how farmers' phone ownership status frequently changes. Throughout the data collection period, many farmers I worked with changed their ownership status once or multiple times. For example, female farmer Blessing (F43) from Kikwe recalled what had happened to the phones she had owned:

"I do not know if it [her current phone] is number three or four. The first one was lost, the second one fell into the water, this is the fourth, the third just lost the battery."

When I first met Irene (F55), a female farmer and entrepreneur from Kikwe, she did not own a device. Her previous (feature) phone had stopped working, and she did not have enough disposable income to purchase a new one. Instead, she relied on sporadically using her husband's feature phone. At the end of my fieldwork, Irene had bought a feature phone. A few months later, she purchased a smartphone. However, when I returned to Kikwe for an informal visit around a year later, the smartphone had broken due to water damage, and Irene once again did not own any device.

Similarly, Marangu (F60) - a young male farmer from Kikwe - did not have a mobile phone when we first met - his feature phone had similarly broken due to water damage at his farm. *“It’s just that it fell in the water, and when I charged it, it got shocked and died,”* he told me. He frequently used his neighbour’s feature phone, sometimes borrowing it for several hours or a full day. At the end of my fieldwork period, Marangu had saved up and purchased a new feature phone. When I returned for the result verification workshop, Marangu had purchased a smartphone, which he used to complement his feature phone.

When I first met Ngakisali (F44), a senior female farmer from Kikwe, she owned a smartphone and a feature phone. She used so many SIM cards that her nickname was *Mama Laini Tano* (Mama Five Phone Lines). One of her daughters worked abroad, and she had purchased the smartphone for her mother to enable them to stay in contact as Ngakisali cared for her daughter. When I returned for an informal visit in 2023, Ngakisali told me that the smartphone had slid out of her apron at the farm and fallen into a stream of water. She held the dead phone up in front of me. *“I am so sad because I lost all my pictures. I have many pictures in here”*, she sighed. These examples illustrate various reasons - such as broken, lost, damaged, or upgraded devices - that cause farmers’ mobile ownership status to shift and subsequently impact their digital access and use patterns.

6.3.4. Co-Existing and Complementary Roles of Basic Mobiles and Smartphones

The findings presented in this chapter illustrate that digital technologies are not necessarily replacing other forms of communication. Instead, this adds to previous research that has emphasised that ICTs are part of an integrated and multifaceted communicative ecology (Tacchi 2006; 2015), where introducing new digital technologies typically complements existing ways of sharing and accessing information and knowledge. This section presents findings that suggest that farmers’ use of smartphones does *not* necessarily replace the use of other (feature or basic) phones. Ten years ago, the ICT4D literature (e.g. Donner, 2005) evidenced that the proliferation of individual mobile phone use was complementing rather than replacing shared use practices that used to dominate ICT access through telecenters. Similarly, findings from this study illustrate how farmers with access to smartphones (either owning it or through shared use) typically integrate it as a *complementary* communication resource within their broader communicative ecology (Tacchi, 2006). Contrary to patterns observed in Global Minority contexts, (basic) mobile phone use is often characterised by a high level of shared use practices (see Section 6.3.5).

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Figure 6.5: Screenshots from Tsan et al. (2019) showing farmers with a tablets in a field.

A Roadmap for Building the Digital Future of Food and Agriculture



Figure 6.6: Screenshot from a World Bank (2021) blog post showing a farmer with a laptop in a field. ^{xxxi}

Marketing campaigns, industry blogs and reports related to digitisation in agriculture in the Majority World often feature pictures of farmers holding smartphones, laptops and tablets in their hands when they are in their fields farming, wearing very clean clothes (see Figures 6.5 and 6.6). The data collected from Kikwe and Ubiri illustrate a different practical digital reality. While working at their plots, most farmers have dirty hands and work in environments where they encounter mud, soil, water, and rain. As farmers know their work environment well, many identify

their plots as hostile to smartphones. For example, Nassor, a male farmer living in Kikwe, owned a smartphone and a feature phone (see Figure 6.8). When we met, he had recently purchased his first smartphone six months earlier and had not brought it to the field once. He explained the respective and complementary roles of his two devices in his life:

“I have two phones because at night, when I'm at home, I use my smartphone. For example, if this one [referring to the smartphone] falls down, it's easily damaged, and it's easy to have any accidents. If it falls and gets damaged... Here [at home] it will likely fall in a safe place. This one [referring to the feature phone] is mostly plastic. But the smartphone is better for keeping up with the world. When I use it at night, I get information from different sources, news from around the world, and various updates. It connects to the internet so that I can access a wide range of information. So, these internet-related news and communication are not found on the feature phone. The smartphone is special for exploring the world, although it's also used for communication. But mainly in the evening, when I'm resting, it helps me relax and take my mind off things. That's why the smartphone is there” (F67).

Nassor's complementary use pattern exemplifies how the smartphone and feature phones fill different yet complementary roles in a farmer's life. Multiple device users in Kikwe and Ubiri use specific devices in different physical places and for different purposes. As exemplified by Nassor, the feature phone functioned as his *farm phone*. Nassor only used his smartphone in the home environment for entertainment, news consumption, and communication purposes. Ngakisali, a senior female farmer in Kikwe, owned two mobile phones when I first met her - a smartphone and a feature phone (see Figure 6.7);

“I like it because the use of a smartphone is important, and it uses a lot of battery. So this little one stays longer with less usage. I go with all [to the farm] because on my smartphone, I have two lines, and I have friends using many networks. This small phone I use for m-pesa. I go with it; I put it in the apron” (F44).



Figure 6.7: Ngakisali (F44) in Kikwe showing different crops in her garden plot (next to her house) while holding her smartphone. She also owned a basic phone at the time.



Figure 6.8: Nassor (F67) with his two mobile phones, which he uses in different and complementary ways.

6.3.5. Device-Specific Sharing Practices

The literature includes strong evidence around shared access practices among resource-constrained mobile phone users in the Majority World (Aiken & Thakur, 2021; Burrell, 2010; De Lanerolle et al., 2017). Findings and observations from Kikwe and Ubiri equally illustrate strong shared use practices. As illustrated in Section 6.3.3, the findings also illustrate how shared use practices have gendered dimensions, with many rural women depending on male relatives' devices, mirroring existing literature on gendered intrahousehold digital access patterns (e.g. Komen, 2016; Rahim et al., 2020).

Interestingly, the data illustrate clear and distinctive differences related to willingness to share devices with others between owners of smartphones and basic or feature phones. While findings indicate widespread shared access practices with basic- and feature phones, different social norms around sharing practices govern the use of smartphones across both communities. This element of device-specific shared access practices has yet to be fully explored in the ICT4D literature.

Findings indicate that smartphones are perceived by the farmers to be more private than basic and feature phones. Smartphone owners expressed concerns that people may access pictures, videos, search histories, and other content deemed personal, leading them to be reluctant to let others use their devices. Farmers explained that basic and feature phones usually contained less personal

content, exacerbated by the limited memory space. This led many farmers to regularly delete most or all of their text messages and pictures to keep their devices functional. On basic and feature phones with a camera, farmers reported that they can typically only store a limited number of photos (in some cases, only one) unless using an external memory card, which comes with an additional cost. Hence, observations suggest that basic- and feature phones typically contain no or very little private content, unlike smartphones, which shape norms and practices around device sharing.

In addition, smartphone owners and users are often more careful as their devices are more expensive. Many smartphone owners are concerned that others may not know how to use it correctly or that they may break it, reservations that were not applied to sharing practices with more affordable basic and feature phones.

Kelvin, a male farmer in his mid-twenties in Ubiri, explained how a particular neighbour often used his smartphone:

“There is a young man here who also begs to take pictures, sends them to others, logs on to Facebook, logs out my insta account, logs in to his account, uses it, and when he finishes, he returns it to me. I just give it to him and tell him to do what you want” (F51).

Kelvin's quote exemplifies that digital practices are not uniform and that there are exceptions to the sharing practices of smartphones. As digital technologies and farmers' appropriation and rescripting of them continue, new nuances of shared and individual use patterns will likely be observed by future research.

6.4. Conclusions

This chapter has shared findings from ethnographically informed and qualitative research conducted with two rural Tanzanian farming communities. The triangulated data provides insights into the knowledge systems and digital realities of the imagined end-users of the digital tools that populate Tanzania's crowded digitisation in agriculture landscape.

The first part of the chapter illustrates how farmers' knowledge systems - including knowledge acquisition, sharing and production - are socially embedded, peer-centric and community-oriented. Farmers' lived experiences exemplify how rural knowledge systems are embedded in the social fabrics of localised social practices, relationships, and networks. The findings illustrate farmers' farming experience as an embodied, tactile, practical experience shaped and re-shaped by their

everyday activities. I shared qualitative data that suggests that farmers in Kikwe and Ubiri do not identify a lack of information and knowledge as one of their primary challenges, and used situated examples to illustrate structural problems that often prevent farmers from making the choices they would like to make. While this study adds to existing evidence of farmers' continued reliance on intergenerational learning rooted in cultural heritage, the findings equally illustrate that local knowledge and practice are continuously shaped and reshaped by a combination of local and external influences, including global industrialisation and modernisation discourses. The dialogue between different epistemologies is manifested in farmers' diverse interpretations of knowledge and knowing and perceptions of ways of farming, where acknowledgement of the relevance and authority of both local and formal knowledge and ways of knowing co-exist.

The second segment of the chapter turned attention to the interaction between digital technologies and farmers' knowledge systems. The findings illustrate critical dimensions of farmers' situated digital realities in two farming communities. These findings illustrate that basic- and featurephone devices and simple mobile phone functions were most common and appreciated among respondents. At the same time, the use and access of smartphones and the Internet were rare. I shared insights about less-examined dimensions of farmers' digital realities, including farmers' interpretations and perceived practical relevance of different mobile phone devices, local notions of a “good phone”, and exploring nuances of how mobile phones are integrated into farmers' lives.

In combination, the chapter's two parts add novel insights to themes related to the study's second research aim, which seeks to *understand Tanzanian rural small-scale farmers' digital realities and local knowledge systems*. The findings about farmers' knowledge systems and the role of digital technologies within them complement existing ICT4D literature by demonstrating the complexities of farmers' knowledge systems and the factors that influence and shape how farmers access, create and share knowledge using ICTs within the boundaries of their knowledge systems. The next chapter explores these themes by sharing data about farmers' digitally-enabled practices within the boundaries of their knowledge systems and digital realities.

Farmers Digitally-Enabled Agricultural Practices

Chapter 7

7.1. Introduction

The previous chapter shared insights about farmers' knowledge systems and rural digital realities. In this chapter, I further enrich the understanding of rural farmers' lived realities by sharing findings about how farmers' mobile phone practices are embedded in their digital landscapes and contextualised knowledge networks. Using situated examples from rural Tanzania, I illustrate how farmers' digitally-enabled knowledge systems include strategies and practices to navigate context-specific digital access challenges and meet agricultural needs and interests.

In the first part of this chapter, I share qualitative insights into how mobile phones are integrated into farmers' everyday lives, introducing themes that run through the rest of the chapter. In the subsequent section, I share insights about farmers' multi-faceted and situated digital access challenges. Building on this, the following section presents findings about farmers' mobile phone practices and unpacks what functions farmers use and for what reason. The data illustrate innovative and resourceful ways farmers use low-tech mobile phone functions to meet their (agricultural) needs and wants.

7.1. Farmers' Everyday Mobile Practices

As discussed in Section 6.3.3, it was uncommon for farmers in Kikwe and Ubiri to own and use smartphones at the time of the data collection.^{xxxii} Most farmers in the field study sites used basic and feature phones. In this section, I share additional findings about farmers' mobile phone practices, providing nuanced insights into what farmers do with mobile phones and how those use

practices and strategies are shaped by their digital realities, knowledge practices, interests and needs.

To ground the thematic discussion in real-life examples of farmers' lived experiences, the section starts by sharing ten testimonies from farmers about an ordinary day in their lives (see Table 7.1). These accounts are illustrative examples drawn from fifty-five farmer dairies collected from two communities using a method I refer to as Jana Diaries (Yesterday's Diary) (see Section 3.6.3). By exemplifying how mobile phones are (and are not) integrated into the day-to-day life of rural Tanzanian farmers, these testimonies showcase the lived experiences of navigating a digital reality characterised by a combination of localised and structural access challenges such as fragile connections, affordability constraints, and time poverty. Equally, these accounts emphasise farmers' challenges in fully realising digital technologies' (imagined) potentials frequently highlighted in techno-enthusiastic digitisation in agriculture literature (e.g. Beanstalk AgTech, 2023; ITU & FAO, 2022; Tsan et al., 2019).

Throughout the chapters, the data generated from the Jana Diaries serve as a bottom-up entryway to engaging with farmers' digital realities as I refer back to the themes interwoven in the lived experiences shared in Table 7.1.

Table 7.1: Illustrative Snapshots from Jana Diaries of Farmers in Ubiri and Kikwe	
Name and background	Summary of Mobile Diary
Hafsa (F27) is a thirty-year-old mother of two who lives with her husband in Kizara, Ubiri. She owns a basic mobile phone.	Hafsa woke up at 5 AM, went to pray and then cooked and ate breakfast. At 6 AM, she took the bus to town carrying two plastic buckets full of tomatoes that she would sell at the market in Lushoto, which happens twice weekly in Lushoto town. On the bus, Hafsa sat next to a woman who was also going to the market, and they helped each other carry their produce. At 6.30 AM, she arrived at the market and cleaned up the area where she would set up her roadside shop. Hafsa had no balance on her phone, but she used her calculator several times to calculate the total cost for her customers. At 11 AM, a family member called to check how it was going. She had lunch at the market with other women she meets weekly and now considers friends. She travelled home at 6 PM and arrived at 6.30 PM, after successfully selling all the tomatoes (although she was unhappy with the price). In the evening, she cooked and ate with her family, and then they listened to the news on the radio via her husband's (basic) mobile phone. However, Hafsa was tired and did not pay attention to what was being said on the radio.
Amina (F13) is a married mother who lives with her children, mother-in-	Amina woke up at dawn and immediately called her husband to check on him as he practices seasonal migration and farms at a plot in another part of Tanzania parts of the year. After praying, she went to one of her plots, and on the way back, she left her smartphone in a kiosk for solar charging. Upon return, she cooked for the family and had

law and husband in Miego, Ubiri. She owns a smartphone and a basic phone.	breakfast. Amina then walked with some neighbours to attend a funeral. As it was a long walk (approximately 1 hour one way), she conversed with her neighbours about personal matters and the upcoming rains and debated the best time for planting. Around 4 PM, Amina returned home, collected her phone from the kiosk, prayed, and spent the evening cooking and eating with her children and mother-in-law. Her phone had been charging most of the day, and she lacked a bundle, so she only used it to communicate with her husband.
Abduli (F5) is a married father of three children in his late thirties. He lives with his family in Handei, Ubiri. He owns a feature phone with four SIM card slots.	Abduli woke up at 4 AM and walked for over an hour to the main road, where a driver was waiting to load his harvest of 100 kg of red and yellow peppers onto a truck. At 7 AM, they started driving towards Dar-es-Salaam, where they arrived late afternoon. When he got to Dar es Salaam, he negotiated with several different buyers who came to look at his crops. He had not agreed on a price beforehand nor found a buyer. He spent two hours negotiating the price before making a deal. He wished to get a better price, but negotiating was hard. He delivered the produce to the Kariakoo market, then took a motorbike to the bus station to return to Lushoto by bus. He arrived home in the early hours of the next day. During the day, he used his phone to call his wife to give her updates and let her know about the different offers. He also used the calculator during his negotiations with the buyers at the market. In the early morning, he also used the flashlight on this phone. He listened to the radio in the car but was tired, so he ignored what was being said. He agreed with the buyer that he would pay Abduli via mobile money in two days.
Johari (F33) is a nineteen-year-old woman living with her family in Handei, Ubiri. She does not own a mobile phone.	Johari woke up at 5 AM, cleaned the house, fetched water, collected firewood, and passed the shop to get sugar and vegetables. She then had tea with her family and after resting for a short while. She went to the field around 10 AM with her mother. It was the season for planting maize, so they were busy. At around 2 PM, they returned home and cooked lunch. At 4 PM, they returned to the field to continue planting maize. They came back at 6 PM when they prepared food again for dinner, showered, ate, and went to bed at 8 o'clock. The family had no electricity, so there were limited activities to do after nightfall. She only met with family that day, apart from briefly greeting neighbours. She did not listen to the radio, use a phone, or watch TV, but she read a newspaper they had at home and was interested in an article about animal husbandry.
Nassor (F67) is a male and married farmer in his thirties with four children. When he is not seasonally migrating to work at his farm in another part of Tanzania, he lives with his family in Kikwe. He owns a smartphone and a basic phone.	Nassor woke up at 6 AM, and after praying and eating, he went to work on the construction of a new mosque in the community, a project many men in the area volunteered their time towards. While working, he exchanged SMS messages with his wife to inquire what she was cooking for lunch and what time it would be ready, using his basic mobile phone. He had left his smartphone at home, where his children could look at the pictures with the data switched off. He was concerned the smartphone might break at the construction site, so he brought his basic phone. He finished the work at 4 PM and accompanied his wife to collect water. Then, he relaxed at home, listening to the news on the radio on his basic mobile phone as the children wanted to continue to use his smartphone.
Iddi (F34) is an eighteen-year-old male student and farmer living with his mother and grandmother in Handei, Ubiri. He	Iddi woke up at 6 AM and swept the house. He went to buy sugar at his mother's request. At 8 AM, he walked to his plot to check if the monkeys had touched his crops, but they had not. He walked back and had morning tea with his mother and grandmother. Iddi then walked back to the farm to weed until 2 PM, when he passed by a neighbour's house, where they listened to the national news on the radio on his friend's phone, and then he went home to have rice for lunch. Iddi spent the late afternoon working on his biology homework. At 4 PM, he went to the house of his classmate, who owned a smartphone,

does not own a mobile phone.	which they used for about an hour to watch news and music videos. They then studied English language pronunciation before he came home at 7 PM and showered before having dinner. He still had homework to do, but he did not have electricity or a lamp at home, so instead, he went to another neighbour's house, where they watched the news on a TV powered by solar.
Irene (F55) is a married mother of four in her mid-thirties who lives with her husband and children. She does not own a phone but sometimes uses her husband's.	After waking up at 5 AM, Irene started her day by cleaning and cooking for the family. She then cared for her elderly mother-in-law's cows before walking to her plot, where she worked until lunch. In the afternoon, she attended a funeral in the community. In the evening, a customer came to her house, where she had a small shop to purchase vegetables. The customer wanted to give Irene her number, so Irene saved it to her husband's phone who had returned home. Apart from that, Irene did not use a mobile phone as she does not own one, and she and her husband were in different locations during most of the day.
Suleiman (F18) is a married man in his forties; he has adult children living with his wife. He identifies as a builder but farms full-time due to a lack of work opportunities. He is the chairman of the hamlet that he lives in in Kizara, Ubiri.	Suleiman woke up at 7 AM when his wife had already been up for 2 hours. He went to collect leaves to feed the cows, and then he went to chop wood. At 9 AM, he went to eat some porridge prepared by his wife. He then called his adult child, who lives in a different area, who was sick. He worked on the plot next to his house, and at 10 AM, he went to pay his condolences to his neighbour whose first wife had passed away the previous day. He stayed there until 1 PM. He then went home to eat and distributed some letters as chairman of the Hamlet he lives in. On the walk there, he called the people to let them know he was coming. He met with neighbours at the funeral and on his way to deliver the letters. He did not call anyone else as he had no more minutes on his phone. He did not listen to the radio, but when he was home watching TV with his wife in the evening, he saw a farmer being interviewed on TV. He put his phone in the charger overnight.
Marangu (F60) is a young, single male farmer in his early 20s from Kikwe. He lives alone close to his mother and owns a basic mobile phone.	Marangu started the day by working on his mother's plot, where he supported her to grow okra. He then had lunch at his mother's house and worked on two plots where he grew eggplant and okra. As the evening arrived, he still had one plot to attend to: his neighbour Grace (F49), with whom he grows sunflowers. By this time, it had already gotten dark, so he used his basic phone as a torch as he finished work on the farm until late in the evening. During the day, Marangu made three phone calls to friends, two of which were social calls and one in which he wanted to ask for advice about a specific seed type he was considering using. He experienced network problems as a roadblock during the day when he tried to make and receive calls.
Baraka (F4) He is a married father in his fifties who lives in Ubiri with his wife, adult child, and grandchildren. He owns a basic phone. He farms in combination with other livelihood strategies.	Baraka woke up at 4.30 AM to pray, then checked on a plot he had recently rented to cultivate. He went to buy some pesticides at the agro dealer in Ubiri and got back around 8 AM. At 9 AM, he had breakfast, then went to one of his other plots in Handei, where he applied pesticides. At noon, he returned home after calling his wife, who said the food was ready, and he arrived there at 1 PM. He showered and had some porridge before going to a community funeral. He returned around 3 PM when he opened his shop by the main road, where he stayed until 9 PM watching TV and discussing with neighbours who passed by the shop. He made a phone call around 5 PM to his younger relative in Mombo; he wanted him to buy some soap for him and send it to his shop so that it would arrive the following day. He also called a contact in Dar es Salaam to check if he had located a specific input that he wanted to get for a better price. Baraka made sure to charge his phone two times that day, as the drivers of the buses he owns often call him if they run out of fuel.

7.2. Farmers Situated Digital Access Challenges

In this sub-section, I use examples from the Jana Diary and additional data from the study to share insights about rural farmers' situated digital access challenges in the two case study locations. The lived experiences expressed in the Jana Diaries illustrate the interconnectedness of various aspects of digital access and the interplay between different spheres of farmers' lives. For example, Marangu's diary describes how he struggles with network connectivity, which is also mirrored in broader findings and observations that illustrate that farmers in Kikwe and Ubiri often cannot make and receive calls, send or receive SMS, or use the Internet as desired due to network problems. A farmer from Ubiri (RVW6) shared the following when speaking of how challenges with network connectivity impact farmers' digital realities:

“If you want to find someone using the network, you will find him tomorrow morning... And if you send an SMS, it arrives tomorrow morning”.

In addition, as illustrated in the Jana Diaries (Hafsa, Amina and Suleiman), in instances when farmers do not have access to airtime, they are often restricted to “passive” use, such as receiving calls and SMS, rather than actively making calls or sending messages. Farmers in Ubiri and Kikwe identified the cost of airtime, bundles, and value-added services (VAS) as significant cost burdens. During interviews, farmers were asked about their current airtime status (on two occasions) and their typical weekly airtime spending (see Chapter 3 for details). Often, farmers had no airtime or bundle on one or both occasions, with a lack of disposable income being the most frequently stated reason. Many farmers in the study reported going without airtime for periods ranging from days to weeks without topping up their airtime, which impacts how they can use their devices. For example, Mansa, a female farmer in Kikwe, shared;

“I don't have airtime. I haven't recharged since the day before yesterday when I was looking to find information about a child who was sick. Yesterday, I ran around, and it [the airtime] was finished” (F62).

At the same time, most respondents perceived mobile phone-related expenses as prioritised expenditures and airtime vouchers as necessary expenses. Most respondents reported spending between 600 TZS (\$0.22) and 2000 TZS (\$0.76)^{xxxiii} weekly to purchase airtime and/or bundles, often at the expense of other competing priorities. However, some farmers in the study, typically women, spent little or no money on airtime vouchers and data bundles. The findings support

broad observations that men typically invested in more expensive and frequent airtime top-ups, whilst women more often de-prioritised airtime to instead pay for food and household items or used the money to finance weekly contributions to savings groups^{xxxiv} (see Chapter 9). These findings indicate that female mobile phone users experience gender-specific affordability barriers.

Some female farmers, such as Blessing - a female farmer and mother of two from Kikwe - revealed that it could be up to two months between her airtime purchases and that she primarily used her phone for other purposes that do not require airtime (calendar, flashlight, etc.) and to receive calls:

“There are so many challenges. If you will cut food, or maybe you don't have the money to grind [maize flour]. There is maize there; you don't have money to go grinding. Are you going to buy a voucher? Are you going to buy a voucher and then grind it to flour? Kids want to eat, what do you do? You leave the voucher! You go to grind the corn to ugali!”

Blessing's quote illustrates the intra-household economic decisions that many farmers navigate, where an airtime voucher purchase may only be able to be purchased at the expense of meeting basic needs. While Blessing does not perceive airtime voucher purchases as justifiable when other basic needs are unmet, other respondents prioritise differently. For example, Subira (F19), a 40-year-old female farmer from Ubiri, shared that she usually bought a new airtime voucher two times per week, typically worth 500 TZS (\$0.21) each time. Although she highlighted that she thought she spent (what she defined to be) too much money on her mobile phone, she frequently prioritised the expenditure over other household expenses as she highly valued communicating with her children and other family via her mobile phone. Table 7.2 compares data on indirect and direct mobile phone costs and other frequent and context-specific everyday household expenditures.

The study also identified structural affordability barriers impacting rurally based and economically disadvantaged mobile phone users. Findings illustrate that airtime vouchers were sold at a significantly higher price in both rural locations where fieldwork was conducted. Across all networks, the cheapest airtime vouchers available in Tanzania are worth 500 TZS (\$0.19^{xxxv}). Yet, in both Ubiri and Kikwe, the 500 TZS (the most common voucher value purchased by farmers due to affordability constraints) is sold at 600 TZS (\$0.22^{xxxvi}). Ngakisali (F44), a female farmer from Kikwe, explained the challenges this presents;

“Using the mobile phone is a challenge because the price I like for phone vouchers... They sell for six hundred. Because here in the village, they sell it for six hundred; maybe if you go out, it is less, it is five hundred”.

Farmers in Kikwe and Ubiri thereby paid a twenty per cent higher price for airtime vouchers than the recommended standardised price used in urban areas. Similarly, other values of airtime vouchers, worth thousand, two thousand, five thousand or ten thousand, were also sold at prices inflated by twenty per cent.^{xxxvii} Observations in kiosks and shops in urban Arusha (and more connected nearby locations like Usa River and Tengeru) and urban Lushoto found that voucher prices were not inflated. Rurally based kiosks and shop owners stated that the price increase is necessary to cover transport costs and gain some profit for the kiosk or shop owners, who typically travel to more urban areas to purchase vouchers at the standard rate.



Figure 7.1: Combined mobile money agent and shop in Ubiri.

Table 7.2: Table outlining relative costs in Ubiri and Kikwe (2021)		
Item	Kikwe TZS	Ubiri TZS
Cheapest voucher (worth 500 TZS) <i>(many networks offer bundles for approximately 40-50 minutes and 20-30 SMS for 500 TZS)</i>	600	600
Charging phone to full battery status	300-500	200
Cost of sending 10,000 TZS via mobile money	360 -670	
Cost of withdrawing 10,000 TZS via mobile money	1552 - 1720	
Watching TV at a kiosk/restaurant <i>(The entry fee typically has no time limit)</i>	500	500
Ortecia fertiliser 1 kg	5000	1 400
Urea fertiliser 1 kg	2000	1 200
Bag of hybrid maize seeds, 2 kg	14 000	12 000
Milling maize into flour, 20 litre bucket	2000	1 200 - 2 000
Green pepper seeds, 100 g	35 000	25 000
Pesticide, 1 litre	8000	4 000
Ugali flour, 1 kg	2000	1 000
Uncooked rice, 1 kg	3000	2 000
Sugar, 1 kg	3000	3 600
Meat, 1 kg	9000	7 000
1 dried fish	8000	2-3 000
Sardines, 1 small bag	1000	500
Cooking oil, 1 litre	6000	5 000
Wheat flour	2000	1 400
Milk, 1 litre	1000	1 000
A plate of rice and beans at a local restaurant	1500	1000
Notebook, primary school	1000	500
Notebook, secondary school	2500	2000



Figure 7.2: Mobile Money agent in Zanzibar (during the pilot), selling SIM cards and airtime vouchers. Kiosk operated by a female farmer at her home, selling airtime vouchers and basic household necessities.

The Jana Diaries also illustrate how Amina left her phone at a kiosk to be charged and was physically separated from her device. Farmers in the study identified significant costs for keeping devices charged, maintained, and repaired. Out of these costs, mobile phone charging emerged as a significant and recurring expense for farmers without available electricity. For households with access to electricity, mobile phones can be charged at home at no additional cost (apart from the electric bill). Some households use solar power, which they primarily gain access to through rent-to-own and pay-as-you-go (PAYGO) models such as M-KOPA, where a daily, weekly, or monthly payment is made until the full cost of the solar system has been repaid, after which the household owns the solar home system and thereby free to use.

However, households with solar access in the case study settings typically have small solar systems that only power one or a few light bulbs. Some respondents reported problems with their solar system, such as old batteries or broken systems, resulting in no or compromised power access despite their solar energy investment. In addition, farmers reported that the solar systems were significantly less helpful during the rainy and cold seasons, as the batteries did not charge as quickly. Therefore, even households with home solar systems frequently had to find other ways to charge their devices, with corresponding costs. Households that did not have access to any form of electricity at their home typically charged their devices at community-based kiosks, shops, restaurants, and private homes, typically against a fee. In Ubiri, the standardised cost for charging

was typically 200 TSZ (~\$0.08) to fully charge a device, regardless of where you charge it. In Kikwe, people typically paid 300 TSZ (~\$0.12) to fully charge a device on a solar system and 500 TSZ (~\$0.2) if the kiosk or household was connected to the grid.



Figure 7.3: Solar charging station at a kiosk in the village centre of Handei Village, Ubiri.



Figure 7.4: The first image shows Suleiman and Saumu's house, where their electrical meter was fixed using a corn cob. The second shows a smartphone and radio charged on a solar panel at Ngakisali's house.

While each payment for charging is not considered unreasonable by farmers, the accumulated cost over time is a significant expense for many. Drawing on the experiences of the farmers I interviewed, farmers typically charge their phones 2-3 times per week. This equates to a monthly cost of 1800 - 6750 TZS (\$0.68 - \$2.58^{xxxviii}) per device. Some farmers had multiple handsets,

which increased the charging cost for complementary purposes. In households where several household members own one or several handsets, the combined charging costs likely represent a large portion of the household's disposable income (for cost comparison with other regular expenses, see Table 7.2). Several respondents reported that they often do not have the money to charge their phones as frequently as they would like, and many reported using frugal practices (De Lanerolle et al., 2017), such as switching off the phone or data when not actively used, to increase the length of time between charges.

In addition, as many farmers used old and partly broken devices, many experienced battery issues, leading them to charge their phones more often and increasingly use frugal use practices to manage their use. As part of the practices of charging phones, many farmers in Ubiri and Kikwe often leave their phones in various places (a neighbour's or friend's house, at home or in a kiosk) whilst physically being somewhere else. Consequently, farmers and their devices are frequently separated by physical distance. During fieldwork, I observed many farmers leaving their phones to be charged at a kiosk and picking them up several days later due to time constraints or conflicting priorities. For example, Fatumah (F65) owned a smartphone and a basic phone during the fieldwork. Yet, when I met her, she rarely had any of her devices with her; at least one device was typically charging somewhere or left at home because it had not been charged.

Another theme that emerged from the data was that many farmers are unaware of the functions and features of their mobile phones and have never used them. This applies to pre-installed apps on feature phones and smartphones (commonly Facebook and WhatsApp) but also to functions on basic mobile phones such as SMS, navigating USSD menus, and being familiar with the function of each icon on the mobile display. Farmers across age groups highlighted awareness and digital literacy as barriers, particularly among older farmers. These findings mirror well-documented patterns of rural-urban, socio-economic and age-related digital divides (e.g. ITU, 2023; Malephane et al., 2022; Neves et al., 2018). *“It is true that a large percentage of farmers use mobile phones and do not enter the internet. It's just by calling, receiving calls and SMS,”* shared a young male farmer, Ubiri. Another male farmer from the same ward shared, *“There are those who use it (a smartphone) as a small phone (basic phone) and just as a flashlight”* (RVW5).^{xxxix} In another

focus group discussion, another farmer said, *“Even those with a big phone (smartphone) do not know how to use a big phone on the internet”* (RVW2).^{xi}

Recent literature has highlighted how digital literacy and awareness interplay with digital inclusion. For example, Landmann et al. (2020:1437) argue that “farmers who own a smartphone, but do not use it in a work-related manner, may still perceive similar usage barriers as those farmers who do not own a smartphone yet.” Similar findings emerged from this study, as users of basic and smartphone devices faced similar challenges and used similar functions - primarily or only to make and receive calls and were unaware of other functions (e.g. SMS, calendar, calculator, radio, camera, and pre-installed applications). The following quotes illustrate the diverse challenges identified regarding utilising mobile phone functions shared by farmers.

“Some people don't know how to read or write messages, they only know how to receive. So they fail to recognise the features of the phone” farmer from Kikwe (FGD16).^{xli}

“Many do not know how to read like these old people, like my mother when she does not know when it is written. But if you call her - "hello" - she answers”, female farmer Kikwe (F43).

“It becomes a reading problem for someone else; someone else can't read... For someone else, maybe reading is hard, so maybe he puts in a lot of minutes... So he will only be calling.” male farmer from Kikwe (F51)

As the last quote highlights, the findings indicate that rural Tanzanian farmers' user experiences of mobile phones fundamentally differ from the instant and direct communication channels mobile phones provide in contexts and situations where users have reliable, affordable and stable connectivity. For example, calls may not go through due to connectivity problems, SMS messages may not necessarily arrive instantly, and internet speed may be slow and intermittent.^{xlii}

As illustrated in the above examples, drawing on rural Tanzanian farmers' experiences, farmers' digital realities must be interpreted through a web of interlinked access challenges. Some of these have been discussed in this chapter section (e.g., battery life, affordability of airtime, network fragility) and appear in the summary of the Jana Diary testimonies (see Table 7.1). The ICT4D and digitisation in agriculture literature equally recognise the presence of multiple and interconnected digital divides that govern rural access to ICTs (see Chapter 2).

7.3. Farmers' Digitally-Enabled Practices

In the previous section, I shared qualitative insights into the everyday challenges that farmers in Ubiri and Kikwe face within the boundaries of their digital realities. Beyond illustrating various dimensions of situated digital access adversaries, the Jana Diaries and wider triangulated data illustrate how mobile phones are versatile, multi-purpose tools that farmers use innovatively to meet their diverse needs. In this chapter section, I break down insights about the perceptions, practical reasoning and interests underpinning why farmers in Kikwe and Ubiri value mobile phones and share insights into their digital practices.

Table 7.3: Examples of Mobile Phone Functions and Services Valued by Farmers	
Phone calls	Social communication - staying in touch with friends and family and sharing informal information. Phone calls to existing social networks for advice, find market prices, check agro-input prices and availability, arrange transportation, and contact middlemen or potential buyers. Call for help in an emergency, e.g., childbirth, a fire or accident. Non-agricultural business-related communication, e.g., communication with customers.
SMS	Social, business and agricultural communication.
Calculator	To assist in calculating the price of inputs, products, transport, and household items.
Flashlight	Farmers frequently navigate indoor and outdoor environments with light during evenings and early mornings to light up roads and rooms in the dark.
Calendar	To assist in planning social and agricultural events in farmers' lives (e.g., when a crop was planted or a new calf was born).
Mobile Money Transfers	To send and receive money to and from friends and family to meet basic needs and unexpected expenses (including agriculture-related costs). To receive payment for agricultural produce from buyers and middlemen. To pay for agricultural inputs, transport of produce, and other agricultural purchases.

Farmers in Kikwe and Ubiri predominantly access and use basic- and feature phones, with a limited presence of smartphones and the Internet in farmers' knowledge systems and practices (see Chapter 6). In this section, I share additional insight into the mobile practices and functions farmers in the

study use and value. In Table 7.3. I summarise common examples of mobile phone functions and services valued by farmers that emerged from the data.

The data provides insights and practical examples of how farmers attribute value to basic phone functions used strategically to meet practical and situated needs and interests. As illustrated in the Jana Diaries (see Table 7.1), valued mobile phone-enabled practices range from lighting up the farm after dark with the mobile phone flashlight (Marangu), calculating the total price when selling vegetables at the market with the calculator (Hafsa), getting paid after selling produce in another geographic location using mobile money (Abduli) and connecting with friends, family or acquaintances to access information informally (Baraka).

Mansa (F62) is the sole caretaker of her elderly grandmother in Kikwe. As we visited the small room without electricity where her grandmother lived in Mansa's courtyard, she explained that she identified the flashlight on her feature phone as the most essential function.

"It even helps when I go to help my grandmother get undressed at night; I use the phone as a flashlight. Hahaha. I need to see while taking off her clothes. Hahaha, I use the flashlight" (F62).

Masudi, a young male farmer, identified the calendar function on his basic phone as the most useful. He makes notes of the exact dates when he plants, plans which days he should travel to the market, and checks the dates. *"It helps me to remember things. For example, if I want to go to the market tomorrow,"* he said as he showed me the calendar on his feature phone. Similarly, Blessing (F43), a 33-year-old female farmer from Kikwe, identified the calendar function as the most useful;

"I like to use it [the calendar] on the farm; I like to use it for a month. I like to use it if maybe my cow gave birth today on a certain date. I am looking at the calendar. What date is today? I look, and how I probably planted on the twenty-fourth of September. I look at the calendar on my phone; it helps me. I have a calendar, calculator, message, flashlight, call. I love it because it helps me" (F43).

Blessing continued to describe the value of her mobile phone in her everyday life;

"The phone is important for calling people for communication. Maybe someone is sick, and I get a call; maybe the market price... I am told today it is a certain price. So, for me, the phone is very important. Maybe there is some [crop] disease, maybe something important in my home, maybe the father [her husband] is in the field telling me to bring food, I send him food. These are things for the phone" (F43).

As demonstrated through the examples above, the findings illustrate the value added by mobile phones to farmers' lives, often through "basic" and low-tech functions and devices.

In addition, the observations and triangulated data illustrate farmers' resourcefulness and innovative strategies to utilise mobile phones. As previously highlighted (see Sections 6.3.2 and 6.3.3, Tables 2.2 and 7.3 and Figure 6.4), many farmers in the study accessed and used sub-optimal devices due to extensive wear-and-tear, old devices and performance issues associated with low-end devices. Observations suggest that these challenges cause farmers significant inconvenience. However, the findings from this study illustrate that farmers use resourceful methods to utilise partly broken, deficient and underperforming devices to create value in their lives.

For example, a female farmer in Kizara, Ubiri - Saumu - frequently had problems with her feature phone. One day, she removed the phone's back cover, took out the battery, and put it back in again. The phone remained unresponsive. *"It will wake up later,"* Saumu said and shrugged. The phone was visibly well-used, and the numbers printed on the buttons were faded; they had been rubbed off by extensive use. However, despite these challenges, Saumu highly valued her device. *"My whole life is in the phone,"* Saumu said. *"I use my phone for everything,"* she added, explaining that her most valued mobile phone function is the clock. In her everyday life, she particularly appreciates that it helps her keep track of time at home and when she works in the fields.

In addition, the examples from the Jana Diaries exemplify common frugal use practices (Nassor), practising shared use of devices (Irene, Iddi, see Section 6.2) and having multiple devices (Nassor). Other observed frugal practices include, e.g. opting for cheaper bundles (often only valid for twenty-four hours), using the practice of beeping^{xliii} (in Swahili, referred to as a verb - to beep someone - *kubeepu*) to get a call-back. The Jana Diary data also illustrate cases where farmers did *not* use mobile phones (Johari and Irene), adding knowledge about non-users (Steinke et al. 2024).

The findings and observations illustrate that mobile phones are used by farmers to support various needs and interests that reach across different dimensions of their lives. John, a farmer from Kikwe, shared how important his phone was across different dimensions of his life;

"Because the phone gives me communication, it can provide me with cooperation between my distant relatives, as well as friends, and my fellow farmers. For example, if I have a problem on my farm, they can help me with it, and I can also get help with borrowing fertilisers or pesticides. I can also help myself" (F56).

Findings from Kikwe and Ubiri suggest that the intimate and fluid connection between social and financial farming and non-farming parts of farmers' lives (e.g., shared time, human and financial resources) is reflected in how farmers use mobile phone functions and services. Table 7.4 outlines the farmers' most common mobile phone practices based on interviews, focus group discussions, and observations during the participatory research, which are divided into personal, agriculture, and business categories.

Table 7.5. Farmer-identified mobile phone practices related to personal, agricultural and income-generating dimensions		
Personal	Agriculture	Non-Agricultural Business and Income-Generating Activities
Communication with friends and family.	Accessing market price information.	Business-related mobile money payments.
News consumption through formal and informal channels.	Accessing and sharing agricultural advice.	The mobile phone is used to get access to day worker (kibarua) opportunities, typically for building projects.
Taking, sharing and looking at pictures.	Calculating the cost of inputs, transport and sales of produce.	Communication for farmers with diversified livelihood strategies, e.g. connecting with customers or suppliers.
Mobile money transactions.	Planning and recording agricultural practices (e.g. using the calendar and clock functions).	Organising transportation of goods.
Communicating within the community.	Contacting agro-dealers to check on the availability and price of inputs to avoid physically using time and financial resources to visit multiple agro-dealers.	
Checking the time.		
Listening to the radio for news and entertainment.	Agriculture-related mobile money payments.	
Organising transportation of goods for the household from other locations.	Photographing crops, pests, diseases or produce to share with others for advice, sales, and purchases.	
	Listening to agricultural radio programmes.	
	The mobile phone was used to access day-worker (kibarua) opportunities, typically for farm labour.	
	Flashlight when walking to or from plots at early or late hours.	

During harvest seasons, farmers in both communities reported using their mobile phones more often to support their agricultural practices, such as communication to coordinate transport, access market price information, hire or be hired as day workers (to work during harvests at larger plots) and other agricultural purposes during harvesting periods. Masudi, a male farmer from Ubiri, shared, “*When it's time for harvest, I use it more because farming is seasonal here*” (F26). A female farmer from Kikwe (RVW10) similarly argued that when “*it is harvest time and we use the phone to inquire about crop prices*”. As a direct result, farmers struggled more to meet access-related costs (airtime and data bundles) during harvest seasons as farmers reported an elevated need for communication during these periods with corresponding increases in airtime and charging costs.

7.4. Formal and Informal Digitisation in Agriculture

In Kikwe and Ubiri, it was rare to encounter farmers who were aware of or had tried digitisation in agriculture applications and services despite extensive efforts. Among the approximately 250 farmers who participated in interviews and FGDs, five farmers reported that they were aware of and had used WeFarm (an SMS-based farmer-to-farmer advisory service that has now been discontinued), one farmer had used T-Hakiki (a USSD-based service that verifies that industrial inputs are not counterfeit), and a farmer in Kikwe had been informed about a mobile-based service by an NGO (but he could not recall the name). In addition, community sensitisation activities on M-Kilimo (see Chapter 8 for more details) were being rolled out by extension workers in both communities during the fieldwork.

“*Maybe someone should come and direct us on how to choose the services to call, but if no one comes, we don't know,*” shared a woman from Kikwe (FGD16) who had never heard about the concept of formal digitisation in agricultural tools. The low awareness and uptake of digitisation in agriculture services is a notable finding contrasted against the crowded landscape of digitisation in agriculture apps identified in Chapter 5.

While the study found that it is uncommon for farmers to know of or use *formal* digitisation in agriculture services, the findings equally illustrate that farmers use *informal* digitally-enabled practices to meet agricultural (and non-agricultural) needs, interests and wants. Earlier segments

of the chapter have illustrated how farmers in Kikwe and Ubiri use mobile phones as prominent and integrated parts of their agricultural and non-agricultural lives (see summaries in Tables 7.1, 7.3 and 7.4).

7.4.1. Informal Digitisation in Agriculture Practices

As exemplified in this chapter, the findings from this study illustrate that, in many ways, farmers in Ubiri and Kikwe are already performing some of the tasks that digital agriculture apps imagine to assist farmers through formal apps, services or platforms. Examples include making phone calls to friends, relatives and family to get agricultural advice or market information, making and receiving mobile money payments for crops and agro-inputs, using the calculator and calendar to help with farm planning and management, or communicating with extension workers and agro-dealers.

Against this background, I propose the introduction of the term *informal digitisation in agriculture practices*, which refers to farmers' practices that utilise available digital technology within the boundaries of their situated digital realities and local knowledge systems as a strategic tool to support their needs and interests (and by extension expand their choices). Informal digitisation in agriculture practices is distinctively different to the digital applications and services that populate the crowded landscape in Tanzania, as they are not dependent on the design or introduction of a specific tool, project or initiative. Informal digitisation in agriculture practices is bottom-up, farmer-led practices rooted in farmers' ability to navigate digital access barriers, rescript available technologies to fit a specific need or purpose and utilise available resources. Including this term in digitisation in agriculture debates opens up research and practice that recognise, focus on and value farmers' digitally-enabled informal practices as part of their agricultural knowledge systems and broader agricultural practices.

To illustrate the identified dissonance between formal digital services designed for farmers and the informal digitisation in agriculture practices observed at the community level, the next section uses market price information as a case study.

7.4.2. Case Study: Market Price Information

Chapter 5 presents the data illustrating that a third of the 108 identified digital agriculture tools are designed to provide farmers with market price information and linkages. These services have been

designed in response to a perceived problem that assumes that a lack of accurate and up-to-date market price information is a bottleneck for farmers' ability to profit from their crop sales. Market price information services imagine that the low rate at which many farmers sell their crops is caused by a gap in market price information, causing farmers to make uninformed decisions and sell their harvests below market price.

An employee at TAHA (Tanzania Horticulture Association), who was involved with running one of the above-listed digital market price information services, shared how their SMS-based service was conceptualised, developed, and implemented. First, TAHA interpreted a problem - farmers were not accessing the “correct” market prices. They perceived farmers to be exploited by middlemen (*dalali* in Swahili) who bought crops from farmers at a low price, sold them at a higher price, and pocketed the profit. Therefore, TAHA developed an SMS-based service (TAHA Information System - TIS) that they imagined would give farmers direct access to updated market prices, enabling them to cut out the intermediaries and sell their crops at a higher price - all because of the market price information they had gained access to through the SMS service.

The officer identified the most prominent problem with their service as farmers' reluctance to use the service due to the associated cost (60 shillings per SMS), a reason the officer thought was illogical as the cost (to him) was marginal. “*They are worried about the cost of the SMS, but they do not understand that the benefit of the information they can get outweighs the cost of the SMS*” (RD 3/8/2021). The TIS service was designed to capture market prices and collect data using human data collectors who visited selected markets thrice weekly and reported the market prices for selected crops, which were updated in the system. However, in practice, the imagined trajectory was not as straightforward as anticipated. However, when reflecting back, the officer explained how they had realised that the problem turned out to be more complex than just disseminating information. First, there were frequent delays in updating the market information caused by human and technical errors. Second, once market prices were updated, prices often changed, prompting farmers to complain about inaccurate information and reducing the relevance of the service.^{xliv} The reasoning behind this particular digital market price information service assumed that farmers did not have access to market price information, or at least not to the *right* market price information.

However, research in Kikwe and Ubiri found two small-scale farming communities where farmers used well-established - often digitally enabled - *informal* methods to acquire up-to-date market

price information from various markets as an integrated part of their decision-making process when selling crops. Some farmers in the study accessed market price information through market price information services. Two young men - Makame (F31) and Omari (FGD10), used Google's search engine to search for market price information in different markets around Tanzania (FGD 10). Neither of them used a specific website or service but relied on the information found when typing in, e.g. “*bei ya soko nyanya Lushoto*” (meaning “market price tomato Lushoto” in Swahili), which prompts questions about how accurate the price information they obtained was.

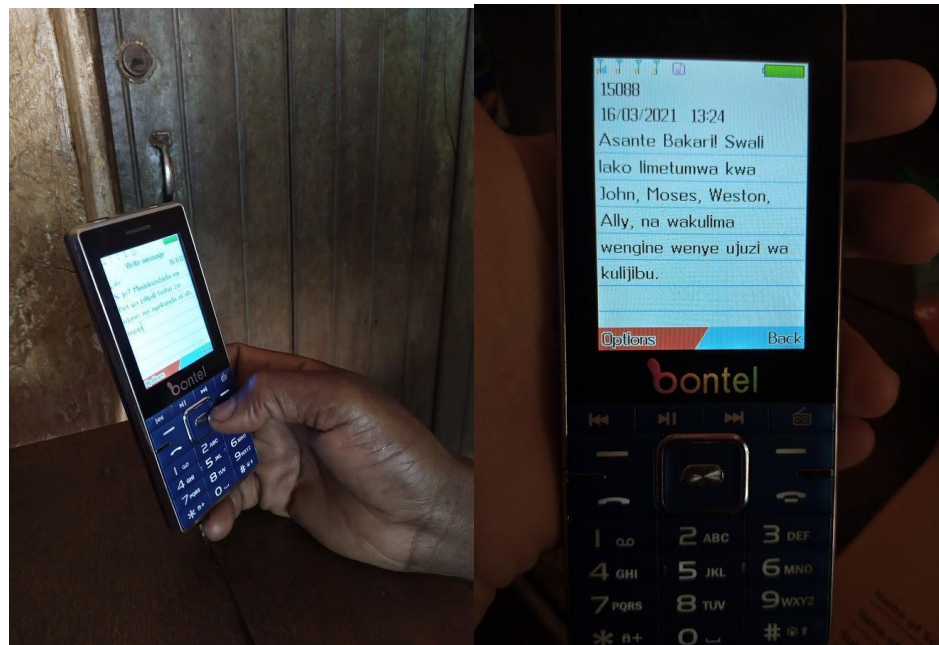


Figure 7.5: Abduli sends a question about the market price of red and yellow peppers using WeFarm and receives a response saying that he should wait for an answer from fellow farmers through the system. April 2021.

Another farmer - Abduli (F5) - farmed yellow and red peppers in his greenhouse in Ubiri - had struggled to find a market for his produce. He listened to the radio daily, working on his farm. One day, Abduli heard about a service called WeFarm,^{xlv} where you could send questions about agriculture and receive answers. Abduli sent a message to the service and asked about the market price of red and yellow peppers. He got an SMS in response telling him to wait for a reply from one of the other farmers who are part of WeFarm. Abduli waited, but he never got a response. A few months later, Abduli decided to make another attempt. He sent a question asking about the market price for red and green peppers and again received a confirmation message telling him to wait. A few days later, he got a reply from another farmer, but the farmer's answer referred to

smaller quantities when Abduli was looking for the price for 100 kilos. He, therefore, deemed the advice useless and deleted the message. However, if Abduli would have used any of the other 107 digitisation in agriculture apps identified in Tanzania, he might have found it useful and aligned with his needs.

Apart from Makame, Omari, and Abduli, none of the farmers in the study looked for market prices online or used formal digital market price information services. However, farmers across both communities reported that they found it easy to call their friends, relatives, neighbours, and acquaintances across Tanzania and instantly access the market price at a given market. For example, Jackson, a male farmer from Kikwe, was a registered user of the government-run M-Kilimo, a digital agriculture service that includes a market price information component. However, when Jackson needed to access market price information, he did not use M-Kilimo. Instead, he called a long-standing contact who worked at a market. When asked why Jackson preferred to call his contact over M-Kilimo, he replied, "*Because I know this guy, and he knows all the market prices.*" Jackson already had established practices embedded in the knowledge system that gave him access to up-to-date, reliable market price information, and he had no incentive to replace his *informal digitisation in agriculture* practices with a *formal digital agriculture* service. Furthermore, this was not unique to Jackson. All farmers who participated in the study - young, old, female, and male - reported they had established ways to access market price information. However, selling produce at different markets also comes with additional investments, such as transport costs, communication costs and time resources, which may outweigh the benefits (particularly for small quantities of produce).

Throughout the study, farmers indirectly demonstrated how informal digitisation in agriculture practices acts as a critical enabler for farmers to utilise their (primarily existing) social networks to make phone calls or send SMS to get updated market prices. The findings from this dissertation suggest that farmers already have digitally enabled informal systems in place to acquire market price information, systems that are a digital extension of their existing knowledge systems and social networks and that function within their digital realities.

7.5. Conclusion

This chapter has offered detailed qualitative insights into rural Tanzanian farmers' mobile phone practices and how these practices influence and are influenced by local knowledge systems and

the context-specific digital reality. The chapter addresses research question 2b, which seeks to understand how small-scale farmers in Ubiri and Kikwe use, negotiate, assimilate, mediate and re-script technologies to meet their needs and interests. The chapter has used triangulated ethnographically inspired qualitative data to illustrate farmers' lived experiences of using mobile phones within the boundaries of a challenging digital reality.

The chapter first focused on unpacking the diverse, situated and context-specific factors that shape farmers' digital access. Findings add nuance to existing knowledge about the experience of being a mobile phone user for individuals and groups that are *less connected* (De Lanerolle et al., 2017). The data adds to existing research through detailed and farmer-centred insights about interconnected individual-level and structural challenges farmers in Kikwe and Ubiri face. Despite the high number of digitisation in agriculture applications deployed in Tanzania (see Chapter 5), the findings suggest minimal awareness, use and uptake of these services in the rural farming communities in this study.

However, the chapter has also illustrated and exemplified farmers' experiences and strategies in navigating complex digital realities characterised by resourcefulness and innovation. The qualitative data shared in this chapter have provided insights into the multifaceted ways that mobile phones are (and are not) entangled with the everyday lives of farmers of different ages, genders, socio-economic circumstances, and mobile ownership statuses. Farmers in the study predominantly use and value low-tech and basic devices and functions to meet their agricultural (and non-agricultural) needs and interests and strengthen their local knowledge systems, using strategies and approaches that mitigate and adapt to the challenges presented by their digital realities. Against this background, I propose the introduction of the term informal digitisation in agriculture practices to recognise and learn from the locally-led, bottom-up ways farmers are harnessing the potential of mobile phones to strengthen their agricultural needs and interests, often in ways that mirror areas that formal, externally design digital solutions imagine supporting farmers.

Together with Chapters 5 and 6, this chapter has provided multi-faceted insights into the national level digitisation in the agriculture landscape and intricate nuances of the digital realities and local knowledge systems in rural farming communities.

As I discussed in Chapter 6, farmers have mixed ideologies about how to farm, and findings from Kikwe and Ubiri suggested that they often prefer “modern” over “traditional” methods and approaches. In the next chapter expands on this by critically analysing how narratives, discourses and ideology shape the design and content of digital tools.

Ideology in Technology

Chapter 8

8.1. Introduction

This chapter explores if and how interests, narratives, assumptions and ideologies are scripted into the design and content of digitisation in agriculture services targeting small-scale farmers in Tanzania. While Chapter 5 has illustrated a crowded digitisation in agriculture ecosystem, this chapter looks closer at three diverse case studies sampled from the landscape mapping (see Table 3.7 for details about sampling).^{xlvi} The case studies are analysed using script theory (Akrich, 1992; 1994) and the conceptualisation of development as freedom expressed through meaningful choice (Kleine, 2009) to unpack if and how their design choices and content reflect ideologically charged assumptions and interests.

The chapter begins by engaging with each of the three case studies. Each digital agriculture tool is introduced and analysed from a script theory perspective, focusing on unpacking the narratives, discourses, and ideologies embedded in each tool's content, design and implementation. I deepen the analysis by discussing the success of the case studies, assessing if and how they can be defined as successful according to subjective parameters of success embedded in their design and content. I then use a choice lens to unpack whether each script expands or restricts farmers' choices and, by extension, if they contribute to development, defined as expanding farmers' choices. The chapter is wrapped up by concluding remarks that connect the chapter's main conclusions to the broader objectives of the thesis.



Figure 8.1: Poster advertising M-Kilimo, including an outline of the project objectives and how to access the service (accessed on the Ministry of Agriculture website in 2020).

8.2. Mobile Kilimo (M-Kilimo)

The first case study is Mobile Kilimo (M-Kilimo). *Kilimo* means agriculture in Swahili, and, as the name indicates, the M-Kilimo tool is focused on utilising mobile phone-based technology to support agriculture (including animal husbandry and fishery). M-Kilimo has three objectives: connecting sellers and buyers, educating farmers on best practices, and providing strategies for solving agrarian challenges (see Figure 8.1). One arm of the service focuses on agricultural markets by connecting sellers and buyers and providing market prices. The other arm seeks to facilitate information dissemination of professional agricultural advice from extension workers to farmers.

M-Kilimo is implemented by the Ministry of Agriculture in partnership with the Economic and Social Research Foundation (ESRF), with support from UNICEF. M-Kilimo stands out in the digital agriculture landscape in Tanzania as a government-led initiative rolled out nationally and aims to register all Tanzanian farmers across the country. M-Kilimo was piloted in 2018, and the roll-out was launched in May 2020, which (unintentionally) coincided with the timing of my empirical fieldwork.^{xlvii} In addition to empirical observations of the roll-out of M-Kilimo in two rural communities, I tested the tool on several occasions between 2021 and 2022 alone and with

extension workers and farmers. In April 2024, I conducted an in-depth structured user testing session (see Chapter 3).

8.2.1. The Imagined Use of M-Kilimo

M-Kilimo targets three user groups - farmers, extension workers and buyers and is designed to accommodate a multi-channel approach that includes USSD, SMS, and web portal access points (see Table 8.1). If a farmer registers with M-Kilimo, she is prompted to submit requests for expert advice, market price information, or market linkages via SMS, USSD, or the web portal. Farmers have offline options (SMS and USSD) and can access the tool using any mobile device to send questions to extension workers, request market price information or look for a buyer for their produce.

Extension workers, however, must register and sign in via the web portal, which requires a smart device, internet access and connectivity. Once logged in, extension workers can access questions from farmers and data dashboards. They can only respond to a farmer's queries through the web portal, and their answers are delivered via SMS to the farmer. In practice, these design choices mean that extension workers cannot use M-Kilimo without a smart device, Internet access and network connectivity. Training extension workers was a core roll-out strategy for the project, and selected extension officers from all of Tanzania's districts were trained. The aim (and assumption) was that the trained extension officers would return to their districts to train colleagues and subsequently register farmers (and other agricultural stakeholders such as buyers) in their respective districts.

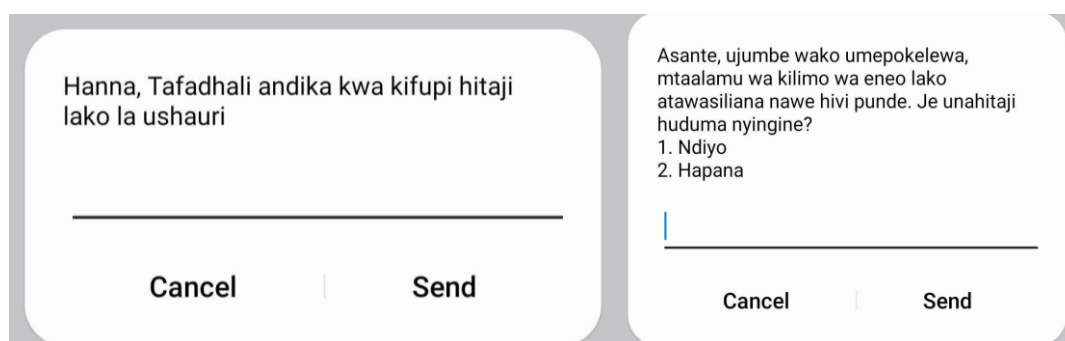


Figure 8.2: Screenshots of menus when selecting the advice option on M-Kilimo's USSD service. The text in the first screenshot, translated to English, reads "Hanna, please briefly describe the advice you need". The text in the second screenshot translates to "Thank you, your message has been received, an agricultural expert in your area will communicate with you shortly. Do you need any other service? 1. Yes, 2. No."

Table 8.1: Overview of M-Kilimo Service				
Tech used	Access point	Target group	Functions	Access Costs
USSD	*152*00#	Farmers and buyers	Registration, market price information, selling and buying agricultural produce, advisory service and feedback.	It can be used on any mobile phone. It does not require the Internet. Using the USSD service is free, and the SMS service comes with the cost of an SMS.
SMS	0689666662	Farmers		
Web portal	http://exts.kilimo.go.tz/	Extension workers and other agricultural officers (to access the portal), limited functionalities targeted at farmers and buyers	Registered users (extension workers and other formal agricultural officers) can access the M-Kilimo interface, which allows them to respond to queries from farmers and access other services. The general public can access four functions without logging in: market prices, submitting questions, market linkages, and news.	It requires an Internet-enabled device, data, and connectivity. Users are expected to self-fund the device and data from their own pockets (including both farmers, buyers and extension workers)

Table 8.2: Registered farmers, extension workers and agricultural product sellers on M-Kilimo Compiled based on data presented by Mushi et al. (2024:5)			
Registered Stakeholders		User Statistics	
Farmers	7,269,106	Number of submitted requests for advisory services	75,623
Extension workers/experts	9985	Number of replies via the advisory service	73,839
Agricultural products sellers	26,927		

8.2.2. The Use and Impact of M-Kilimo

The M-Kilimo website does not include information about the initiative's current status, number of users, and impact.^{xlvi} Although a high number of farmers have been enrolled, anecdotal and qualitative evidence from primary and secondary sources raises questions about whether it is delivering the intended impact.

Mushi et al. (2024)^{xlix} report that close to 7,300,000 farmers, 10,000 extension workers and experts and 27,000 agricultural product sellers have been registered with M-Kilimo. The same paper reports that 76,000 advisory consultations (requests for advice) and close to 74,000 replies to farmers' queries have been facilitated using M-Kilimo (see Table 8.2).

Empirical observations and interviews from fieldwork in Lushoto and Meru suggest that government-employed extension workers were explicitly instructed to enrol all farmers in their respective ward(s)^l starting in 2020. In January 2022, 3,429^{li} farmers had been registered in the Lushoto District, representing approximately 1% of the Ward's population. In Meru District, 45,818^{lii} farmers had been registered in April 2024, representing approximately 14% of the population (Ministry of Finance and Planning, 2022). However, informal phone calls and SMS conversations with farmers and extension workers from both communities suggest that the awareness and use of M-Kilimo have remained low. An extension officer from Meru shared his experiences;

“One of the evaluation methods was to measure the interaction between farmers, buyers, and extension officers... So far, it remains as registration data only, but the interaction is very minimal”^{liii} (A10).

As illustrated in the previous paragraphs, the identified data about M-Kilimo reveals the registration of millions of farmers (and extension officers). However, let us, for the sake of simplicity, assume that each of the reported 76,000 consultations (Mushi et al., 2024) was done by 76,000 individual farmers.^{liv} In this scenario, 1% of the 7.3 million registered users would have engaged in an advisory consultation via M-Kilimo with an extension worker. This would mean that 99% of registered users would have never submitted a request for or received advice through M-Kilimo. The number may be even lower as individual farmers may have been involved in multiple consultations. This example illustrates the pertinence of asking questions about what - if anything - registration statistics can tell us about the use and impact of digital agriculture (see

discussion in Section 2.2). The available data illustrates that users have been registered and that advisory consultations have taken place through the platforms, but questions around which type of advice was given, if and how it was used and how it may have impacted farmers (and extension workers) cannot be answered based on the identified data.

The testing of M-Kilimo revealed significant and frequent technical challenges, including functions not performing or delivering as intended (e.g. no response to submitted questions) and technical dysfunctions (e.g. tool being out of order, malfunctionings).

8.2.3. Unpacking the Script of M-Kilimo

In this section, I analyse the assumptions, narratives and ideologies embedded in the script of M-Kilimo's design and content. I use examples to illustrate how M-Kilimo, like any technology, is not a neutral tool but aligned with broader discourses in development and agriculture.

In line with script theory, the analysis reveals assumptions about epistemic and financial realities of farmer users which are mis-aligned with actual realities. In addition, the user testing suggests several features that may misalign with rural Tanzanian farmers' digital, epistemic and financial realities based on observations during fieldwork (see Chapters 6 and 7). For example, M-Kilimo users must navigate a long and complicated USSD^{lv} menu that requires a certain level of digital literacy and literacy. Users are prompted to respond to multi-step and multiple-option menus. Observations suggest that long and complicated menus cause confusion or uncertainty about what option to choose to get to the preferred service. There are no available explanations to guide users on what different options in the USSD menu mean in practice. This is particularly relevant to highlight as several options have complicated text (e.g. acronyms) that many rural farmer users are likely unfamiliar with.

These challenges relate to the technical boundaries of USSD menus related to the character limitations. This leads to USSD-based services relying on text that must be short by default. Notably, many farmers in Kikwe and Ubiri were not strong and confident readers with limited experience navigating USSD menus. In contrast, other farmers were very comfortable as they had used USSD to recharge their airtime vouchers and signed up for bundles for years. In addition, many respondents in the study complained about poor eyesight and that reading text on small screens was difficult.^{lvi} While M-Kilimo's full ten-option USSD menu fits on a smartphone screen,

farmers using a basic mobile phone need to scroll to view all options, adding to the challenges of understanding the options and selecting the desired course of action. In practice, this gives users very different user experiences depending on the device they use to access M-Kilimo. The devices that farmers in Kikwe and Ubiri used had various problems, including cracked or faulty screens, making such tasks even harder (Chapter 6 further expands on farmers' digital realities). Observations from Kikwe and Ubiri suggest that users need time to read through and understand options on USSD menus before making a choice. The required time to do so is likely longer for users with any combination of the previously mentioned challenges.

While testing the USSD menu, I timed how long it would take for the menu to time out if the user was inactive. On three separate occasions, on two different devices, an error message appeared after approximately 30 seconds if I did not choose and submit an option, translating to a relatively short window for users to familiarise themselves with the options, select one and respond.^{lviii}

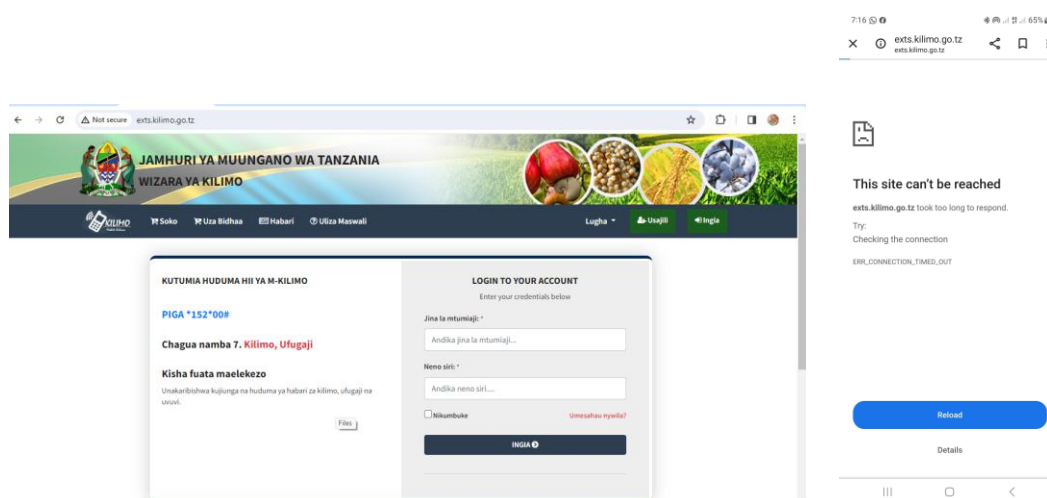


Figure 8.3: The first image is a screenshot of the web portal log-in page accessed on April 2nd, 2024. Translated to English, the text next to the log-in box reads “To use the M-Kilimo service dial *152*00#, choose number 7. Farming, Livestock. Then follow the instructions, you are welcome to subscribe to services and information on agriculture, livestock and fishing.” The second image is a screenshot of my smartphone as I tried to access the same web portal on April 1st, 2024, when the website was not possible to access despite multiple attempts throughout the day on different devices, using mobile data and Wi-Fi options.

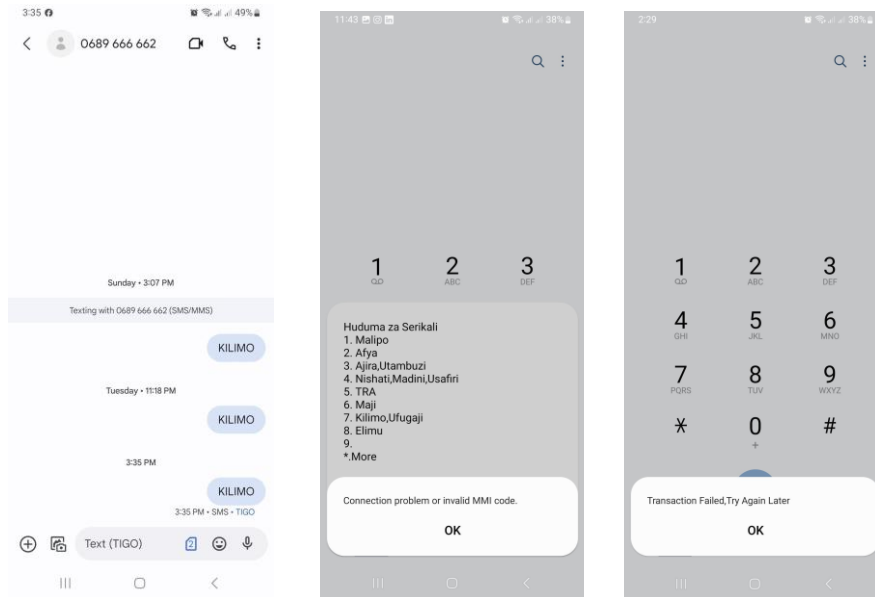


Figure 8.4: Screenshots showing failed attempts to register for M-Kilimo in March and April 2024. The first screenshot shows three SMS messages sent with the Swahili word “kilimo” – which means “agriculture” in English – following the registration instructions provided to potential users. The second and third screenshots show failed attempts to use the USSD service on April 5th 2024.

Additional aspects emerged from the data illustrating design-reality gaps between M-Kilimo and the digital realities of rural farming communities in Tanzania. During fieldwork in 2021, interviews and participant observations noted enthusiasm about the potential for M-Kilimo among extension workers and other government officials at a regional and national level.

However, extension workers in Lushoto and Meru voiced concerns about how the service's design choices fit their practical realities. For example, several extension workers in the study did not own smart devices during all or part of the fieldwork,^{lviii} which prevented them from (regularly) accessing and using the M-Kilimo service. The Ministry of Agriculture had not equipped the extension officers with mobile phones but relied on extension officers using their privately-owned devices. In addition, extension officers emphasised network fragility - intermittent or no network connectivity - in the villages where they worked, preventing them from using M-Kilimo when visiting farmers. This inadvertently led extension workers in the study to spend more time in their office or other physical spaces with access to network connectivity, as they were expected to access M-Kilimo regularly (review submitted questions and answer them).

The above example illustrates how the introduction of a new technology (M-Kilimo) with a specific script can (unintentionally) lead to new arrangements of people and things (Akrich, 1992;

1994). M-Kilimo illustrates how a design choice (extension worker interface dependent on internet connectivity) may have incentivised specific behaviour among technology users (spending more time in the office and less in the field). At the same time, farmers in the study continuously emphasised the need for extension workers to spend more time in the communities and that farmers would benefit from more face-to-face interaction. In addition, despite being instructed to use M-Kilimo by their employer, extension workers were not provided with data bundles and expected private contributions to fund the internet needed to utilise M-Kilimo, which extension officers in the study found highly problematic as many already paid their transportation for work privately.

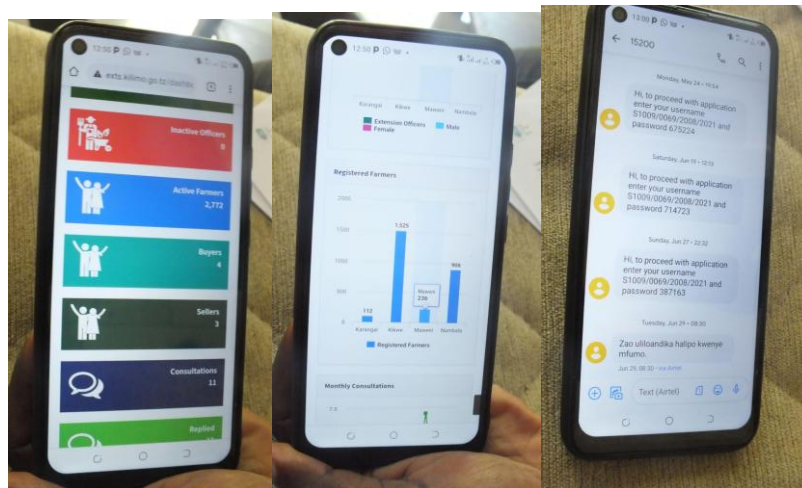


Figure 8.5: Extension worker in Kikwe showing the extension worker interface of the M-Kilimo service.

Moreover, observations from Kikwe and Ubiri suggest that farmers with pre-existing, close and active relationships with extension workers were more likely to be aware of and use M-Kilimo than other community members. By utilising social resources in the form of a relationship with the extension officer, farmers were introduced to M-Kilimo, reproducing and mirroring larger patterns of unequal epistemic resource distribution at the community level. For example, brothers Mohamed (F41) and Mwalimu (F42) regularly communicated and met with the assigned ward-level extension worker in Kikwe due to their involvement in a business-oriented farmer group. Their interest in modern farming and their positionality as high-status, middle-aged men had led them to be considered successful farmers by the extension officer. They had the extension worker's mobile phone number and could call or text him at their convenience, which they frequently did.

During a visit to Mwalimu's home, he scrolled down the message on the small screen of his mobile phone that was so well-used that the numbers on the buttons were no longer visible (see Figure 8.6), and shared the following about M-Kilimo;

"The service is still new, so not that many farmers know about it yet, but I think it will be popular later. It is easy to use the service because I can use the SMS on my phone. But many women in the village do not know how to use SMS", Mwalimu (F42).



Figure 8.6: Farmer in Kikwe showing a message he got from the extension officer using the M-Kilimo service.

A female farmer, a member of the same farmer group as Mwalimu, had also been briefly introduced to M-Kilimo by the extension worker. She had, however, not fully understood how to use the service. Therefore, after registering (with help from the extension worker), she did not use the service. Equally, many farmers from the communities unaware of M-Kilimo often did not know where or how to contact the extension officer.^{lix} Therefore - if we bypass the dysfunctions and technical challenges of M-Kilimo and focus on the intended use - the pattern of registration and use of M-Kilimo in Kikwe and Ubiri reproduced existing social patterns of exclusion.

From a script theory (Akrich, 1992; 1994) perspective, the analysis also identified that M-Kilimo's design rests on an embedded implicit assumption that the tool can offer an easier and more efficient communication channel between extension workers and farmers (compared to possible existing communication channels). Similarly, the market price module implicitly assumes that M-Kilimo -

once rolled out - would be a convenient and preferred channel for sellers and buyers to interact. However, data from Lushoto and Meru suggest that the value-added M-Kilimo for farmers with established and familiar communication channels to extension workers was limited. However, farmers in the study typically already had an established line of communication with extension officers via calls and SMS (see Chapters 6 and 7 for more examples of farmers' informal digitisation in agriculture practices). Findings from Ubiri and Kikwe suggest that M-Kilimo adds additional complexity due to the requirement for extension workers to access and respond to farmers' queries online. An extension worker from Meru shared this sentiment:

“A farmer once told me the quote, “It’s better to call the extension officer than to use M-Kilimo because it delays communication” (A10).^{lx}

In addition, the script of M-Kilimo has embedded assumptions about the roles and functions of farmers. Examining the imagined functions for each imagined user group - farmers, buyers and extension workers - illustrates how the script aligns with dominating historical and contemporary discourses. Extension workers are invited to participate as knowledge contributors by answering questions submitted by farmers. Farmers' roles are, on the other hand, within the boundaries of M-Kilimo, confined to asking for advice and receiving information. The script invites farmers to participate as passive recipients of information and knowledge, while extension workers are framed as experts and active knowledge holders and creators. This design choice restricts farmers to the role of information end-user and prevents farmers from participating in knowledge sharing and co-production.

A final key observation about M-Kilimo relates to implicitly embedded ideological connotations in the design choice to facilitate knowledge transfer from extension officers to farmers. While, as emphasised in the previous paragraph, it reproduces framings of farmers as information-poor and passive information recipients, the script does leave the door slightly open for farmers, as M-Kilimo invites farmers to formulate the questions they submit. This study has not analysed the ideological affiliation of responses submitted through M-Kilimo^{lxi} as this goes beyond the scope of this study and the available data. However, it is reasonable to predict that extension workers' backgrounds, education, lived experiences, and ideological convictions influence whether their advice aligns with specific agrarian approaches such as organic, regenerative, conventional or industrial agriculture.

Against this background, it should be noted that M-Kilimo is an embedded component in the government's existing package of extension services and is used by public sector-employed extension workers. The extension workers, who respond to farmers' questions via M-Kilimo, are trained and employed by the government. It is, therefore, not unreasonable to assume that discourses and ideologies embedded in the Tanzanian government's policies around agriculture likely impact the ideological underpinning of the advice provided. As I elaborate in Chapter 4, Tanzania's historical and contemporary agricultural policies are dominated by agrarian intensification and modernisation narratives. The focus of M-Kilimo is built upon assumptions that align with the hegemonic narrative around agricultural development in Africa and which is frequently reproduced in technology solutions, which portrays market linkages as broken and inefficient and small-scale farmers as information-poor (see Chapter 2).

8.3. Ugunduzi

The second case study analysed in this chapter is Ugunduzi, which means discovery in Swahili. Ugunduzi aims to facilitate farmer-led research on agroecological practices. It is designed to foster and support locally identified and farmer-led agroecological transitions to organic agricultural practices. The development of Ugunduzi dates back to the research project Sauti ya Wakulima (the Voice of Farmers).^{lxii} Within the scope of Sauti ya Wakulima, participating farmers used “smartphones to take pictures and record voice messages about diverse issues related to local agriculture. These audiovisual contents can also include tags, and may be enriched with geographical data. The contents are published on the project's website, thanks to a mobile app which was developed specifically for this case study” (Tisselli, 2016:25). Building on this initial work, the development of Ugunduzi continued together with farmers using a co-creative methodology (see, e.g. Kihoma et al., 2021; Kihoma et al., 2023; Hilbeck et al., 2022; Hilbeck et al., 2024; Hilbeck & Tisselli, 2020) where farmers from Masasi, Mvomero and Bagamoyo Districts were engaged as co-designers. The tool was first used in 2019 and was then used by sixty farmers, with funding from SWISSAID. The next steps for Ugunduzi were still being operationalised at the end of the data collection period (April 2024).

I have had informal conversations (online and in-person) with individuals who have been involved with the application since its inception.^{lxiii} In addition, In November 2023, I attended a presentation about Ugunduzi at the Third National Ecological Organic Agriculture Conference (NAEOAC) in

Dodoma (see Kihoma, 2023). I tested the Ugunduzi Web application, which is not presently open to the public, using log-in credentials provided by the implementing team (see Chapter 3). I attempted to test the smartphone app, but it was only partly possible due to a technical malfunction of the app.

Table 8.3: Overview of Ugunduzi				
Technology used	Access Points	Target Group(s)	Functions	Access Costs
Smartphone application	Online database portal and smartphone app download link available: https://sautiyawakuli.ma.net/ugunduzi	Farmers	Creating visualisations of farms and plots, keeping farm records,	Ugunduzi is free to download and use for users who have been given login credentials. The online database requires data and connectivity, but the smartphone app can be used offline once downloaded.
Online Database Portal		Farmers and researchers	Engage with data from the users of the Ugunduzi app (farm records and registered farms)	

8.3.1. The Imagined Use of Ugunduzi

Ugunduzi consists of a smartphone application and an online database portal. The primary intended users of Ugunduzi are farmers, but researchers are also an intended end-user group for the online database when engaged in joint research endeavours with farming communities.

The script of the Android smartphone application invites farmers to “draw” one or several digital farms (representing their physical farms) by entering the plot's name and size (in acres), which is visualised as a rectangle on the farmers' screen (see Figures 8.7, 8.8, 8.9 and 8.10). There is a function to add plots (maximum sixteen) to each farm from the menu and adjust the size of each plot. Users can add crops and treatments (if applicable) to the plots they created by clicking on a question mark symbol in the corner of each plot visualisation. The user is prompted to choose from predefined lists of crops, (natural/organic) pest- and disease treatments and (natural/organic) fertilisers. The drop-down menu also includes farm records (can be viewed and edited), farm

balance (available balance), switching between farms (if the user has more than one), creating or deleting a farm and a direct link to the website. The app invites farmers to register information in their farm records for each farm or plot via text, a picture, or a voice message.

Besides the Android app, Ugunduzi has an online database where user data (farm records and farms) can be viewed. The online database can be accessed through the Sauti ya Wakulima website and requires a valid username and login, which I received from the Ugunduzi team. Once logged into the online database, the start page is blank with a top header with three options. The first states the user's name, but when you press it, nothing happens. The second menu icon is labelled *kila mtu* (everyone) and brings the user to a scroll-down menu of records submitted by various users. The third menu icon is labelled study and brings the user to a new interface where data from individual users can be viewed by selecting their names and farms from drop-down menus.

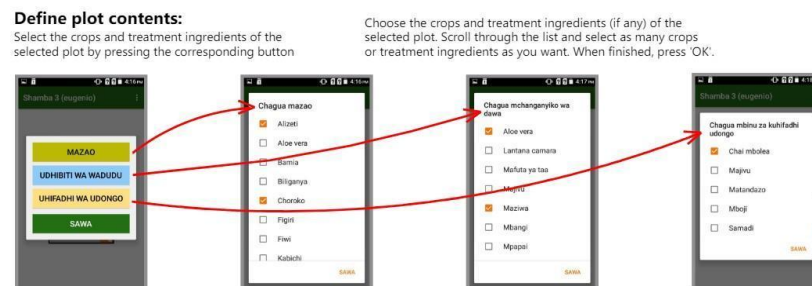


Figure 8.7: A screenshot showing options available for crops and treatment ingredients (for pest, disease and soil health management).^{lxiv} The image shows a step-by-step guide of the user's choices in the application. In the first screen, the user can choose between three categories (crops, pest control and soil conservation), and there is also an option to choose "ok". The second screen shows what happens when a user chooses crops; the user is presented with a checklist of crop types (e.g. sunflower, aloe vera, okra, eggplant, mung beans. The third screen shows what the user is shown if choosing pest control, where the user is presented with a checklist and prompted to choose pest control treatments (e.g. aloe vera, lantana camara, kerosene, milk). The last screen shows the interface where users are prompted to select soil conservation methods (e.g. compost tea, ash, manure).

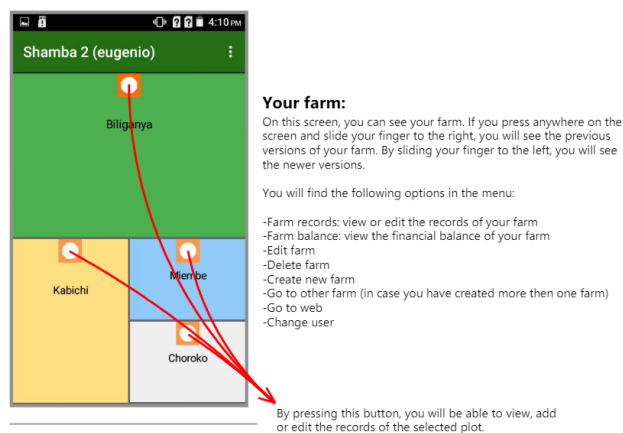


Figure 8.8: A screenshot from the Ugunduzi user manual showcasing the functions available to users related to the digital farm visualisation. The visualisation shows a farm divided into sections farming different crops, including cabbage (yellow), mung beans (white), mango (blue) and eggplant (green).

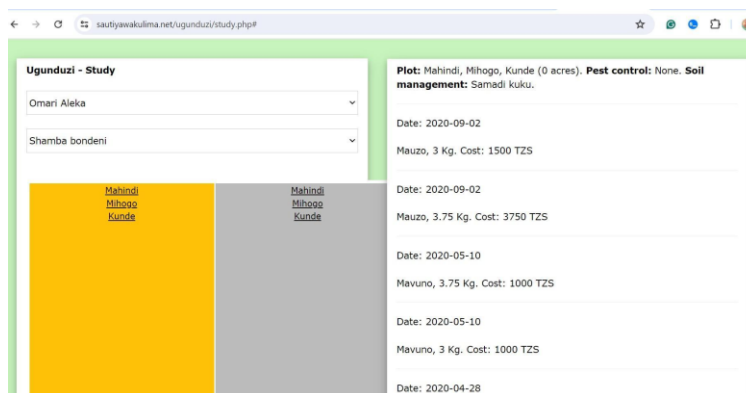


Figure 8.9: A screenshot from the Ugunduzi Online Database portal demonstrating data registered by a farmer for his lowland plot, where he has registered maize, cassava and pulses as crops and chicken manure as an input. The data shows dates when he has harvested or sold crops, including the financial aspects of those activities.



Figure 8.10: Screenshot from the Ugunduzi user manual, demonstrating how farmers can add pictures, text and audio recordings to their records.^{bxv} The text in the screen – translated to English – reads “Picture + Audio: Farm 2 Crop: Eggplant. Pest control: ash, milk. Soil management: Compost tea.” There are also three buttons that read “take a picture”, “record audio again” and “save”.

8.3.2. The Use and Impact of Ugunduzi

This study lacks primary data from app users, as Ugunduzi has only been used by a small group of farmers and was not implemented in the geographic locations where this study's fieldwork occurred. However, Ugunduzi stands out as a well-documented digitisation in agriculture tool in the Tanzanian landscape, with multiple academic publications exploring its methodology and results (see, e.g., Kihoma et al., 2021; Hilbeck et al., 2022, 2023, 2024; Tisselli, 2022).

The literature on Ugunduzi emphasises its participatory methodology and approach. A study on Ugunduzi (Kihoma, 2023) draws on qualitative and quantitative data from sixty farmers from three districts (Masasi, Mvomero and Bagamoyo) who have used the app. The study concluded that Ugunduzi supports farmers in identifying context-specific agroecological practices and seasonal planning. It is designed to be a supportive tool encouraging increased knowledge and information sharing around agroecology. However, the study also recognises challenges, such as the need for comprehensive training for farmers to fully understand and utilise the smartphone application efficiently for the intended purposes. In contrast to M-Kilimo, Ugunduzi has not been taken to scale. Despite being the product of a process dating back to 2016, the work has focused on proof of concept and participatory work with smaller groups of users.

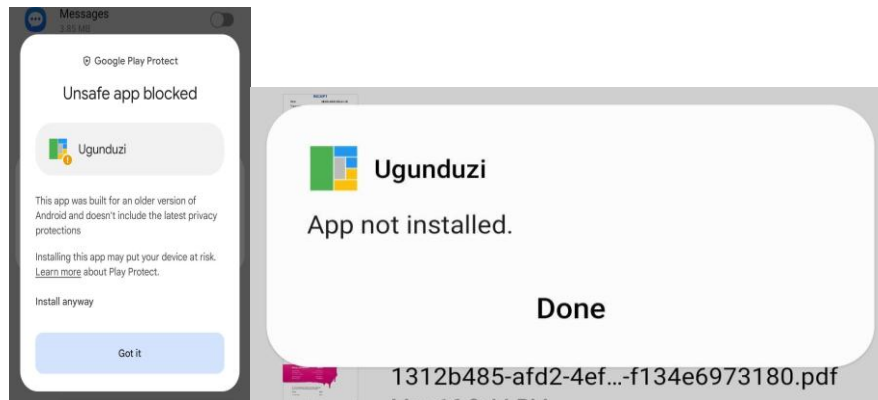


Figure 8.11: Screenshots from two attempts to install the Ugunduzi app on different devices in May 2024. The app is labelled as unsafe, as it was built for an older version of Android and, therefore, does not include the most updated privacy protections and was not installed.

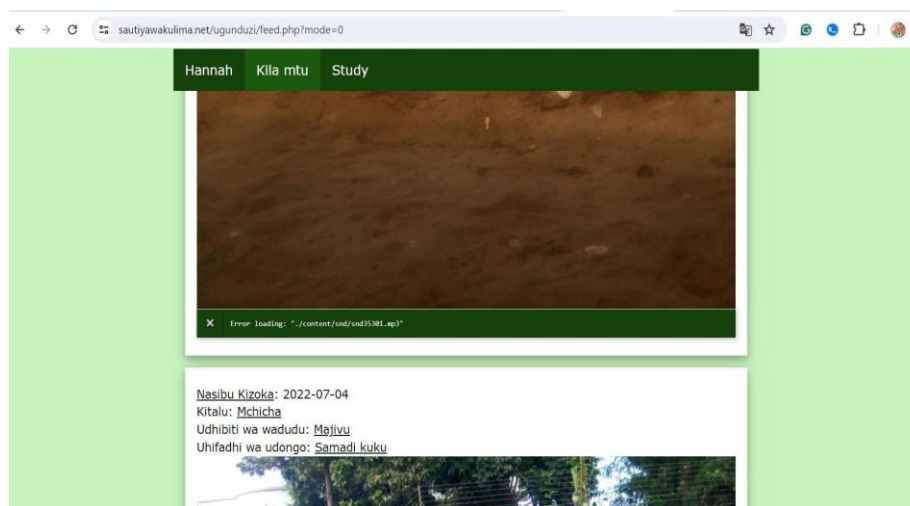


Figure 8.12: Screenshot from the Ugunduzi data portal, documenting an error message when attempting to listen to an audio recording within a farm record.

During user testing, the Ugunduzi smartphone application could not be downloaded because it was built on an older version of Android (see Figure 8.11). In addition, the Ugunduzi team informed me that the audio function was being updated, and this was observed during testing as it was not operational.

8.3.3. Unpacking the Script of Ugunduzi

Using examples, this sub-section analyses the assumptions, narratives and ideologies embedded in Ugunduzis' content and design.

From a script theory perspective, the analysis reveals that Ugunduzi's script positions farmers as

active knowledge producers yet the lived realities of rural farmers may pose risks for misalign with the imagined trajectory.

First, as described, Ugunduzi has an outspoken intention to foster participatory and farmer-led research processes (Tisselli & Hilbeck, 2020). Farmers are framed as innovators and knowledge holders, evidenced by the intention for researchers and other farmers to learn from the knowledge farmers share through their record-keeping. The content and design have been developed to make Ugunduzi a tool for bridging the gaps between local, indigenous, contextualised and formal scientific knowledge. As Hilbeck et al. (2022:32) expressed, “*In the spirit of the socially oriented principles of agroecology, the intention was to respect the farmers’ ways of knowing*”.

In practice, this intention is reflected in how the script frames farmers as active contributors invited to participate in tasks that require farmers to share, participate and create knowledge actively. Ugunduzi’s script positions farmers as *active* in creating knowledge as they are invited to participate in experimentation, data collection, and record keeping. For example, the record-keeping functionality intends for farmers to record their knowledge in ways that align with local ways of doing and knowing. The digital script translates this into options to include text, pictures and audio files. This design invites farmers with varying literacy levels and knowledge-sharing practices to choose between different forms of expression. However, it is relevant to consider that introducing and framing Ugunduzi as an innovative tool could impact the status and perception of existing localised knowledge-sharing practices already in place.

However, from an intersectional feminist perspective, it is relevant to consider *which* farmers are included in processes dubbed as participatory and - by extension - which voices may be excluded. Like any community, farmer communities in Tanzania are shaped by gendered social norms and values that influence the knowledge systems and digital realities in heterogeneous farming communities (see Chapters 6 and 7). The design choices that have shaped Ugunduzi come with attached requirements for accessing and using the service. Farmers need access to a smartphone; they need to be able to afford and prioritise data to download the app and upload content; they need digital literacy skills to enable them to navigate the various menus; literacy skills and time resources to participate in training and to record farming activities on the app continuously (see Chapters 6 and 7). Different groups of farmers, e.g. women with a high burden of reproductive and productive responsibilities and a resulting time poverty, may be less likely to participate in

participatory research processes, such as the ones Ugunduzi intends to foster - even if they would be explicitly invited to do so. While the script centres farmers' knowledge, experiences and priorities in line with agroecological principles around knowledge sharing, co-creation and respect for local values and knowledge, the design also risks reproducing or creating power hierarchies as it likely favours farmers with socio-economic characteristics that enable them to own a smartphone, can afford data and have time to dedicate to the tasks in Ugunduzi. The participatory framing of the tool, its design, and implementation may mask potential unintentional reinforcement of already powerful voices and, by extension, which knowledge is included in the farmer-researcher knowledge exchanges the tool seeks to facilitate.

Second, as previously mentioned, smartphone access is a prerequisite for using Ugunduzi. Therefore, the implicit embedded assumption is that farmers using Ugunduzi have or are given smartphone access. As is discussed in more detail in Chapters 6 and 7, smartphone ownership and use were not widespread among farmers in this study. In addition, the farmers who owned and used smartphones predominantly used basic functions such as calling, SMS, USSD, camera and calendar rather than more advanced features equivalent to the task's users are imagined to perform when using Ugunduzi. While farmers have been proven to successfully use the Ugunduzi App (e.g. Kihoma et al., 2023), they did so at a relatively small scale with dedicated support and training. This type of training and support is likely needed for farmers to successfully use Ugunduzi both in the short- and long-term (which was also highlighted by Kihoma et al., 2023). If Ugunduzi aims to scale to reach more users, the feasibility and sustainability of providing the needed level of (continuous) capacity building and user support would be financially and practically challenging, drawing on the extensive documentation of ICT4D projects that have failed to scale resource-intensive pilot-level projects. There exists substantial evidence in the ICT4D literature that creating an impact and getting results with a small number of users in a pilot-like setting is fundamentally different from taking a project to a larger scale and sustaining it over time (e.g. Breytenbach et al., 2013; Foster & Heeks, 2013; Keijdener et al., 2018).

Third, the Ugunduzi script invites farmers to participate actively in farmer-led agricultural research. In doing so, the script invites farmers to take on several roles within the tool, which in itself opens up for greater choice. Farmers are framed as data collectors who record detailed farm-level data, use Ugunduzi as a planning tool, and openly share knowledge and practices. While the

overarching aim of Ugunduzi is to put local knowledge and ways of knowing at the centre of agroecological debates, the approach can equally be argued to align with scientific paradigms of knowledge, which privilege formalised knowledge. By asking farmers to spend considerable time documenting their practices in a digital tool, their time use patterns will likely divert from previously embodied farming experiences towards digitally logging data about their farming practices, potentially altering their use of time and space.

Finally, in the digitisation in agriculture landscape (not only in Tanzania but globally), Ugunduzi stands out as an application developed with an explicit aim to align with agroecological principles and a goal to transition away from conventional agriculture towards ecological agrarian systems (Hilbeck et al., 2022). While multiple digitisation in agriculture tools (in Tanzania and beyond) may align with selected agroecological principles, Ugunduzi has been *purposefully* designed with an ideologically informed agenda to further an ecological and organic transition (Hilbeck et al., 2022). The design of Ugunduzi is built on FAO's ten elements of agroecology (FAO, 2018b) and the ICT for Agroecology principles (Tisselli & Hilbeck, 2020:23-25), which include diversity, co-creating and sharing knowledge, synergies, efficiency, recycling, resilience, human and social values, culture and food traditions, responsible governance, and a circular and solidarity economy (Tisselli & Hilbeck, 2020:23-25). As an app that has the explicit aim to further an agroecological transformation, it stands in contrast to the dominant industrialised high-input discourse that shapes a majority of digitisation in agriculture initiatives. By doing so, Ugunduzi can equally be understood as expanding choice for farmers.

However, at the same time, the choices presented to users in the Ugunduzi app align with an ideologically informed trajectory of transitioning from conventional and industrial practices to agroecological practices. In doing so, the script positions agroecology as *the* solution. This ideologically charged approach is visible in, for example, the choices of inputs available in the interface, which restrict farmers from considering alternative approaches (beyond agroecology). This framing may alienate farmers who do not identify with agroecological practices and may practice hybrid or industrial methods.

8.4. Fertilizer Optimizer App

The third and final case study is the Fertilizer Optimizer App,^{lxvi} an Android smartphone application developed to enable users to optimise fertiliser use to maximise profitability from crop

production. The digital tool was developed as part of a larger multi-country project - Optimiser Fertilizer Recommendations in Africa (OFRA). OFRA was funded by the Alliance for a Green Revolution in Africa (AGRA) and implemented between 2014 - 2017.

The app is a digitised version of the Fertiliser Optimizer Tool. It stems from a research project that included 80 trials in Uganda led by one of OFRA's partners, the University of Nebraska-Lincoln (Jansen et al., 2013). CABI was the leading implementing partner, and the project spanned thirteen African countries, including Tanzania, Kenya, Uganda, Rwanda, Burkina Faso, Ethiopia, Ghana, Malawi, Mozambique, Niger, Nigeria and Zambia.^{lxvii} OFRA partnered with a local partner in each of the project countries. In Tanzania, the local partner was the Tanzania Agricultural Research Institute (TARI) branch in Mlingano, Tanga.^{lxviii} During the application development, the local partner TARI was involved in and facilitated activities (2013 - 2017) that involved 730 extension workers from 16 district councils in Tanzania, 18 input suppliers, 32 university students, and 71 researchers.

Table 8.4: Overview of the Fertilizer Optimizer App				
Technology used	Access Points	Target Group(s)	Functions	Access Costs
Smartphone Application	https://play.google.com/store/apps/details?id=org.cabi.ofra&hl=en_GB	Farmers, extension workers	Provide customised fertiliser recommendations	It is free to download and use. The app requires a charged Android smartphone, data ^{lxix} and connectivity. It can be used in offline mode
Paper-based tool	Not identified		A paper-based version tailored to each agro-ecological zone	Printing costs of paper tools

I visited TARI's office as I conducted fieldwork in Tanga, where I learned about the Fertilizer Optimizer App and TARI's role in the development and (lack of) implementation of the smartphone application. Apart from field visits and interviews, TARI shared a written document summarising the Fertilizer Optimizer App journey in Tanzania, which forms the basis of this case

study (together with user testing data and secondary data). I tested the application multiple times using different smartphone devices during my fieldwork. In April 2024, I conducted in-depth structured user testing of the app (see Chapter 3).

8.4.1. The Imagined Use of Fertilizer Optimizer App

The application is designed to function as a decision-support tool for farmers and extension officers by guiding users towards better decisions on using fertiliser based on their available budget. The application prompts users to share (what the designers and content creators deem to be) essential information and customises evidence-based recommendations to each user's specific needs based on geographical location, financial resources, and crop types.

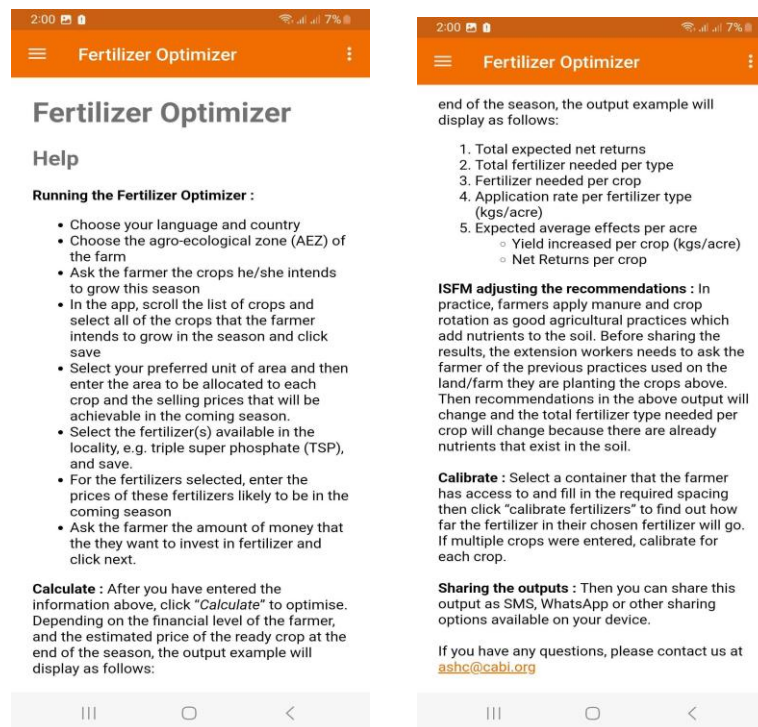


Figure 8.13: The Fertilizer Optimizer App's help page addresses extension workers or others working to support farmers' app use. There are no instructions that directly address farmers.

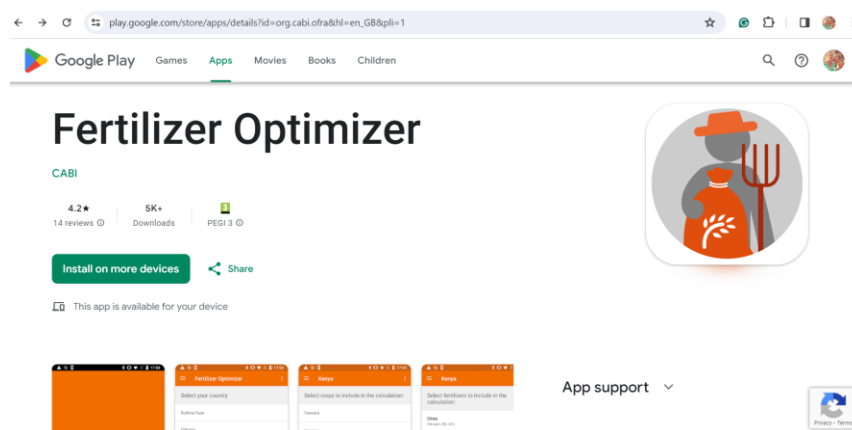


Figure 8.14: Screenshot of the Fertilizer Optimizer App in Google Play Store (9/4/2024)

The application asks the user to select an agroecological zone based on a pre-defined list, select one or several pre-selected crops, and manually input data on land unit size, area planted, and expected crop value. The application then requests the user to select fertiliser types and manually add the fertiliser price and the total budget the user has available to invest in fertilisers. Based on these choices, the application generates a recommendation on how to *optimise* the users' investment in fertilisers to maximise productivity.

The application invites the user to refine the calculation by adding data points related to any additional soil management practices they may be using, based on thirteen predefined options. In the final step, the application gives the user an option to calibrate the results by choosing a pre-defined container option (or adding an option based on the measurement and shape of the container of choice) that the farmer will use to apply the fertiliser. After completing all the steps, the user can view the final recommendations directly in the app and share via SMS, WhatsApp, or online.

8.4.2. The Use and Impact of Fertilizer Optimizer App

The local implementing partner, TARI, reported positive results from field testing the fertiliser optimisation tool (the paper-based tool on which the mobile app is built). They used recommendations from the tool on 250 farmers' plots to verify the outcomes and validity of the advice generated by the app, mainly related to maize and rice crops. In addition, TARI provided evidence of positive outcomes (measured as increased yields) by an irrigation scheme in Korogwe that used the paper-based tool in 2017, by 45 farmers in 2018 who used recommendations generated by the app and by one farmer in Muheza.

Google Play Store statistics reveal that the app has been downloaded over 5,000 times since its release in February 2018 (as of April 2024). When interpreting this number, it is valuable to consider that the project spans thirteen countries, that Tanzania alone has a population of 61,7 million (PHC, 2022) and that the application has been operational for several years. As highlighted in this thesis, over-reliance on user registration as a proxy for using a digital tool has also been extensively highlighted in the ICT4D literature (see Section 2.2). The same logic applies to smartphone app-based digital tools and download statistics. Just because an individual downloads an app does not mean that they will use it, and if there is use, download statistics do not say anything about the type, frequency and (potential) impact of that use (e.g. Edney et al., 2019).

When the OFRA project closed in July 2017, the app was not yet finalised or launched. No second round of funding had been secured, which left the local partner unable to carry out activities for roll-out, implementation and evaluation, creating a bottleneck for awareness, uptake and use. TARI allocated a small amount of internal funding but only managed to train 54 extension workers and twenty researchers in the Muheza District. In a written summary of the project, TARI highlighted this challenge and shared that *“awareness creation on the use of the App was done to few extension officers when compared to more than 10,000 extension officers who are working with farmers in Tanzania”*.^{lxx}

Qualitative data collected through interactions with TARI staff in 2021 and 2022 confirmed no official application use due to a lack of funds. Still, users may have independently identified, downloaded, and used the app. Representatives from the local partner felt that the project had effectively ignored the context-specific implementation needs the local partner identified as necessary for potential users to gain the awareness and skills required to (potentially) use the app. Therefore, despite positive preliminary results on agricultural productivity - that aligns with the project's definition of success - the application's implementation stopped, and available data suggests that use has been minimal (if not non-existent) in Tanzania.

8.4.3. Unpacking the Script of the Fertilizer Optimizer App

Using a script theory lens, the analysis found that the Fertilizer Optimizer App script frames farmers as passive recipients of pre-defined recommendations generated by the application. The farmer's role is strictly confined to inputting data based on questions in the script, some chosen

from pre-determined options. There is no function to capture queries or feedback from farmers that do not fit into the script. The script thereby positions the recommendation generated by the app as the undisputed solution, disregarding additional contextual aspects that the app may not have captured and alternative trajectories and approaches. By extension, the application's design implicitly assumes that farmers will be willing and able to follow the recommendations provided, reproducing information deficit model logic (see Chapter 2).

Moreover, the project's implementation strategy has embedded techno-deterministic assumptions. As mentioned, the Tanzania-based project was a component of a larger multi-country project. The main focus and resources of the project were the design and finalisation of the application. Still, once the application was completed, the local partner was left without any funding for awareness-raising, training, and roll-out, and the momentum subsequently diminished. This evidence suggests an overreliance on the technology component of the project and a failure to identify and cost out the additional components needed to make farmers and extension officers aware of and able to engage with the tool.

In addition - just as Ugunduzi - the Fertilizer Optimizer App is only accessible through the Android smartphone app, which requires any user to access a smartphone, data and connectivity. As discussed in Chapters 6 and 7, this study found limited smartphone access and use in two rural farming communities in Tanzania, suggesting potential design-reality gaps between the smartphone-only design of the Fertilizer Optimizer App and farmers' digital realities. Moreover, the application content is unavailable in Swahili or other local languages used in Tanzania. The vocabulary used in the application's content is technical and likely difficult for rural farmers to engage with, particularly in English. For example, users are asked a mandatory question and asked to choose between options of pre-defined agroecological zones representing the area in which they work and farm. The different agroecological zones have different names, but users do not get any guidance to understand what agroecological zones are or how to determine which one fits the user's location.

Finally, the Fertilizer Optimizer App has embedded ideological assumptions. The description in Google PlayStore describes the intent in the following way; “*We’ve created the Fertilizer Optimizer app so that extension workers and farmers can have free access to fertilizer advice, on mobile devices.*”^{lxxi} The app seeks to do so by calculating “*the most profitable combination of*

fertilizers to purchase”^{lxxii} based on the embedded optimiser tool, nutrient substitution table, and fertiliser calibration tool and invites users to adjust the recommendations based on (possible) use of integrated soil fertility management (ISFM) practices.

As illustrated, the script is built on the assumption that (all) farmers seek to maximise yields and profitability and has predetermined the method to reach this goal - industrialised fertilisers. From a political economy approach, the content of the Fertilizer Optimizer App aligns with the hegemonic agricultural discourse, which centres around the modernisation and industrialisation of agriculture in Sub-Saharan Africa and mirrors Tanzania's agricultural policies, which are heavily focused on using industrial inputs.

In addition, the funder behind the project was the Alliance for Green Revolution in Africa (AGRA), a key player on the continent that has promoted and worked to enable a green revolution for Africa centred on industrialised inputs. By promoting solutions based on industrial fertilisers, the Fertilizer Optimizer App reinforces farmers' dependence on industrial inputs and reproduces the narrative of the dominant hegemony of modernity.

8.5. Unpacking the Success of Digital Tools Designed for Farmers

Following the individual analysis of the three case studies, this section adds analytical depth by discussing the emerging joint themes. discussing whether and how digital services can be successful. As part of this discussion, I analyse whether each digital tool can be considered successful based on the tools' subjective (implicit and explicit) definition(s) of what success looks like. Secondly, I unpack how each digital tool can be understood as successful based on the definition of development used in this thesis - the expansion of choice (Sen, 1999; Kleine, 2013).

8.5.1. Unpacking Thematic Findings

Across the three case studies, four common themes emerged. First, each of the case studies frames their intended farmers in different ways. Ugunduzi frames farmers as active knowledge creators tasked with functions designed to generate, share and co-create knowledge. Contrarily, M-Kilimo and the Fertilizer Optimizer App are illustrative examples of scripts that frame farmers as passive by inviting them to participate, but with significant limitations that largely contain their role as passive recipients of information and knowledge.

Second, each digital tool script makes assumptions about farmers' epistemic realities. Notably, all three tools are designed with the implicit assumption that users will accept and trust the digital tool as a platform for sharing and/or receiving information. M-Kilimo and the Fertilizer App assume their users have limited agricultural knowledge and need decision support. Ugunduzi, on the other hand, positions farmers as knowledgeable and capable and invites them to contribute towards a growing knowledge base on agroecological practices. The Fertilizer Optimizer App is built on a pre-defined definition of what type of needs farmers use the app have - advice on optimising fertiliser use to maximise productivity. M-Kilimo, on the other hand, has a more open script that allows farmers to open questions but has made design choices that shape the script. Notably, the design of M-Kilimo assumes that the functionalities it includes (advisory services from extension workers, market price information and market linkages) align with farmers' needs. M-Kilimo and the Fertilizer Optimizer also assume that farmers have a linear decision-making process.

Third, assumptions about farmers' digital realities are equally expressed in the scripts of the case studies. M-Kilimo stands out among the case studies as a tool that includes a diverse set of access points, including USSD and SMS options, that are accessible through any mobile device and do not require Internet connectivity. However, the design of M-Kilimo has made different assumptions about different user groups, which is evident in the extension worker functionalities that are only available on a smart device with internet connectivity. The practical implications of this design choice included changed patterns of the use of time and space, as extension workers in the study spent more time in their head office - where they had better connectivity - than in the local communities (aligning with priorities expressed by farmers). The Fertilizer Optimizer App and Ugunduzi are both exclusively designed for use on smart devices, which stands in sharp contrast to the digital realities in Ubiri and Kikwe that were dominated by the use of basic mobile phones (see Chapters 6 and 7).

Fourth, each digital tool has different (implicit and explicit) ideologically charged definitions of success manifested in its design and content. The analysis of the design and content of M-Kilimo suggests a definition of success framed around the successful facilitation of farmers' increased productivity and profitability. This success is imagined to be realised by providing digitally-enabled advice from extension officers, access to market price information, and linking buyers and sellers across the value chain via any or a combination of the tools' access points. The gathered

primary and secondary data on the roll-out of M-Kilimo suggests that M-Kilimo has not fulfilled its subjective definition of success due to a combination of factors. The tool has significant malfunctions and design-reality gaps, which impact end-users (farmers and extension workers) and their ability to use M-Kilimo. In addition, the tool aims to introduce a digital solution that mirrors informal ways of knowledge exchange that already exist in rural Tanzanian communities (see Chapters 6 and 7). M-Kilimo has enrolled millions of farmers onto a platform, but available data suggests the actual use is limited.

Table 8.5: Summary of Analysis of Three Digital Agriculture Tools			
Digital Agriculture Tool	M-Kilimo	Ugunduzi	Fertilizer Optimizer App
Requires Smartphone (or other smart device)	Yes (but SMS and USSD-based services are also available)	Yes	Yes
Works offline	Partly	Yes	Yes
Successful technology components (during user testing)	No	Partly	Yes
Definition of Success (Intended Impact)	Connecting sellers and buyers, educating farmers on best practices, and providing strategies for solving agrarian challenges	A farmer-led agroecological transition	Maximising productivity through the optimisation of fertiliser use
Success based on intended impact	Partly, enrollment of a large number of farmers and facilitation of advisory consultations. However, based on available data, the roll-out was not as impactful or sustainable as expected.	Yes, but only used by a small number of farmers that demonstrated the utility of using Ugunduzi.	No, the app is not actively used in Tanzania
Embedded discourses	Modernisation of agriculture, knowledge transfer from government to farmers	Agroecological principles, participatory development, co-creation of knowledge	Industrialised agriculture trajectory, knowledge transfer from experts to farmers

The analysis illustrates how Ugunduzi defines its success based on its ability to support a farmers-led transition towards agroecological practices. The tool itself and the structures around it are shaped by participatory approaches that centre farmers' knowledge and ways of knowing. According to this definition, Ugunduzi has proved that the tool can support the intended result, but only with a small number of farmers. The proof of concept has only been demonstrated using fewer farmers. Drawing from documented experiences in ICT4D, achieving and maintaining impact at scale will likely require an updated plethora of tools, including extensive training and provision of smart devices or exploring alternative low-tech access points that align with farmers' digital realities.

In the case of the Fertilizer Optimizer App, the analysis indicates that its design and content suggest that the subjective definition of success is centred on the ability of the smartphone app to provide advice that farmers use to inform their decisions, which leads to optimised use of (industrial) fertilisers and - by extension - to improved (and maximised) productivity and yields. The analysis found that the digital application has not achieved this goal in the context of Tanzania, primarily because the project was designed and funded in a way that did not allow for roll-out, training and awareness raising of the application by the local partner.

8.5.2. Digitally-Enabled Expansion of Farmers' Choices?

As elaborated on in Chapter 2, this study has chosen to define development based on the work of Sen (1999) and Kleine (2009; 2013), which recognises development as expanding people's choices to live the lives they have reason to value. From the perspective of development as the freedom to choose (Sen, 1999), digital agriculture tools' ability to expand farmers' choices forms the basis for measuring the success of any digitisation in agriculture initiative. From this perspective, I use a choice lens to analyse to what extent the three case studies support the expansion of farmers' choices (based on available data).

From the problem formulation to the practical design and content of M-Kilimo, farmers are framed as information recipients needing expert advice, formal sources of market information and market linkages. Farmers are presented with choices within M-Kilimo, such as formulating questions freely and deciding which crop-specific market price information to request. However, the boundaries imposed on farmers' roles within the design of M-Kilimo do not recognise farmers as active knowledge creators and contributors. The framing and positioning of farmers within the

design of M-Kilimo indicate embedded assumptions about farmers' need for agricultural advice and who is best placed to advise farmers. This equally suggests the implicit embedded design assumption that access to professional advice will, by extension, lead to farmers making “better” choices in their farming (aligned with the professional advice they receive). Therefore, M-Kilimo is not deemed successful in expanding the choices of farmers.

Ugunduzi was co-designed with Tanzanian farmers and aligns with the Principles for Agroecology (ICT4AE), a set of guidelines to follow agroecological principles through the design, implementation, and evaluation of digital agriculture (Ajena et al., 2022; Kihoma et al., 2023; Hilbeck et al., 2022; Hilbeck et al., 2023; Tisseli, 2016; Tisseli & Hilbeck, 2022). As outlined in the previous section, if judged by the parameter of success defined by Ugunduzi - aligning digital agriculture with agroecological principles - Ugunduzi can be framed as a success. Equally, when utilising a choice-based definition of development that centres around expanding people’s choices (Sen, 1999), Ugunduzi can be understood as expanding choice as it offers an alternative pathway to the dominant discourse that characterises much of digitisation in agriculture. However, at the same time, because Ugunduzi has a closed script with a predefined ideological alignment and offers a specific solution package, Ugunduzi is not categorised as successful based on the criteria of this thesis. Farmers using Ugunduzi do not - in fact - have the choice of which ideological discourse to align with. In the case of Ugunduzi, the script privileges agroecology as the solution presented to farmers, which inherently is not aligned with the choice definition of a digital agriculture tool that aligns with a choice definition of success, as it should be up to each user to choose.

The problem formulation that underpins the Fertilizer Optimizer App’s design embodies a normative position: that (industrial) fertiliser use is a preferred method to reach a normatively defined aim (maximising productivity). The script presents a specific imagined trajectory where choices presented to users are centred around *which type* and *how much* fertiliser to use. The script effectively excludes or sidelines non-industrial approaches to agriculture (e.g. organic practices) and centres industrial fertilisers. Leading partners in the project have outspoken ideological affiliations and have been strong advocates for a specific type of agricultural trajectory in Africa. For example, the Alliance for a Green Revolution in Africa (AGRA) has a history of advocating for increased use of industrial fertiliser as part of an African green revolution as a pathway out of

hunger and poverty (see Chapter 4).^{lxxiii} Thereby, the Fertilizer Optimizer App is not considered successful in expanding farmers choices.

8.6. Conclusion

This chapter has presented and analysed findings related to research question 1b, which seeks to understand how embedded ideologies, narratives and assumptions shape digital tools designed for Tanzanian farmers. Through the conceptualisation of development as the expansion of (farmers') choice, this chapter has equally engaged with the choice of digitisation in agriculture services and applications present to their intended users (often farmers).

Through nuanced and in-depth analysis of three diverse case studies of digital tools developed for farmers in Tanzania, this chapter has illustrated that digitisation in agriculture can - and should - be interpreted as tools used to influence (imagined) users to make choices that align with ideological and political agendas (Akrich, 1992; 1994). The case studies in this chapter have exemplified how three different technology scripts have embedded assumptions about development, modernisation, farmers' role, and the type of choices farmers are (implicitly or explicitly) encouraged to make. Against this background, this chapter has illustrated how digital applications are ideologically charged and strategically positioned to further various interests and agendas that can amplify specific agricultural trajectories and ideological pathways.

This chapter completes the presentation of data from this study, which critically examines the relationship between digitisation in agriculture tools and the digital realities and local knowledge systems they seek to enter and improve. The next chapter transitions into analysing and discussing the contribution and relevance of the combined findings to the academic and practical field of digitisation in agriculture.

Discussion

Chapter 9

9.1. Introduction

In this chapter, I synthesise and discuss the cumulative relevance of the findings shared in Chapters 5, 6, 7 and 8. The aim is to recognise the contribution of each thematic data chapter and to analyse the big picture formed when the study is interpreted as a whole. The chapter begins by examining the broader significance of the extensive mapping of Tanzania's digitisation in agriculture landscape (building on Chapter 5). Next, I reflect on ways insights about farmers' digital realities and local knowledge systems may inform and extend existing debates on digital access, digitisation in agriculture and the framing of farmers (building on Chapters 6 and 7). I then use the conceptual lenses of script theory (Akrich, 1992; 1994) and choice (Kleine, 2013) to explore if and how interests, narratives and ideologies shape the digital tools that target Tanzanian smallholder farmers (Chapter 8). The analysis is then extended to discuss the choices that digitisation in agriculture apps presents to farmers and the broader implications of that. Thereby, the analysis is positioned within current academic debates about the intersections between digitisation, farming, and knowledge.

9.2. Looking at the Big Picture

The proliferation of digital apps and services implemented in the name of supporting agricultural development across Global Majority communities and countries has been well-documented (e.g. Ayim et al., 2022; Aker et al., 2016; Steinke et al., 2021; Tsan et al., 2019).

The mapping of Tanzania's digitisation in agriculture landscape mapping, which consists of a comprehensive catalogue of digital tools designed for Tanzania's agriculture sector, forms one of the study's key contributions (see Chapter 5). The inventory (see Table 5.1 and Appendix 7) presents a level of detail about country-specific digitisation in an agriculture setting that I have not

identified in the existing academic and grey literature. The most salient finding is the extensive number of initiatives, which amounts to 108. While these findings align with previous research that has pointed to a crowded and growing digital agriculture sector on the African continent (Beanstalk AgTech, 2023; CCARDESA, 2022; FAO & ITU, 2022; Jadhavand & Kimaro, 2023), this study uniquely identifies the number of digital apps in a single country context.

9.2.1. Pilotitis Revisited

When interpreting the inventory data, it is hard not to draw parallels to debates on top of the ICT4D agenda 15 years ago. In the 2010s, the term *ICT4D pilotitis* was frequently used to refer to and problematise the influx of digital development pilot projects in Global Majority countries, with a particular focus on digital health pilots (Huang et al., 2017; Ndlovu et al., 2021; Otto et al., 2015). The pilotitis debate was sparked by a mapping similar to this study, illustrating how a specific country context - Uganda - was flooded by overlapping, fragmented, technology-centric and unsustainable digital development initiatives (Figure 9.1). This mapping prompted critical scrutiny, and pilotitis was subsequently identified as a pattern characterising digital health implementation in other Global Majority geographies and within other sub-domains of ICT4D.

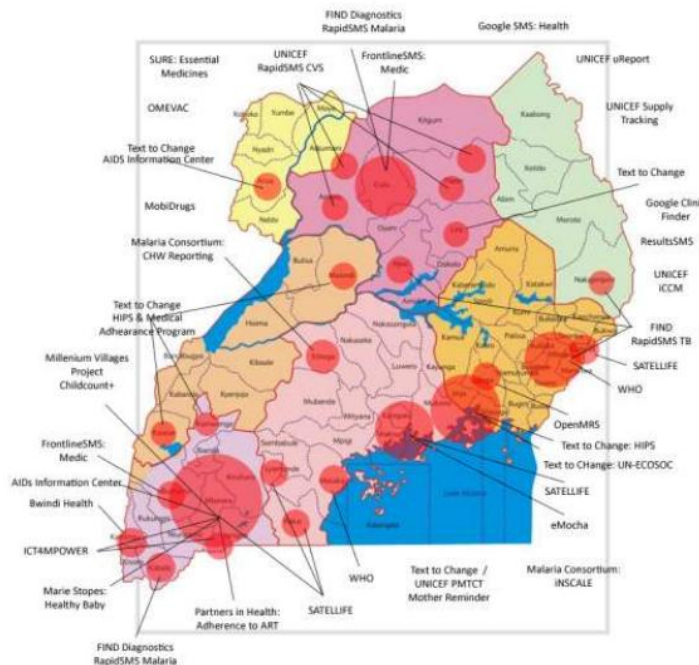


Figure 9.1: Screenshot visualising the number of digital health pilots in Uganda in 2010 (Source: Otto et al., 2015:8).

The mapping of Uganda's digital health landscape and the discussions it prompted indirectly contributed to an increased focus on sustainability, scale, interoperability, harmonisation and government ownership within ICT4D as an academic discourse and practical field. In Chapter 2, I discuss how ICT4D has evolved and attempted to respond to concerns underpinning pilotitis debates, expressed in, for example, a growing presence of critical ICT4D scholarship, increased focus on human-centred design and the development of practical initiatives such as the Principles for Digital Development. While ICT4D scholarship and practice have progressed, this study illustrates that the uncoordinated, fragmented and unsustainable deployment of digital solutions targeting Global Majority populations is a phenomenon that continues to be reproduced. The mapping of 108 digital tools designed for Tanzania's agricultural sector prompts considerations about the continued relevance of these debates today, more than a decade later.

Pilotitis used to be referred to by the ICT4D community as a “disease” spreading across the digital health sector. (Re)interpreting this analogy to fit today's context, the inventory of Tanzania's digitisation in agriculture landscape clearly shows that the patient is presenting with symptoms of a morphed and mutated strand of pilotitis. Much like the landscape mapping of Uganda's mobile health landscape sparked debate 15 years ago, the findings from Tanzania's digitisation in agriculture ecosystem present an opportunity for critical reflection.

9.2.2. Tapping into the Zombies of Digitisation in Agriculture

It is interesting to reflect upon what the mapping did *not* find. As discussed in more detail in Chapter 5, I found it challenging to map the landscape due to difficulties accessing information about identified apps, determining their status and understanding where and how to access and use them (Section 5.3). This had two main implications for the final inventory (Table 5.1 and Appendix 7).

First, although the inventory includes 108 digital tools, there are significant gaps in detailed information about many individual apps. Notably, I could not obtain data to verify the status of 69 out of 108 identified tools. It is striking that 64% of the digital apps and services are in a state of in-between, which I refer to as the *zombies* of the digitisation in the agriculture landscape (see Section 5.3.4). The zombies are digital tools that are neither dead nor alive. They present a black

box of untapped insights into lessons learned from the historical and contemporary design, deployment, successes and failures of digitisation in agriculture in Tanzania (and beyond).

Existing literature and practice on digitisation in agriculture typically concentrate on identifying and tracking *active* digital agriculture tools (e.g. GSMA, N.d; Tsan et al., 2019). This study demonstrates the value of looking at the bigger picture to capture the fluid and ambiguous nature that characterises the practical implementation of digitisation in agriculture. If this study had only included digital tools I could verify as active, it would have been an incomplete landscape representation. This work aspires to stimulate further research to take a holistic approach to understanding the complex nature of digitisation in agriculture (and other sub-strands of ICT4D) by using methodologies and sampling frameworks that recognise and capture data from the (many) zombies roaming the field.

However, it is tempting to conclude that with more accessible and available data about previous and current digitisation in agriculture work, actors in the landscape may build on what works and avoid reproducing what does not work. However, any such conclusions would echo information deficit model logic (see Chapter 2) and reduce a complex problem to a simplified explanation centred on access to information. This in-depth case study adds to existing voices in the literature that have suggested that policies, programmes, politics and behaviour of individual and collective actors in the digital agriculture sector, ICT4D and the development industry at large are driven by multiple incentive structures and interests that are unlikely to be altered by increased knowledge sharing practices (e.g. Abdulai, 2022; Hilbeck et al., 2022; McCampbell, 2021).

Second, it is reasonable to assume that there are additional initiatives utilising digital technologies to support small-scale farmers (and other target groups in the agricultural sector) that were not captured in the mapping due to a combination of factors such as lack of documentation, awareness, visibility and institutional memory. In addition, the landscape continuously changes, and the inventory should be interpreted as a resource representing a snapshot in time and as a baseline to build on through further research.

Beyond the compiled catalogue of digitisation in agriculture initiatives, the research process behind it lends valuable insights. It shows that, despite significant time and resource investments, obtaining updated, detailed and comprehensive data about digitisation in agriculture tools and how

to use them is challenging, time-consuming, resource-intensive and sometimes futile. This project had access to multiple smart devices and internet connectivity. It was led by a university-educated, digitally literate, and English-speaking person with access to research funding, which allowed significant time investment into the task over several years. Yet, obtaining data was challenging, and the final inventory remains with substantial knowledge gaps. These observations cast doubt about whether it is realistic to assume that small-scale farmers - who often face multiple digital access challenges - will find and learn how to use these digital apps when a multi-year research project with dedicated time and a budget has been unable to do so.

9.3. Farmers' Lived Experiences

After analysing the broader relevance of the national-level inventory of digitisation in agriculture tools, this section shifts the focus to a discussion about the “big picture” significance of the findings related to the farmer-centred component of the study. More specifically, I discuss how the findings expand knowledge about how small-scale farmers – and other less connected communities at the margin - navigate complex and dynamic digital realities (de Lanerolle et al., 2017).

One of this study’s central contributions is an in-depth case study of the practical manifestation of digitisation in agriculture. In academic debates and grey literature related to digitisation in Africa, vocabularies such as digital *revolution* or digital *transformation* are commonly used (e.g. Jawad et al., 2021; Kanyam et al., 2017; Ndemo & Weiss, 2017). In contrast, the findings from Kikwe and Ubiri illustrate a *slow* and *subtle* process of digitisation of rural farming lives. Strikingly, while the landscape mapping identified 108 digital apps, only a handful of farmers in the study were aware of a single digitisation in agriculture tool, and even fewer had used one. A similar observation has been made by Ouma and Mann (2021), who have reflected on their research examining data-driven digitisation in agriculture:

“You may assume that a radical transformation is occurring in rural areas and that Kenyan smallholder farmers are enthusiastically adopting digital applications and platforms en masse. However, adoption remains slow and unenthusiastic”.

This depiction resonates with this project's findings, which illustrate the complexities of the multilayered digital realities of rural Tanzanian farming communities (Chapters 6 and 7). Notably, the findings also demonstrate farmers' active role and agency in shaping local manifestations of

digitisation. Digitisation in agriculture is not happening to farmers in Kikwe and Ubiri; they are actively shaping the digitally enabled practices embedded in their everyday lives and farming.

In the following sections, I reflect on how the findings from the ethnographically informed qualitative fieldwork with two rural farming communities in Tanzania lend insightful perspectives to existing knowledge and debates – with farmers at the centre.

9.3.1. Navigating Digital Realities of the Less Connected

Adding to previous research about the mobile phone practices of the *less connected* (De Lanerolle et al., 2017), this study has built on and added to existing knowledge through insights about the nuances that shape digital realities and practices of communities at the margin (e.g. Blumenstock & Eagle, 2012; De Lanerolle et al., 2017; Medhi et al., 2011; Steinke et al., 2024; Wesolowski et al., 2012; Wyche, 2017; Wyche & Steinfield, 2016; Wyche et al., 2015; Wyche & Olsen, 2018; Wyche et al., 2019).

In response to knowledge gaps about African farmers' digital realities and practices, Chapters 6 and 7 present novel insights about less explored dimensions of how farmers perceive, appropriate, and use mobile phones. For example, the study illustrates how smartphones complement rather than replace the use of basic and feature phone models. The findings also demonstrate how farmers in the study who owned a smartphone were reluctant to bring their smartphones to the field and instead typically used a second, basic device as their “farm phone”. This contrasts with the assumption embedded in the scripts of smartphone apps designed to support farmers while they farm. In addition, the study provides insights into how the social norms governing the use of smartphones differ from well-established shared-use practices that have been well-documented for basic mobile phone devices among less connected communities (De Lanerolle et al., 2017). Examples of other noteworthy contributions include insights into farmers' priorities and perspectives about mobile phone devices and their functions, which reveal that farmers in the study value device characteristics that align with their situated digital realities (e.g. long battery time, strong flashlights and robustness) over smartphones, challenging notions of a universal consensus of what makes a device a “good phone”. Through these nuanced accounts of farmers' relationships to mobile phones, this study contributes novel insights about what technology farmers access, why they value it and how they use it. The study offers additional insights, extends the understanding

of the intricacies of rural digital realities and practices, and complements and expands work that has similarly explored the digital realities and practices of communities at the margin.

This research project also builds on and adds to conceptualisations of digital access (Kleine, 2019; Roberts & Hernandez, 2019, see Chapter 2). Findings from Kikwe and Ubiri exemplify the non-binary nature of digital inclusion, where digital access is often manifested as fluid, dynamic, and on a sliding scale. I have synthesised the findings in a comprehensive Digital Access Matrix (Table 9.1) that outlines the identified context-specific digital access challenges experienced by farmers in the study, ranging from situated expressions of network marginality to socially shaped and gendered social norms around the use of time and space. In addition, the table includes a structured summary of findings about the intentional responses, strategies, and mitigation measures that farmers in the study use to harness the potential of digital technologies amid multiple interlinked digital access barriers.

Table 9.1: Digital Access Matrix^{lxxiv}		
Digital Access Category	Examples of Locally Identified Access Barriers and Challenges	Local Strategies, Responses, Mitigation Measures, Innovative Approaches
Availability E.g. network connectivity, devices, and electricity.	• Unavailable and unreliable network connectivity for internet, calls, and SMS. • Access to functioning handsets (both basic and smart devices). • Limited availability of electricity.	• Identifying local network connectivity “hotspots”. • Utilisation of multiple SIM cards. • Complementary information and communication methods.
Affordability E.g. handsets, airtime and data, keeping a device charged and repairs and maintenance.	• Cost of handset. • Cost of airtime vouchers and bundles. • The expiry time on bundles (the cheapest ones are often only valid for 24 hours). • Cost of charging, e.g., paying to charge the phone at a kiosk or private house or paying a PAYGO solar system or electrical bill.	• Purchasing used or cheaper handsets, e.g., using existing social networks to buy handsets in other parts of the country at a more affordable price. • Shared use practices. • Using partly broken devices. • Switching off a device or data when not actively used. • Frugal airtime and data management (e.g. seldom buying airtime, using data on particular hours when discounted, etc).

Awareness E.g. mobile phone functions, value-added services and digitisation in agriculture applications and services.	• Lack of awareness about smartphone functions and the Internet. • Lack of awareness of available digital services, including formal digital agriculture services.	• Intergenerational peer learning, e.g. young people supporting and sharing awareness within their households. • Informal digital agriculture practices.
Abilities E.g. formal education, literacy, digital literacy, language and diverse abilities.	• Digital literacy challenges. • Literacy challenges for illiterate or semi-illiterate farmers. • Limited ability to access information through formal digital challenges. • Lack of time to develop digital literacy skills. • Limited content in Swahili on digital agriculture tools and the internet.	• Intergenerational peer learning, e.g. young people supporting and sharing awareness within their households. • Informal digital agriculture practices. • Usage patterns and practices are adapted according to language, digital literacy, literacy level, and abilities (e.g., avoiding functions involving written communication). • Re-scripting of technology to align with needs, skills and interests.
Agency E.g., influence on the ability to make decisions, recognition, and influence on knowledge and ways of knowing.	• Limited influence on digital and agricultural policies • Lack of inclusion in the design and roll-out of digitisation in agriculture tools	• Use of digital technologies to maintain and strengthen social networks and knowledge systems (informal digitisation in agriculture practices) • Re-appropriation of mobile phone devices and functions, and use of innovative and frugal practices
Gendered Social Norms on the Use of Time and Space For example, local norms, values, and practices influence how groups and individuals utilise time and space.	• Time poverty impacts the time available to use phones (particularly for women). • Limited places/spaces in the community with solid network connectivity. • Mobile money agents and places to charge mobile phones are far away from some farming households.	• Device-sharing practices within and between households. • Gendered frugal practices, e.g. staying long periods without airtime as a passive user, only receiving calls.

In Section 2.3, I reference Steinke et al. (2024:1), who have rhetorically asked, “What is holding back farmers from seizing the opportunities that come with mobile information services?”. The Digital Access Matrix synthesise findings illustrating that many interrelated factors challenge rural farmers in seizing the opportunities presented by digital technologies. However, it also demonstrates that farmers are already very much seizing the opportunities, just not necessarily in the ways the dominant discourse has conceptualised and imagined the process. This study has

illustrated that farmers use complex, intentional and strategic digital practices that navigate needs, interests and context-specific digital access-related challenges and opportunities.

9.3.2. Reframing Digitisation in Agriculture with Farmers at the Centre

Chapters 6 and 7 demonstrated that rural Tanzanian farmers' digital realities are dynamic and that farmers are adapting and innovating in ways that enable them to utilise mobile phones to meet their needs and interests while facing multiple interrelated digital access barriers. For example, findings suggest that farmers are highly aware of the fluid nature that characterises mobile phone access, use, and ownership in their communities and have developed various frugal and innovative strategies to adapt and mitigate the negative impact through multi-faceted digital access strategies (see Table 9.1).

Despite the crowded digitisation in agriculture landscape identified in Tanzania – only a mere handful of farmers in the study were aware of or had used these digital apps and services. However, farmers in Kikwe and Ubiri were utilising mobile phones in their everyday lives to support their agricultural needs and interests. To conceptualise and recognise these practices, I introduced the concept of *informal digitisation in agriculture practices* in Chapter 7. The perspective recognises that meaningful digitally enabled practices that support farmers do not have to be facilitated through an externally introduced app. It represents and includes the bottom-up, farmer-driven nature of practices that shape if and how farmers use digital technologies to meet their needs and interests and to expand their choices.

The findings suggest that many digital apps offer services that already exist more efficiently - from a farmer's point of view - through farmers' informal digital agriculture practices. This invites us to broaden our perspective on what digitisation in agriculture means and what digitally enabled practices are deemed meaningful within the existing discourse. A comparison between the focus of digital agriculture tools developed for smallholder farmers in Tanzania (Chapter 5) and farmers' informal mobile phone practices in Kikwe and Ubiri (Chapters 6 and 7) illustrates that they are surprisingly closely aligned. Formal digital agriculture tools and informal digital agriculture practices centre around many of the same areas, including information, advice and knowledge exchange, market price information, farm management and value chain linkages that connect stakeholders such as farmers, buyers and agro-dealers. The main difference is that the formal tools

are receiving significant investment and attention, but - based on my data - are having limited impact and utility.

Hampshire et al. (2015) have previously recognised informal mobile health practices in Sub-Saharan Africa. Marginalised groups' informal digital practices may not be valued and recognised by development partners (e.g. government and NGOs) as they diverge from pre-established assumptions about what type of digital technology use could contribute towards development. This illustrates the value of documenting and conceptualising farmers' innovativeness and contributions as a form of legitimacy in the digital agriculture sector. In a recent publication, Steinke et al. (2024:4) have equally highlighted that “*designers of mobile information services may need to minimise, as much as possible, requirements for learning, and prioritise the technologies farmers already use intuitively*”, which aligns with the conclusions and recommendations of this study.

The thesis proposes focusing on *informal digitisation in agriculture practices* as a crucial area for further research. The assumption that farmers already utilise digital technologies as part of their everyday lives and within the boundaries of their situated context, digital realities and existing knowledge systems is well evidenced in this thesis. This underscores the relevance and necessity of this next step for digitisation in agriculture research and literature.

The informal digitisation in agriculture perspective recognises farmers in their roles as (digital) innovators who navigate complex digital access challenges, dynamic agricultural contexts, cultural norms and environmental changes with ingenuity, resourcefulness and originality. It also acknowledges farmers as active knowledge producers, which challenges outdated ideas about information and technology transfer from Global Minority to Global Majority contexts by recognising the innovativeness of Global Majority small-scale farmers.

The informal digitisation in agriculture perspective contrasts the roles commonly scripted for farmers in digitisation in agriculture, where their role is often reduced to passive information recipients. In addition, this framing builds on scholarship that has acknowledged the adaptability, agility, responsiveness and innovation among rural small-scale farmers that navigate highly complex and changing agricultural landscapes (e.g. Mortimore, 1989; Richards, 1985). While this falls outside the scope of this study, exploring how farmers' role as innovators within the context

of digitisation in agriculture can be understood through the lens of diverse innovation frameworks presents a promising direction for further research.

Digital technology will continue to evolve (Akbari & Masiero, 2025), which makes it challenging to respond to with research, practice and policy (Kleine, 2013). This study adds evidence that suggests that farmers will continue to be at the forefront of using innovative methods to make these useful to further the generation of agricultural knowledge and practices. It should be the role of stakeholders involved in digitisation in agriculture, and ICT4D more broadly, to centre farmers - and their choice and agency. This perspective recognises that digitisation in agriculture can be understood as processes that strengthen local farmers and their practices, fostering an enabling environment where farmers can continue to innovate as they negotiate, mediate and re-script technology to fit their situated needs and interests.

9.4. Two Parallel Worlds: (Mis)Matches between the Digitisation in Agriculture Landscape and Farmers' Lived Experiences

Script theory is a useful lens for exploring the digitisation of Tanzanian agriculture (Akrich, 1992; 1994). In Figure 9.2, I have visualised the application of script theory to digitisation in agriculture, building upon Figure 2.2.

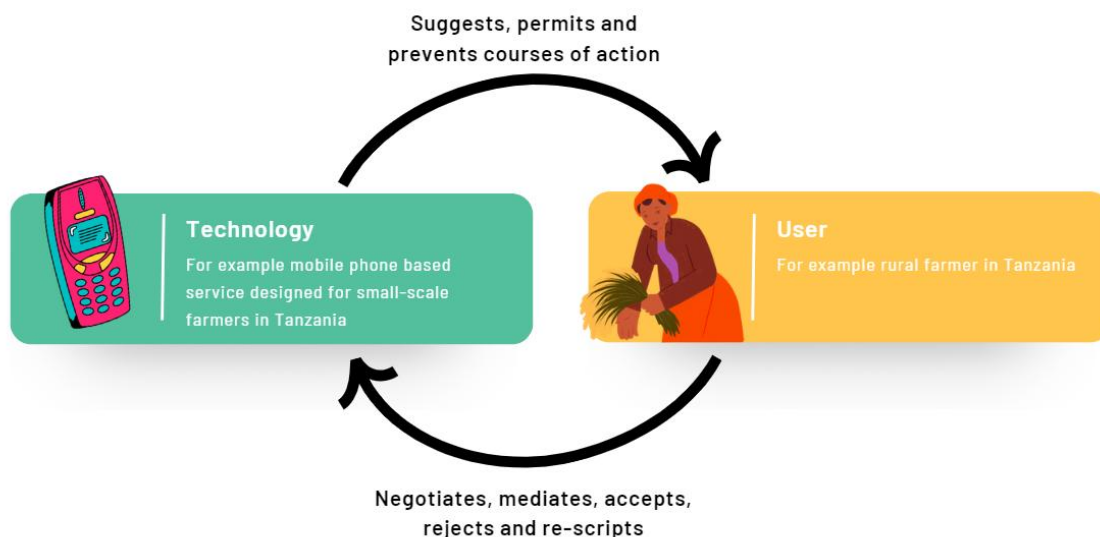


Figure 9.2: An updated visualisation of script theory applied to digitisation in agriculture, by Author.

From a script theory perspective, the design process involved in creating digital tools is interpreted as an intentional process to shape a tool active in constructing its intended users (farmers). Technology is never neutral (Castells, 1996), and by extension, neither is digitisation in agriculture apps. This perspective acknowledges the interests, discourses and biases embedded within digital tools, which aim to shape and incentivise farmers' behaviour and decisions through specific design and content choices. In the context of this study's focus on digitisation in agriculture in Tanzania, examining the specific design choices and content of individual digital tools and trends that emerge from landscape mapping becomes relevant. From the other perspective, as discussed in the previous section, farmers are active in negotiating, mediating, accepting, rejecting and re-scripting technology. By taking a social construction of technology approach (Pinch & Bijker, 1984), this study argues that farmers' interaction with digital tools must be understood as a process where farmers interpret, mediate, negotiate, resist or accept its script in light of their existing lived experiences, situated knowledge and practical realities (Akrich, 1992; 1994; Rose et al., 2018).

Against that background, I now proceed to discuss the manifestation of design-reality gaps (Heeks, 2002) between scripted assumptions about farmers' digital realities and local knowledge systems in Tanzanian digitisation in agriculture tools, contrasted with the findings from Kikwe and Ubiri. As noted in Section 2.4, the design-reality gap (Heeks, 2002) has been widely applied in ICT4D research to examine the (mis)alignment between design assumptions and on-the-ground realities, and its links to ICT4D failure. In the following two sub-sections, I contribute towards this body of literature by exemplifying and analysing two ways in which design-reality gaps manifest in the context of digitisation in agriculture in Tanzania, drawing on script theory and the concept of choice. First, I discuss how the trends from the extensive landscape mapping reveal patterns that suggest certain assumptions about Tanzanian farmers' digital realities. Second, I focus on how farmers (and, by extension, their knowledge and ways of doing and knowing) are framed in digitisation in agriculture tools, revealing the assumptions of app developers.

9.4.1. Design-Reality Gaps: Farmers' Digital Realities and Practices

In this section, I explore and exemplify the nuances of (mis)alignments between the imagined reality scripted into digitisation in agriculture tools and the findings from Kikwe and Ubiri. By observing the basic design of digital agriculture tools through a choice and script theory lens, this study has exemplified how a technology solution's script has embedded assumptions about the

intended end users (Akrich, 1992;1994). The design process to build a digital tool for farmers involves multiple decisions, which, in the case of digitisation in agriculture, include technology-centred design decisions related to what access points to use (e.g. smartphone or basic phone) and the choices farmers are (implicitly or explicitly) permitted or prevented from making within the boundaries of the technology design and content (Monteiro, 2019; Terceiro, 2023).

From a script theory perspective (Akrich, 1992; 1994), design choices about technology access points are based on assumptions about the end-user's digital realities. When an internet-reliant smartphone-based app is designed, this is a direct result of the designers' assumption that intended users have access to the necessary device, resources (e.g. data bundles) and infrastructure (e.g. electricity access and internet coverage) to access and use the tool.

Chapter 5 shares findings that illustrate how 76% of digitisation in agriculture tools identified in the Tanzania context have farmers as (one of) the primary target groups. The data also shows that 47% of identified tools require users to access a smartphone and the Internet. However, the landscape mapping also identified 9% of tools designed to enable access on different devices (online and offline), and 22% of the identified digital tools are offline solutions accessible through any mobile device. These findings mirror the literature, which has similarly indicated that current digitisation in agriculture solutions targeting farmers in the Majority of the World predominantly focuses on mobile phones – and specifically smartphones - as an access point (e.g. Ayim et al., 2022; Steinke et al., 2024).

The focus on smartphone-based solutions for farmers in Tanzania echoes enthusiastic framings in the dominant ICT4D discourse around the opportunities presented by increasing access and use of mobile broadband and internet-enabled devices in Global Majority contexts. For example, the GSMA's annual The State of Mobile Internet Connectivity Report for 2024 (Shanahan & Bahia, 2024) presents data that states that 57% of the global population uses mobile internet access from privately owned devices and that 96% of the global population lives in places with mobile broadband connectivity available.

Against this background, the findings presented in Chapters 6 and 7 and further unpacked in Section 9.3, about farmers' digital realities, are particularly interesting as they shed light on the nuances of the roles of mobile phones in farmers' daily lives in two rural farming communities.

These findings, which suggest a low smartphone penetration in the two rural farming communities, reveal glaring design-reality gaps in the landscape. These findings spark critical questions about the growing enthusiasm around the proliferation of smartphone access and use in Sub-Saharan Africa, which has been a recurring theme for over a decade in ICT4D literature (see, e.g. GSMA 2012; Molapo & Densmore, 2015).

In 2013, Wyche & Murphy used findings from Kenya to motivate a digital solutions agenda where the design aligned closer with the digital realities on the ground, including limited electricity access, low-end devices, and sub-optimal devices. The findings from this study illustrate that their call remains relevant more than a decade later, according to the opinions of the rural Tanzanian farmers who participated in defining the design characteristics of a good mobile phone.

9.4.2. Design Reality Gaps: Farmers' Local Knowledge Systems and Practices

The digitisation in agriculture mapping found that 76% of identified digital tools had farmers as (one of) their intended target groups (see Chapter 5). In addition, the data from the mapping of 108 identified digitisation in agriculture initiatives illustrate a focus on information dissemination, advisory services and decision-support tools. Interpreting these findings in tandem with the emphasis on farmers as the intended users of these services suggests that a dominant discourse (re)produces an information deficit model logic that frames farmers as information-poor.

The information deficit model typically assumes that non-elite groups are in a knowledge and information deficit without adequately addressing or acknowledging structural marginalisation, including socioeconomic, geographical, cultural, and racial factors. Such a framing moves the focus away from the multiple interconnected layers of marginalisation that many small-scale farmers in Tanzania are subjected to. Historically, farmers who do not adopt and implement expert advice have typically been framed as expressing irrational behaviour (Kristensen & Jakobsen, 2011). The information deficit model logic has been widely criticised, and Kristensen & Jakobsen (2011:3) argue that if “criticism of the knowledge-deficit model is accepted, it is easier to accept that farmers may disagree with experts and their science-based recommendations for numerous other reasons than lack of knowledge.” Findings from Kikwe and Ubiri suggest that farmers' behaviour and choices should be interpreted as rational behaviour based on farmers' unique situation, values, interests, and what else is going on in the farmers' lives at the time, e.g. environmental factors, weather, available financial resources, mood, and previous experiences,

impact which choices the farmers see as possible. This mirrors existing research (e.g., Dadzie et al., 2022; Liu, 2024) highlighting the interconnected and various social, cultural and economic factors influencing and shaping farmers' choices, decision-making and behaviour.

The mapping of Tanzania's digitisation in agriculture landscape illustrates that assumptions underpinning an information deficit model continue to influence the logic behind one-way, top-down approaches of information diffusion more broadly, but also influence many models of digital agriculture services that seek to address perceived information deficits despite widespread criticism of the approach. As demonstrated through the example of market price information services, there is a strong narrative inscribed in digital agriculture services in Tanzania that implies that farmers are not maximising their profits, adapting to the negative impacts of climate change, using the latest innovations, or adhering to a specific global best practice because of a lack of information. The narrative scripted into the basic structure behind market price information dissemination assumes that Tanzanian small-scale farmers' market-related challenges are related to an information deficit, overlooking the structurally disadvantageous neoliberal market system influenced by modernisation discourses (Bezner Kerr, 2023). The information deficit framing, by extension, suggests that if farmers maximise the use of (formal) market price information, they can sell their produce at a profit. This simplified logic does not match the practical realities of farmers in Ubiri and Kikwe. Farmers in these communities already use informal digitisation in agriculture practices to check, verify, and compare market prices (and the prices of inputs). However, despite the widespread access to market price information in the two communities, farmers struggled due to low market prices and high input prices. Findings from this study suggest that it is not a lack of information that is primarily causing farmers' problems, but several interrelated factors that jointly shape patterns of structural marginalisation of smallholder farmers in Tanzania. As mentioned in Chapter 2, Jensen (2007) suggested that fishermen in Kerala, India, accessed market price information via mobile phones, shaping farmers' behaviour and decisions on where to sell and improving their bargaining power. Srinivasan and Burrell (2013) revisited the same fisherman communities and demonstrated that while fishermen were indeed appropriating and mediating mobile phones to meet their needs and interests, their choices of where to sell their fish were rooted in a multiplicity of factors that were not confined to an information deficit.

Similarly, the relative failure to demonstrate the impact and utility of digitisation in agriculture (Kante et al., 2015) is often explained using information-deficit model logic, which frames users' lack of awareness, interest and skills as the problem (Krone et al., 2015; Mercy Corps, 2016). Yet, there has been limited analysis applied to the relationship between (predominantly scientifically based and generalisable) agricultural information disseminated through digital agriculture tools and farmers' situated knowledge (Barrios et al., 2006; Dafoe et al., 2012; Rose et al., 2018; Vanlauwe et al., 2017). This can be contrasted with the high hopes around digital agriculture centred around assumptions that ICTs may provide more effective channels to reach smallholder farmers and also reproduce assumptions that access to 'better' (western) information (through modern technology) leads to 'improved' smallholder farming practices (Aker, 2011).

This study contributes a critical perspective to an already strong evidence base of the harmful impact of the continued reproduction of the information deficit model logic. The assumption that small-scale farmers' challenges and solutions can be attributed to an information deficit is incorrect, simplistic, and harmful, yet continues to be scripted into the design and logic of services, applications, and projects across the digital agriculture landscape. Table 9.2 outlines examples of how the information deficit model logic is embedded in digital agriculture tools in Tanzania.

These findings invite us to rethink and challenge information deficit model assumptions by recognising farmers as knowledgeable and their contexts as characterised by structural marginalisation, which frequently limits farmers' choices and ability to act on information and knowledge. This is rooted in the recognition that many farmers in Global Majority contexts are farming within social, political and economic structures that are not designed to benefit small-scale farmers. Rural small-scale farmers need to be recognised as active knowledge creators and innovators rather than passive information recipients of advice and information. At its core, this discussion is connected to perceptions about what knowledge is and whose knowledge is valued. Here, digitisation in agriculture can (theoretically) play a role in reproducing colonial, racially-charged, gendered and harmful knowledge hierarchies or challenge these same structures.

Table 9.2: Examples of Information Deficit Model Logic Embedded in Digital Agriculture Tools in Tanzania			
Approach and/or function embedded in digitisation in agriculture tools	Imagined trajectory	Examples from Tanzania's digitisation in agriculture landscape.	Information Deficit Model Logic and Assumptions
Pre-packaged information distributed to farmers	Pre-packaged expert knowledge is disseminated to farmers. Farmers accept and trust the information. The information fosters behaviour change.	E.g. Viamo 3-2-1, Akilimo.	A one-size-fits-all approach. Top-down dissemination of information approach
Farmers submit questions or pictures to experts and get advice	Farmers send questions/pictures to experts and seek advice. Experts provide advice tailored to farmers' needs. Farmers accept and trust the advice. The advice fosters behaviour change.	E.g. M-Kilimo.	Farmers will be able to and want to act on advice. Assumes that farmers have an information deficit.
Market price information provision	Farmers seek market price information on digitally-enabled services, providing them with accurate market price information. Farmers accept and trust the service's market price information, fostering behaviour change.	E.g., the TAHA Information System (TIS), the Dairy Farmers Information System (DFIS), M-Kilimo, Tigo Kilimo, and Kilimo Fasta.	Assumes that farmers do not have access to market prices. Assumes that access to information is the bottleneck that keeps farmers from maximising their profitability. Assume that access to market price information will influence farmers' buying and selling behaviour.

9.5. Examining the Choices Digitisation in Agriculture Presents to Farmers

Previous sections of this chapter have discussed how farmers mediate, negotiate, accept and re-script mobile phones to align their use with farmers' (individual and collective) needs and interests (Section 9.3). The chapter has also examined assumptions about farmers and knowledge embedded

in the scripts of the digital tools designed with Tanzanian farmers as the intended users (Section 9.4). In this section, I extend these discussions and examine how ideology shapes the choices digital tools present (and prevent) to Tanzanian farmers (e.g. Castells, 1996; Diaz Andrade & Urquhart, 2012; Kleine, 2009).

I start by reflecting on the findings from this study, followed by an analysis of the potential dual role of digitisation in agriculture in (re)enforcing or challenging dominant discourses about agriculture and development. I then extend the discussion by reflecting on the broader significance of this element of the study and propose a conceptual tool to guide future research that examines ideology in technology in the domain of digitisation in agriculture.

9.5.1. Insights from the Case Studies and Wider Findings

In Chapter 8, I used three digitisation in agriculture initiatives as case studies to analyse how ideology has shaped their scripts and the choices they present to (potential) users. Each digital tool was found to have a script that aligns with a specific ideologically informed solution package for farmers. Although the prescribed models of farming these tools align with are diverse (ranging from input-intensive “modern” farming methods to agroecological practices), they all present commonalities in that these ideologically-charged imaginaries of agriculture are reflected in their design and content. The case studies exemplify scripts that seek to incentivise, influence and encourage farmers to make specific choices, align with certain types of behaviour and, by extension, align with a particular kind of imaginary of what the future of farming should look like.

These case studies illustrate how normative imaginaries of development, progress, and success are embedded in the technical fabric of digitisation in agriculture tools. Drawing on this, I suggest that digitisation in agriculture apps should be recognised as potential instruments for behaviour change that can be (and are being) used in an attempt to shape a specific type of farmer and – by extension – a specific kind of agricultural future aligned with agenda-driven and ideologically grounded interests.

9.5.2. Shaping Choices: Dominant Discourses and Alternative Imaginaries

The data presented in this study suggests that while Tanzania’s digitisation in agriculture landscape includes diversity, it largely conforms to dominant agricultural and development discourses. As further elaborated in Chapter 2, these hegemonic imaginaries of farming futures and development

have historical ties to modernisation theory and ideas around technology and knowledge transfer from Global Minority to Global Majority contexts (Akbari & Masiero, 2025).

From a social constructivist perspective, technologies amplify human intent (Toyama, 2015). This recognition opens up the way to interpret digitisation in agriculture as vessels that amplify (individual and collective) human actors' implicit and explicit political, economic, and ideological interests. Therefore, it is relevant to note what stakeholders are actively funding, designing and deploying digitisation in agriculture in Global Majority contexts. As emphasised by Kleine (2009;181), "If one agrees with the premise that technology is not neutral, then it would seem a logical step to analyse the political and economic agenda behind the technology."

This case study - set in Tanzania - echoes the broader literature (e.g. Hilbeck et al., 2022; Rose et al., 2018) in recognising the presence of both "old" and "new" actors in digitisation in agriculture. Data from the landscape analysis suggests that this country-specific case study aligns with broader trends that have noticed the growing prominence of private sector actors – including multinational corporations from technology and agro-input backgrounds – in funding and implementing digital solutions targeting farmers. The growing and more prominent presence of private sector actors, particularly multinational agricultural and technology companies, not only brings their money to the table but also comes with implicit and explicit commercial interests (Abdulai, 2022; Hilbeck et al., 2022).^{lxxv} For example, policies and projects have been designed to incentivise farmers to use more industrial inputs in line with the imagined trajectory of an African green revolution and commercial interests embedded in the agro-input market (Hepelwa et al., 2013; Ickowitz et al., 2019). This study recognises that digital tools developed for farmers can be another instrument to further industrialised agriculture discourses - or other farming trajectories – by aiming to influence farmers' choices. In addition, although this study does not directly investigate data sovereignty, data governance and data colonialism, further research is needed to examine how the growing private sector presence coupled with big data models have the potential to increase the power and control of large corporations on the expense of marginalised farmers (see, e.g. Canfield & Ntambirweki, 2024; Carbonell, 2016; Montenegro de Wit & Canfield, 2024; Rose & Chilvers, 2018; Wolfert et al., 2017).

This study's findings align with literature that has recognised that digital tools are (potential) vessels for supporting modernisation and industrialisation-driven transformations of Majority

World agriculture in a manner that positions industrialised, large-scale and high-input farming models at the core of imagined trajectories for the future of agriculture. Digitisation in agriculture can reinforce dominant discourses and further cement farmers' lock-in to commercialised and industrialised models of farming (Abdulai, 2022; Hilbeck et al., 2022; Ingram et al., 2022; Ingram & Maye, 2020). This is problematic as path dependency and lock-in to any agricultural trajectory marginalise alternative pathways, discourses and imaginaries of farming futures. If choices are limited – due to a deeply entrenched path dependency – farmers' choice and agency to choose a future they have reason to value is also restricted.

For example, in Chapter 6, I shared findings about how farmers in Kikwe and Ubiri understand, conceptualise, value, and interpret narratives about development, knowledge and agriculture in their local context. In Section 6.2.3, I shared findings from focus group discussions that illustrate how farmers in the study associate “modern”, input-intense, industrialised farming models as directly associated with opportunities for success, progress, wealth and status. At the same time, other agricultural imaginaries (e.g. traditional, organic, small-scale models) were perceived in a more negative light and were, in practice, often used as a plan B. These examples illustrate local manifestations of the hegemony of modernity, which suggests that proponents of an industrialised model of agriculture have been highly successful in painting a clear picture of the type of farming futures farmers can imagine for themselves and aspire towards within the boundaries of a modernity trajectory.

This study does not seek to privilege certain choices over others but centres on farmers' agency and sovereignty to decide their own futures. In line with the conceptualisation of development as the expansion of choice (Kleine, 2013; Sen, 1999), farmers are entitled to exercise their agency to make subjective choices on how to farm. However, there are well-documented negative consequences on ecosystems stemming from the long-term use of chemical inputs (Mandal et al., 2020; Meena et al., 2020). Equally, existing research has shown unfavourable impacts from the introduction of commercialised, industrialised, large-scale models of agriculture on small-scale rural farming communities (Demi & Sicchia, 2021; Giller et al., 2021; Zaehring et al., 2021). From this perspective, the alignment between the hegemony of the agricultural modernisation paradigm (Boogard, 2021:43) and farmers' imaginaries of their farming futures is problematic because it indicates that alternative imaginaries are marginalised and farmers' choices are limited.

These findings suggest that farmers in Kikwe and Ubiri cannot visualise what a “successful” farming future could look like outside of the boundaries of the hegemonic discourse.

From a choice perspective, the role of digitisation in agriculture should be to open up more choices to farmers that enable them to exercise agency and choice. I argue that the role of digitisation in agriculture is not to place judgment or influence farmers' choices on how to farm and why, but to expand their choices as they navigate increasingly complex agricultural landscapes characterised by climate change, rising input costs and digital access challenges. However, the findings from this study suggest that – at present – digitisation in agriculture apps does not frame farmers as the decision-makers positioned to choose if they want to align with “modern”, high input farming methods, agroecological principles, a mix of both, or additional alternative pathways. Instead, the study suggests that tools tend to seek to influence farmers' choices. From this perspective, this study is also relevant to connect to more extensive discussions about the direction of African (and Global) agricultural futures and digital technologies' active role in shaping the trajectory.

Table 9.3: Dimensions of the choice concept applied to Digitisation in Agriculture (Kleine, 2007; 2009; 2019; Sen, 1999)		
Choice dimension	Definition	Application of choice dimensions to digitisation in agriculture
Existence of choice	These are choices that exist within the boundaries of an individual's resources and structural context.	The choices are enabled (and disabled) for intended users (farmers) through the design and content of digitisation in agriculture tools.
Sense of choice	These are choices an individual is aware of and perceives to be attainable given their positionality, context, and life situation.	The choices presented by digitisation in agriculture tools that users (farmers) know and perceive to be attainable given their interpersonal characteristics, digital realities and existing knowledge systems.
Use of choice	The extent to which a person makes a choice.	The extent to which intended users (farmers) exercise choices through the support of digitisation in agriculture tools.
Achievement of choice	Achievement of choice occurs when the outcome of a choice matches what the individual intended to choose.	Intended users (farmers) are able to achieve their intended choices through the use of digitisation in agriculture tools that align with their expressed preferences.

9.5.3. Possibilities for Further Research

In conclusion, this study has used practical examples to illustrate that digitisation in agriculture apps has embedded design intentions - a script - that structures a series of actions and choices that are aligned with ideologically-informed interests of actors with influence over the design process (Akrich, 1992; 1994).

This project complements the literature by critically engaging with commercial and ideological interests and their impact on the design, intent and implementation of digitisation in agriculture tools in Tanzania. By doing so, I have placed the case study (digitisation in agriculture in Tanzania) within the broader context of African agrarian development (Abdulai, 2022; Bates & Block, 2013; Friedmann, 1993) when analysing and framing how digitisation in agriculture's script relates to historical, political, and economic factors and interests that have shaped Tanzania's agricultural sector.

To enable further research to continue to explore this less-examined dimension of digitisation in agriculture, I propose a framework to guide future research. In Table 9.3, I have built upon the conceptualisations of choice that differentiate between the existence of choice, use of choice, and achievement of choice (Alsop & Heinsohn, 2005) and sense of choice (Kleine, 2007) (see Section 2.4.1). By doing so, I am proposing a framework to assess whether digitisation in agriculture tools contributes to farmers' subjectively defined interests and needs (secondary development outcomes) and, ultimately, the expansion of farmers' choices (primary development outcome).

9.6. Conclusion

This chapter discussed and situated the combined findings from this research project within broader academic conversations. I started by reflecting on the findings from the Tanzanian digitisation in agriculture mapping that has catalogued 108 digital tools (see Table 5.1 and Appendix 7). I have suggested that this study, grounded in evidence from the crowded and fragmented landscape in Tanzania, is well-placed to trigger further reflection, research and contemporary reinterpretations of the morphed yet lingering symptoms of *pilotitis*.

I have also discussed how the digitisation in agriculture landscape in Tanzania is not only crowded but also challenging to grasp, learn from and build on. Notably, 64% of the identified digital apps and services are *zombies* that cannot be determined dead or alive. The untapped potential in

learning from and building on these initiatives in the Tanzanian context represents a missed opportunity and a roadblock for meaningful change of structural challenges reproduced in ICT4D.

The chapter also reflected on how the study contributes to expanding the knowledge about how less connected communities at the margin navigate complex, multifaceted digital access barriers by using innovative and resourceful methods and practices. In contrast to the enthusiastic vocabulary that characterises much of mainstream debates about Africa's digital transformation, this in-depth case study of two rural farming communities illustrates how the digital “transformation” for small-scale farmers is a slow and subtle process. In particular, the study expands dominant narratives in the debates by demonstrating farmers' active role in shaping what digitisation in agriculture looks like at the local level. While diverting from mainstream imaginaries of what a digital revolution of the agricultural sector would and should look like, this study has documented and conceptualised the frugal and innovative digitally-enabled practices that farmers are already using as part of their everyday lives to meet their needs and interests within the boundaries of their digital realities.

Contrasting the high number of digital tools developed for Tanzania's agricultural sector, it is noteworthy that most farmers in the research project were unaware of any of these apps and services. I introduce the concept of *informal digitisation in agriculture practices*, which recognises farmers' agency and practices centred on a bottom-up, contextualised, situated use of available ICTs within the boundaries of their digital realities and driven by their interests and needs. I argue that there is an inherent value in documenting and recognising these practices to support the legitimisation of their significance in digitisation in agriculture literature and practice. The study suggests that these findings prompt more research to better understand the phenomena of informal digitisation in agriculture practices, including how actors can support an enabling environment conducive for farmers to continue to be innovative in the appropriation, re-scripting, and mediation of technologies. This re-framing and expansion of the focus of the field of digitisation in agriculture recognises farmers as innovators and active knowledge producers, contrasting dominant trends that typically position and frame farmers as passive recipients of information, advice and, ultimately, development. In contrast, this study has evidenced that farmers in Kikwe and Ubiri actively shape digitisation in agriculture. Rural farmers are not the recipients of digital

agriculture; they are moulding the trajectory and meaning of (informal) digitisation in agriculture in the future.

Limited research has explored and documented the community-based farmer perspective and experiences of the proliferation of digitisation in agriculture. This study has demonstrated misaligned assumptions about rural realities scripted into the design of digital solutions targeting farmers and identified digital apps with a dominant focus on information and advice dissemination, suggesting a pattern that reproduces assumptions of farmers as information-poor. Overall, the chapter has discussed how design choices embody assumptions about farmers, knowledge and knowing and specifically demonstrated the presence of assumptions that frame development challenges as being rooted in farmers' inability to make the “right” decisions (according to subjectively scripted and ideologically influenced definitions) because of a lack of information. This framing overlooks the structural marginalisation that characterises the lived experiences of rural Tanzanian farmers. This study suggests that (much) digitisation in agriculture seeks to shape a particular type of farmer, making specific choices and behaving in a certain way, which, by extension, is part of an agricultural future that serves specific interests.

The chapter concludes that digitisation in agriculture can either be a tool to reinforce dominant discourses about knowledge, development, and agriculture and further cement harmful stereotypes about rural African farmers as information-poor recipients of expert advice or challenge them and open up pathways for expanded choice.

Conclusion

Chapter 10

10.1. Introduction

In drawing this dissertation to a conclusion, this chapter synthesises the findings and contributions of this research project. In doing so, I reflect on the study's relevance to the academic and practical field of digitisation in agriculture and the associated multidisciplinary debates. I start by providing a concise chapter-by-chapter overview of the dissertation. In the subsequent section, I respond to the study's five research questions, grouped under the three research aims. Transitioning to the next section, I discuss and outline this research project's conceptual, empirical and practical contributions and reflect on the scope and boundaries of the study. In the final part, I highlight suggestions for further research before closing the dissertation with final concluding remarks.

10.2. Summary by Chapter

To consolidate the contributions of this study and anchor the conclusion in central themes and key findings across this interdisciplinary research project, I set the tone for the concluding chapter by summarising key elements from each dissertation chapter.

Chapter 1 built a foundation for the thesis by motivating the study's relevance and outlining the research objective, aims and questions that guided the project. In particular, the introduction recognised that there has been a rapid proliferation of digitisation in agriculture initiatives over the past two decades that seek to design and deploy digital solutions to work “better” and “smarter”, particularly in Majority World contexts. With the objective to critically examine the relationship between digitisation in agriculture tools and the digital realities and local knowledge systems they

seek to enter and improve, the introductory chapter specified that the project contributes with an ethnographically informed qualitative case study set in Tanzania.

Chapter 2 situated the research within existing academic discourses and debates. I positioned the empirical and conceptual contributions as tied to digitisation in agriculture, but also recognised the study's interdisciplinary nature. The literature chapter situated the research at the intersection of discourses on development, agriculture, knowledge, and technology and integrated insights from relevant academic debates across diverse fields, including digitisation in agriculture, information and communication technology for development (ICT4D), development studies, science and technology studies (STS), rural livelihoods and multidisciplinary work on knowledge systems.

Against this background, I introduced conceptualisations of choice (Kleine, 2007; 2009; Sen, 1999) as a lens to conceptualise development as the freedom to choose a life one has reason to value. In the context of digitisation in agriculture, this translates to a perspective that views successful digitisation in agriculture as the digitally-enabled expansion of farmers' choices. In addition, the chapter introduced an additional conceptual framing drawing on STS literature (Pinch & Bijker, 1984) and script theory (Akrich, 1992; 1994) as a theoretical framing to unpack if and how ideology is embedded in the scripts of digital applications designed and deployed for farmers in Tanzania. In the context of digitisation in agriculture, a script theory perspective provides a framework for understanding how users (in this case, farmers) accept, mediate, negotiate, reject and re-script digital technology to meet their situated needs and interests. The literature chapter concluded that digitisation in agriculture remains with research gaps and that while this study is limited in scope, it is well-placed to contribute towards and expand ongoing conversations. Specifically, the significance of this study is grounded in its focus on less-researched dimensions related to the interplay between farmers' digital realities, local knowledge systems and ideologically charged digital solutions designed with small-scale rural farmers as the intended users.

Chapter 3 detailed the methodological framework designed and implemented in response to the study's objective, aims and research questions. This study has used an ethnographically inspired and qualitative methodology to meet the objective and aims of the study and answer the research questions. First, I detailed why and how I used a combination of desk research, participant observations and qualitative interviews with key informants and farming communities to gather

data about Tanzania's digitisation in the agriculture landscape over a period spanning from October 2017 until April 2024. Second, the chapter described how I triangulated multiple ethnographically informed and qualitative methods in my fieldwork in two rural farming communities in Lushoto and Meru Districts to understand the nuances and heterogeneity of rural Tanzanian farmers' digital realities and local knowledge systems.

Chapter 4 introduced the case study-specific context: the United Republic of Tanzania. The chapter provided a contextual backdrop to the study by engaging with the historical and contemporary political, economic, and social dynamics that have shaped the intersection of digital technology, knowledge, agriculture and farmers in this specific country context. The chapter provided a situated foundation before the dissertation moved on to delving into the data chapters and analysing key findings.

Chapter 5 illustrated how the global proliferation of digitally enabled tools – such as agro-advisory services, decision support tools, and agricultural extension services - targeting small-scale farmers in the Majority World is playing out in the country-specific context of Tanzania. I presented data that illustrates a crowded and fragmented digitisation in agriculture landscape in Tanzania, with 108 identified digital tools. I shared that although the identified digital applications are diverse, dominant themes illustrate a dominant focus on small-scale farmers as intended end-users, services that seek to disseminate information and advice and designs that require users to access smart devices, internet connectivity and data. The chapter also highlighted findings from the data collection process that illustrate structural challenges attached to obtaining information about the landscape and the individual digital solutions within the ecosystem. These findings suggest that it is difficult for stakeholders in digitisation in agriculture – particularly the imagined end users (Tanzanian farmers) – to use, learn from and further build on the knowledge and experience generated from the significant investments made into digitisation in agriculture in Tanzania.

Chapter 6 complemented the national-level landscape findings presented in Chapter 5 by sharing nuanced insights about the knowledge systems and digital realities based on ethnographically inspired and qualitative data from two rural farming communities. These findings illustrate nuanced and situated intricacies of the socio-technical dynamics between farmers with diverse livelihoods and contexts, knowledge systems, and digital technologies essential to understanding farmers' rural digital realities and provide insights into the layers of digital realities of diverse rural

smallholder farmers living in Tanzania. The insights illustrate complex and multi-faceted knowledge systems characterised by strong community links and reliance on existing social networks. The findings also demonstrate how a blend of community-based actors and external influences shaped many of the farmers' in the study's knowledge systems, agricultural practices, and perceptions about knowledge and knowing. The findings further illustrate that it was common among farmers in the study to have integrated digital technologies into their knowledge systems and practices and that mobile phones played a varying but equally important role across personal (non-agricultural) and agricultural spheres of life.

Chapter 7 added nuance to the findings presented in the preceding chapter by contributing additional perspectives focusing on farmers' digitally-enabled agricultural practices. The chapter provided insights into the lived experiences of diverse farmers in Kikwe and Ubiri who are navigating challenging digital realities while harnessing the potential of mobile phones to strengthen their knowledge systems and meet their interests and needs. The findings suggest minimal awareness and use of formal digital tools designed for small-scale farmers in Kikwe and Ubiri. At the same time, the chapter shared findings that illustrate how farmers in the study used innovation and resourcefulness to utilise existing digital devices – predominantly basic mobile phones and functions and their existing social networks - to carry out many of the tasks, functions and roles that formal digitisation in agriculture applications imagine supporting farmers with. Against this background, I proposed the introduction of the term *informal digitisation in agriculture practices* to recognise and build upon farmers' experiences and methods at the frontline of digitisation in agriculture.

Chapter 8 used three case studies of digital initiatives targeting small-scale farmers in Tanzania to analyse if and how ideology is embedded in the design and content of digitisation in agriculture tools. The chapter exemplified how three diverse case studies demonstrate how discourses around development, modernisation, knowledge and farmers are embedded in digital initiatives for small-scale farmers in Tanzania. By extension, the chapter utilised a script theory perspective to illustrate how embedded ideologies implicitly and explicitly shape technology scripts that seek to influence and shape farmers' behaviour by presenting and framing ideologically charged choices within the technology script. The chapter used a complementary choice perspective, using the three case studies to exemplify how ideological assumptions and interests are scripted into the design and

content, by extension, shaping the choices the digital tool presents (and does not present) to the user.

Chapter 9 analyses the combined relevance of the data shared in Chapters 5 to 8 and uses script theory and choice as conceptual lenses to unpack how ideologically charged assumptions are shaping the way digitisation in agriculture apps and services are being designed and, by extension, the choices they seek to present to farmers. On the contrary, the chapter also unpacks the contributions of this study through the rich accounts of the intricate nuances of digital practices and realities of rural communities at the margin. The chapter discussed the significance and importance of recognising *informal digitisation in agriculture practices* as it represents a shift to a farmer-centred perspective that seeks to enable rural Tanzanian farmers to continue to be at the forefront of innovating and appropriating digital technologies to shape their agricultural futures. The chapter suggests that digitisation in agriculture has the potential to reinforce dominant discourses of development, agriculture and knowledge and further manifest historically anchored narratives around farmers as passive information recipients. On the contrary, digitisation in agriculture can also be reframed as an opportunity to broaden farmers' choices, strengthen their agency as digital innovators and enable them to continue mediating and re-scripting technology to meet their needs and interests in an increasingly dynamic and challenging agricultural sector.

The chapter-by-chapter summary set the stage for the next section, which answers each of the study's research questions.

10.3. Returning to the Research Questions

The objective of this study was to critically examine the relationship between digitisation in agriculture tools and the digital realities and local knowledge systems they seek to enter and improve (see Table 1.1). The objective was operationalised into three research aims (RA1, RA2 and RA3) and five research questions (RQ1a, RQ2b, RQ2a, RQ2b, RQ3), which I respond to in the following three sub-sections.

10.3.1. Research Aim 1: Critically analyse Tanzania's digitisation in agriculture landscape and the digital tools designed for small-scale farmers

The first research aim sought to critically analyse Tanzania's digitisation in agriculture landscape and the digital tools designed for small-scale farmers. The first research question (RQ1a) asks

what past, current and planned digitisation in agriculture tools have been designed for and deployed in Tanzania.

The study has contributed novel insights by compiling a landscape mapping of digitisation in agriculture in Tanzania that is more comprehensive and detailed than previous identified work. The final inventory includes 108 past, current and planned digitisation in agriculture initiatives in Tanzania (see Chapter 5 and the complete inventory in Table 5.1 and Appendix 7). The key defining characteristics of Tanzania's digitisation in agriculture landscape are listed below;

- The digitisation in agriculture landscape in Tanzania is crowded, as evidenced by 108 identified digital apps and services.
- A majority of identified digital tools (76%) have farmers as (one of) the intended user group(s).
- The identified digital apps have a dominant thematic focus on information dissemination, advisory services and decision-support tools (52%). The focus on market price information and market linkages is also significant among the identified digital tools (33%).
- Based on identified evidence, there is limited uptake and impact of digitisation in agriculture apps have been demonstrated in the Tanzanian context.
- The digitisation in agriculture landscape includes diverse stakeholders, including a growing presence of private sector actors, including multinational agriculture and technology companies.
- Identifying, determining the status of, allocating the access point, user testing, and learning about digitisation in agriculture is difficult for individual tools and the ecosystem as a collective.

The second research question (RQ1b) asks ***how embedded ideologies, narratives and assumptions shape the choices digital tools present to Tanzanian farmers.***

By going beyond examining design-reality gaps between digital tools and the lived realities of the farmers they target, this study has unpacked interests, discourses and ideologies that underpin the continued proliferation of digitisation in agriculture in Tanzania and beyond. From a script theory perspective, digitisation in agriculture apps is understood as an instrument for behaviour change, which actors can utilise to incentivise the intended users to align with their ideologically informed

interests. This study has illustrated how embedded ideology can be manifested in both pronounced and less pronounced ways. The research project has illustrated how digital applications are ideologically charged and strategically positioned to further various interests and agendas that can amplify specific agricultural trajectories and ideological pathways. This includes assumptions and framings of farmers and their active or passive roles in processes of choice within the script of a digital tool. The study has also demonstrated how digital tools have embedded assumptions about farmers' digital realities and knowledge systems, as well as subjective interpretations of what successful agriculture and development mean. Examples of explicit ways include digital tools with an outspoken focus on supporting a specific approach to farming - such as industrialised agriculture or agroecology. At the same time, implicit expressions of ideologically shaped choices can be detected in, for example, the framing of farmers' role in the technologies script or the content displayed in the tool. The analysis of the scripts of three individuals' digital agriculture tools in Chapter 8 illustrated that they each align with explicit ideological trajectories. Although different, they all demonstrate that digitisation in agriculture apps —like any technology—can never be neutral (Akrich, 1992;1994).

This study is built on a choice-based definition of development (Kleine, 2009), which is the realm of digitisation in agriculture represents a framing where optimal, meaningful digitisation in agriculture is centred around the aim to expand farmers' choices to live their lives – and farm – in ways they have reason to value (Sen, 1999).

While multiple discourses exist, the findings from this study suggest that dominant modernisation and intensification discourses influence the design and content of digitisation in agriculture apps in Tanzania. This study has illustrated how this hegemony of modernity is mirrored in the dominant discourse that underpins the digitisation of agriculture - including individual digital tools, but equally in rural farmers' perception of farming.

Using choice as a conceptual lens, this thesis has examined the choices digitisation in agriculture tools aims to make for farmers. From this perspective, digital agriculture tools' ability to expand farmers' choices forms the basis for measuring the success of any digitisation in agriculture initiatives.

At its core, digitisation in agriculture can provide Tanzanian farmers with access to more or fewer choices, thereby contributing to expanding or restricting development. Without placing value on any specific agricultural development discourse and instead centring the definition of successful digitisation in agriculture tools around its ability to expand farmers' choices, it opens up new ways of interpreting its contribution and value proposition.

10.3.2. Research Aim 2: Understand Tanzanian rural small-scale farmers' digital realities and local knowledge systems

The study's second aim (RA2) was to understand Tanzanian rural small-scale farmers' digital realities and local knowledge systems. **The project's third research question (RQ2a) asked *how small-scale farmers in Ubiri and Kikwe access, generate, transmit and act upon agricultural knowledge and information.***

The study illustrates how farmers in Kikwe and Ubiri primarily rely on community-based epistemic resources, such as family, household members, neighbours, and community groups. While many respondents have frequent (digitally enabled) interactions with people in other geographical locations, these individuals are typically pre-established actors in their social network rather than new connections. This implies that many farmers in Ubiri and Kikwe interact less frequently with people and institutions outside their immediate local community and pre-existing social networks. These findings illustrate the importance of community-based knowledge sharing and production in farming communities. In addition, the findings demonstrate how actors with a frequent presence in farmers' knowledge systems often play a role that transcends into the realms of both agricultural and personal life and have relationships centred on trust.

Moreover, respondents experience and conceptualise agricultural learning as an embodied, practical process in the field. Farmers in Kikwe and Ubiri predominantly observe and learn agrarian practices, techniques, and knowledge from family members, neighbours and community groups. However, the intergenerational, peer-to-peer knowledge exchange practices and community-based experimental learning that dominated in Kikwe and Ubiri do not necessarily equate to reliance on historically dominating “traditional” and indigenous agricultural knowledge

and practices as they adapt to changing contexts and are influenced by external discourses about agriculture, development and prosperity.

In addition, the data reveal heterogeneity within local perspectives on how knowledge and expertise are valued and perceived by farmers. Narratives and perceptions that centre formal “experts” (representing formal knowledge and institutions) and the recognition of farmers themselves as knowledge holders and producers (representing informal knowledge) co-exist and interconnect. Moreover, farmers in the study illustrate a plurality of views about what constitutes “good agriculture”. While many aligned themselves with “modern”, industrialised and high-input approaches, others used agroecological practices; some farmers in the study combined and blended elements of both to meet different needs. These findings illustrate the complexity of rural farming perceptions and approaches to farming.

While many farmers expressed frustrations with their lived experiences of navigating multiple interlinked layers of structural marginalisation – such as financial poverty, infrastructure marginalisation, lack of access to basic needs and digital access challenges, most farmers in the study did not identify a lack of information and knowledge as one of their primary challenges. This is particularly interesting to note when contrasted with the dominant focus of digitisation in agriculture tools designed for Tanzanian small-holder farmers, which are heavily focused on information and advice dissemination.

The study illustrates the constraints on choice for farmers and the limited utility of increased access to information or advice alone in contexts of marginalisation. Many farmers in the study highlighted that they often could not act on the knowledge and information they already had, such as using the inputs they wanted to use, planting when they tried to grow, and selling when and where they wanted to sell, or new advice or information they obtained. These findings suggest that many of the rural farmers in the study often make decisions whilst facing high levels of uncertainty. As I elaborate more on this in the next section, this study adds to evidence suggesting that less connected populations utilise digital technologies to strengthen their small-scale, close-knit social network and community.

The fourth research question (RQ2b) inquired *how small-scale farmers in Ubiri and Kikwe use, negotiate, assimilate, mediate and re-script digital technologies to meet their needs and interests.*

The study has contributed with nuanced insights about what ICTs farmers in Kikwe and Ubiri use (mainly basic mobile phone models and functions), how farmers relate to and perceive mobile phones and has presented novel findings about the intricate details of ways in which farmers perform re-scripting of mobile phones to meet their needs.

By looking at two rural case study communities in Tanzania, this study has exemplified the non-binary nature of digital access and digital inclusion. Rural farmers – individually and as a group - in Kikwe and Ubiri face multiple, situated and interrelated digital access challenges, including network connectivity, affordability of devices and airtime, gendered social norms and structural affordability barriers that discriminate against rural mobile phone users.

The application of script theory to the case of digitisation in agriculture in Tanzania has illustrated how farmers in Kikwe and Ubiri negotiate, mediate and re-scripting mobile phones. As mobile phones are versatile multi-purpose tools, this study has exemplified ways that rural Tanzanian farmers innovatively utilise predominantly basic – and often suboptimal – mobile phone devices to meet their diverse needs. Many of the most valued mobile phone functions among farmers in the study include the calendar, flashlight and calculator applications available on any mobile device.

While the study found close to non-existent awareness and use of digitisation in agriculture apps, findings show surprising similarities between the imagined functions of these apps and the ways in which farmers are *already* utilising mobile phones. Based on this observation, I have introduced the concept of informal digitisation in agriculture practices, which consists of farmers' intentional and innovative negotiation, mediation and re-scripting of (often basic) mobile phone models and functions to meet their needs and interests within the boundaries of multiple digital access barriers.

The study has demonstrated that farmers use context-relevant, localised innovative methods to use low-tech basic mobile phone functions to meet their interests and needs, actively shaping the manifestation of digitisation in rural agriculture in Tanzania.

10.3.3. Research Aim 3: Understand the relationship between farmers' digital realities and local knowledge systems and digitisation in agriculture tools in Tanzania.

The third and final research aim sought to understand the relationship between farmers' digital realities and local knowledge systems and digitisation in agriculture tools in Tanzania. The project's fifth research question **(RQ3) examined *if and how digitisation in agriculture initiatives (mis) aligns with Tanzanian small-scale farmers' digital realities and local knowledge systems.***

The study has illustrated various ways the crowded landscape of digitisation in agriculture apps is mismatched with the practical realities, local knowledge systems and farmers' roles in agricultural development processes.

First, the study suggests a significant difference between the assumed and actual impact of digitisation on agricultural apps. Contrary to tendencies of techno-optimism in discussions about the opportunities presented by smartphones and the internet, this study provides a sobering example of the slow and subtle nature of digitisation in rural Tanzanian farming communities.

Digitisation in agriculture apps has exploded in Tanzania, as evidenced by this study, which has mapped out a crowded landscape. Yet, the findings illustrate a context where the utility of digital agriculture is unknown, and there is a lack of knowledge about whether and how many people use the 108 identified apps and if it has any impact. In chapter 1, I pointed out that the inherent paradox of continued investment in digitisation in agriculture despite limited evidence of its impact and utility raises questions about the motives and interests that underpin the continued funding, implementation and promotion of digitisation in agriculture solutions in Sub-Saharan Africa. The political economy of international development - which extends far beyond digital agriculture – has anchored deep-seated structures and associated incentive structures that drive development stakeholders to operate in ways that are inherently unsustainable – e.g. short funding cycles, per diem culture, expectations of quick and easily measurable impact, premiering new innovation over sustainability, and competition rather than collaboration. This study has illustrated that the digitisation in agriculture landscape in Tanzania is an example of, and the result of, international

development structures and processes that incentivise particular ways of “doing development”. This study seeks to contribute towards future trajectories that position farmers to be able to navigate the agricultural sector on their terms, and the findings suggest that it is not only individual projects and initiatives that are misaligned with farmers' needs and wants. The findings from this study suggest that one of many interlinked factors relates to the potential role of digital agriculture apps to be utilised as tools to “produce” a specific type of farmer who makes particular choices that align with (dominant) ideological, political and economic interests of NGOs, private sector actors and government stakeholders. This study suggests that structural changes are needed to allow for the plurality of development discourses to present real choices to farmers.

In addition, the study suggests that there is a mismatch between the assumptions scripted into apps and farmers' and extension agents' lived realities. When we look at how farmers are actually using their phones, it stands in great contrast to the imagined trajectory of digital agriculture. The apps are often not working (they are designed for a phone model many farmers do not have, and do not consider digital access challenges at the local level), and because they offer services that already exist in more efficient form in real life (informal digital agriculture practices). This opens up reflections around whether there are tendencies for digital solutions to be designed and deployed based on the interests and needs of donors and funders, who are footing the bill and are thereby the “clients” whose needs they cater to, rather than the needs, interests and realities of rural farmers. Meanwhile, farmers have already developed informal digital agriculture practices, in which they use phones holistically (not just for specific apps) to strengthen their already established agricultural knowledge practices and networks, which have received little to no attention in the digital agriculture sector.

There is a broad academic consensus regarding the urgency of identifying and adapting sustainable agrarian solutions on the African continent. Recognising the innovativeness and agency of rural smallholder farmers strengthens the perspective that digitisation in agriculture could benefit from having farmers at the centre. In addition, farmers' heterogeneity is reflected in the data as farmers are diverse and value and rank mobile phone types and functionalities differently. Findings similarly suggest that striving to own, access and use a smartphone is not universally applicable to all farmers. While some farmers strive to own and use smartphones, others have other priorities and aspirations.

However, all respondents in this study recognised the incompatibility of smartphones and the farm environment. Farmers identified good phones as devices with strong flashlights and long batteries suitable for the context in which they spend their everyday lives. The study has illustrated that rural access and ownership of devices are complex. Farmers use various methods and sharing practices to navigate challenges, including using others' devices, inserting SIM cards in others' phones, and borrowing more advanced phones. Smartphones are not replacing basic phones - they are being used in a complementary manner. Farmers in the study typically did not use their smartphones in the field. Social norms around device sharing practices differ depending on the device type, related to elements of privacy, value of the device, and status.

Finally, the study has looked at particular aspects of how trajectories of digitisation in agriculture play out in farmers' lives using the example of market price information services. The study has illustrated that information deficit logics are embedded in the design of digital agricultural tools. This study suggests that digital agriculture tools are positioned to reproduce or challenge historical patterns of epistemic injustice inflicted on small-scale farmers' ways of knowing and doing.

10.4. Contributions

This interdisciplinary research project has sought to build on and further extend scholarship on digitisation in agriculture. In the following sections, I reflect on the conceptual, empirical and practical contributions this research has offered to the academic and practical field of digitisation in agriculture.

10.4.1. An In-depth Empirical Case Study of the Practical Manifestation of Digitisation in Agriculture in a Country Context

A central contribution is the in-depth account of the practical manifestation of digitisation in agriculture – from contrasting perspectives – in a country-specific context. First, the case study, using a script theory and choice lens, contributes with nuanced insights and learnings about how multiple interlinked factors have shaped multifaceted design-reality gaps in the context of Tanzania. For example, a prominent example of deep-seated discrepancies that emerged from the data includes gaps between the perception of digitally empowered farmers as enabled through "formal" digital applications, and the more prominent role of innovative informal digitisation in agriculture practices by farmers in Kikwe and Ubiri. An additional example is the clash between mainstream perceptions and assumptions around what a good mobile phone is – that typically

favours smartphones, and the much more complex factors that influenced why and how farmers in Kikwe and Ubiri dominantly valued durable, simple and functional basic device models that align with their situated and context-specific needs and preferences.

Secondly, the empirical contribution embodied by the inventory of 108 digital apps and services designed for and implemented in Tanzania can be used to spark critical debates and build on future research. The mapping of Tanzania's digitisation in agriculture landscape exemplifies a morphed version of the once well-debated topic of pilotitis. This research project sets itself apart and is a unique case of identifying such a high number of digitisation in agriculture tools in one country's context. This study presents an opportunity, as the data has the potential to trigger debates about foundational elements of ICT4D, just like a visualised mapping of Uganda's pilotitis-infested digital health space did 15 years ago (Otto et al., 2015). The overcrowded, fragmented, donor-driven digital health landscape in Uganda ignited a spark that was the catalyst for the term pilotitis and associated debates around ICT4D sustainability, interoperability, donor coordination, local ownership and best practices in digital development. Indirect ripple effects included the USAID-led launch of the Principles for Digital Development in 2016, which sought to unite donors, implementors, the private sector and governments around common best practices. Against this background, the findings from this study, which bear striking resemblances with the core problems identified in Uganda's mHealth space in 2010, have the potential to re-ignite discussions about how ICT4D as a sector can and should do better. Despite the academic debates, conference side-tracks and joint principles that has emerged since Uganda 2010, Tanzania's digitisation in agricultural landscape presents a sobering example of a contemporary crowded and fragmented landscape where foundational elements of ICT4D that are widely supported (on paper) by ICT4D academics and practitioners - such as building based on what is already there, embracing interoperability and collaboration, building for sustainability, local ownership and designing with the users - are not reflected in practice.

10.4.2. Expanding Knowledge about the Digital Realities and Practices of Rural Farmers at the Margin

The detailed and nuanced accounts of farmers' diverse lived experiences contribute to the literature on digitisation in agriculture by illustrating context-specific and situated design-reality gaps between digital tools and the digital realities they seek to enter. While various perspectives explore

the digital realities of *less connected* communities, this study has contributed additional value through nuanced qualitative data that recognises the intricacies of farmers' lived realities in two rural wards in Tanzania.

The findings presented in this study contribute towards closing knowledge gaps in the broader digitisation in agriculture and ICT4D literature by engaging with nuances and intricacies of what it means to be digitally included, which are often ignored, neglected, unseen or treated as peripheral in debates about the intersection between digital development and rural livelihoods. The study is building on and adding to conceptualising digital access for marginalised communities – multi-faceted, not to be understood as binary, fluid, gendered and everchanging.

10.4.3. Adding to Literature that Recognises the Role of Farmers as Innovators

The study contributes to reframing digitisation in agriculture by introducing the concept of *informal digitisation in agriculture practices*. The findings in this study extend the scholarly narrative of continuous innovation among farmers, challenging outdated assumptions that farmers - and their knowledge and practices - are static and resistant to change. Dominant international development discourses typically fail to align with this more dynamic narrative around farmers in the Majority of the World. The findings I have presented and analysed in this study add empirical and conceptual contributions that address the dissonance between how farmers in general – and African rural farmers in particular - have historically been framed and the innovative ways farmers in Ubiri and Kikwe harness the potential of mobile phones. Against this background, this dissertation has contributed towards widening the conceptualisation of African rural smallholder farmers within the digitisation in agriculture literature. This study highlights further research opportunities to explore and conceptualise digitisation in agriculture models and approaches that centre farmers' local innovation and practices. This study's findings add to current debates by unpacking mismatches between digital technology's imagined and actual roles in farmers' lives. Based on the findings, this study suggests that rural small-scale farmers must be recognised as active knowledge creators and innovators.

The conclusions of this study add to a long history of academic literature highlighting farmers' contributions as proactive, intentional innovators (e.g. Feierman, 1990; Mortimore, 1989; Richards, 1985). In the context of digital agriculture in Tanzania, this study illustrates how farmers

- as innovators - navigate, conform, reject and rescript the script of digital agriculture tools and digital technology in general. By doing so, this dissertation contributes to existing debates around digital agriculture by challenging assumptions about farmers' roles in utilising emerging technologies and innovation in agricultural practices - exploring nuances around the nexus between digital technologies (mobile phones) and rural African farmers' practices, behaviour and choices.

10.4.3. Practical Contributions

Based on the conceptual and empirical contributions, the study offers practical recommendations for future digitisation in agriculture research and practice. In Table 10.1, I have listed key findings from the survey and corresponding practical implications and recommendations for future digitisation in agriculture research and practice.

In addition, the digitisation in agriculture landscape inventory compiled for Tanzania can be built on – and is available online to anyone, with clear links to the sources, so future mappings do not have to start from scratch (see Appendix 7).

Table 10.1: Practical Relevance of Findings about Farmers' Digital Realities and Knowledge Systems for Digitisation in Agriculture Research and Practice	
Finding(s)	Practical Implications
Farmers in Kikwe and Ubiri predominantly use basic and feature phone devices. Owning, using and accessing smartphones and the Internet were rare in the case study communities.	These findings re-emphasise the need for digitisation in agriculture to align any initiatives closer with the digital realities of the intended end-users. Mainly related to smartphones, it is important to unpack the nuances of how these devices are being (and not being) perceived and used and the ways they complement rather than replace the use of basic mobile phone devices.
Regardless of the device used, farmers in Kikwe and Ubiri predominantly use basic mobile phone functions. The study found limited awareness and skills in using more advanced functions on smart devices.	Ownership and (shared) use of smartphones cannot be equated with the skills, awareness and aspiration to utilise smartphones and the Internet in ways that mirror other situated contexts (e.g. urban localities, Global Minority contexts). Digitisation in agriculture initiatives should seek to support farmers in identifying ways that smartphones can (potentially) support their needs and interests and seek to strengthen such practices.

Farmers' ownership and access status to specific devices and SIM cards are fluid and frequently change.	The empirical data prompts the need to consider these fluid access and ownership patterns when designing, implementing and evaluating digital agriculture tools.
Factors such as limited awareness, digital literacy, literacy, and diverse abilities (e.g. eyesight problems) impact farmers' ability to fully utilise mobile phones, including basic functions.	There is significant room for further research and practice to explore pathways to support an enabling environment for rural small-holder farmers to access and use mobile phones.
Many farmers use sub-optimal devices, characterised by, for example, broken screens, faulty batteries, and buttons without characters on them. In addition, many farmers use low-end (often Chinese) brands, which come with quality challenges.	Initiatives seeking to support farmers through mobile phone-based apps and services must understand, respond to and design solutions adapted to the multifaceted digital access challenges that characterise the digital realities of rural small-holder farmers.
Farmers' definition of a "good phone" is diverse, and not everyone strives to own a smartphone. For devices meeting farmers' needs in the field, they emphasise durability, strong flashlight(s), dust- and water resistance and long battery life as essential characteristics of an ideal device.	Digital development trajectories in rural Africa (and elsewhere) are not necessarily a linear process that mirrors other contexts (e.g. urban or Minority World contexts). The situated realities of rural communities at the margins influence and shape the characteristics that farmers value in a mobile phone device and its functions. Not everyone strives to own a smartphone.
Smartphones are not replacing basic phones - farmers with smartphone access are using them complementarily.	Basic mobile phone devices remain a key resource and highly valued asset for rural small-holder farmers. This must be recognised by actors making design decisions within the sphere of digitisation in agriculture.
Many farmers perceive smartphones as incompatible with farm environments due to the exposure to rain and mud and the perceived risks of dropping the device. Therefore, many farmers who access and own smartphones do not bring their smart devices to their farms.	Digitisation in agriculture apps designed for farmers must seek to recognise, respond to and design for local smartphone perceptions and practices that shape where, when and how a smartphone is used.
Social norms around device sharing are different for basic devices and smartphones. Farmers are less likely to share smartphones to the extent that shared access practices have been found to do so by existing literature.	Despite significant research evidencing shared use practices of basic mobile phone devices among less connected communities, these practices cannot be generalised to smartphones. Additional research is needed to unpack these dynamics further.
Farmers primarily rely on community-based epistemic resources, e.g. family, household members, neighbours, community groups and other actors in their social networks. Digitally-enabled communication pathways are integrated into how farmers communicate with key actors in their knowledge systems. These actors typically exist in both their agricultural and non-agricultural lives.	These findings are of broader relevance for digitisation in agriculture as they speak to the nature and dynamics of the epistemic resources that farmers rely on and typically trust, and which likely shape farmers' expectations and preferences when seeking advice and deciding what information to trust (e.g. through digitisation in agriculture service).
Farmers in Kikwe and Ubiri interact less frequently with external actors outside their local community and pre-existing social networks.	The importance of the personal connection for trust.

Farmers pre-dominantly conceptualise agricultural learning as an embodied, physical experience happening in the field. A key component here is learning by doing, experimentation, observing what works, and building trust in practices over time.	Digitisation in agriculture initiatives that seek to support farmers' agricultural learning should seek to support and build upon local ways of doing and knowing. Further research should explore how digital technologies can further support farmers' embodied learning, experimentation and innovation.
Farmers use a combination of epistemologies. The strong presence of intergenerational, peer-based learning does not equate to relying on "old" knowledge. Still, they engage with sub-sets of "traditional" knowledge, which changes over time with the influence of external discourses such as modernisation and industrialisation, combined with their trial-and-error practices and practical experimentation.	
The data reveal heterogeneity within local perspectives on how knowledge and expertise are valued and perceived by farmers. Recognising farmers as knowledge holders and gaining value from engaging with formal "experts" are complementary and compatible components of farmers' knowledge systems.	Digitisation in agriculture should recognise farmers as knowledge holders and creators and actively seek to utilise approaches that are not confined to reproducing outdated information deficit model logic.
Farmers use <i>informal digitisation in agriculture</i> practices to meet their needs and interests within the boundaries of multi-layered digital access barriers. Many of these practices are closely aligned with the dominant focus areas of apps and services developed with farmers as imagined users.	Digitisation in agriculture should seek to build on and strengthen local <i>informal digitisation in agriculture practices</i> .

10.4.4. Recommendations for Further Research

My empirical findings and documentation of informal digital agriculture practices and what devices and functions farmers value are areas of academic inquiry that have received limited attention. Exploring and further understanding the *informal digitisation in agriculture practices* of individuals and communities at the margin. Such research could, with benefit, include components that examine pathways of digitisation in agriculture discourse to strengthen these practices and enable farmers to continue to innovate as digital technologies and agricultural contexts change. Relevant theoretical questions to guide further research suggestively explore how farmers' informal digitisation in agriculture practices, while resisting information deficit-based theoretical approaches and assumptions, and recognising the agency, knowledge and resourcefulness of farmers.

The recognition of farmers as active knowledge producers, as opposed to the roles as passive recipients of information that they are frequently reduced to in the scripts of digital tools, offers opportunities for further research. While this goes beyond the scope of this research project, future research further exploring this avenue will benefit from acknowledging the diversity of conceptualisations of innovation. While Western conceptualisation of what innovation is and how it happens dominates, the literature equally includes indigenous and local innovation frameworks. I invite further exploration into innovation models that build on my findings. This research gap - further unpacking pathways for locally-led digitisation in agriculture innovation - goes beyond this project's scope. Therefore, determining which innovation frameworks would be suitable is equally beyond my scope. However, I hope that further research would consider building on decolonial discourses and inclusive innovation frameworks (see, e.g. Khene & Masiero, 2022; Jimenez et al., 2022).

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Appendix 1: Data Points and Categories for Digital Agriculture Inventory

Data point/ category	Description & Coding Criteria
Name	The official name of the digital agriculture tool, or as referred to in identified data.
Short Description	A summary of the digital agriculture tool, based on information from identified data
Aim	The digital agriculture tools aim, based on information from identified data
Status	The status of the DA tool is coded into three categories Active: The collected data clearly indicates an active status through an updated website, available and updated access points, published reports, articles, or updated social media accounts in the past six months (from March 2024). Digital agriculture tools where stakeholders confirmed that the service was active were also coded into this category. This study differentiates between an operational and active digital agriculture tool, as digital agriculture tools (e.g., a mobile app) may be launched and remain operational without active use and implementation. Unconfirmed: The collected data was insufficient to determine the digital agriculture tool's status. This category includes, e.g., digital agriculture tools that have access points and/or websites without recent activity or that were wholly or partly not functional, DA tools that were functional but no data was identified confirming active use, implementation, or formal closing of activities or where data was insufficient to determine the status. Closed: Collected data confirmed that the digital agriculture tool was officially closed, e.g., a clearly stated project period or final reporting. Where data was available, digital agriculture tools' start/launch and end/closing dates were included.
Target Group (Categories are not mutually exclusive; one digital agriculture tool can be applied to several categories).	The digital agriculture tools imagined end-users coded based on information from identified data. The data was coded into 15 categories: 1. Farmers 2. Extension workers 3. Pastoralists 4. Traders, retailers, buyers, and/or middlemen 5. Agri-businesses and/or startups 6. Agro-input stakeholders (dealers, companies, producers, suppliers) 7. Stakeholders working with farmers (companies, NGOs, cooperatives, etc.) 8. Financial institutions 9. Consumers 10. Government and policymakers 11. Regulators 12. Researchers 13. Investors 14. Landowners and managers 15. Insufficient data to code
Geographical Focus	Based on information from the identified data. The data was coded into six categories: 1. National (Tanzania) 2. Specific region(s) and/or district(s) in Tanzania 3. Multiple Countries (in Africa) 4. Multiple Countries (multiple continents) 5. Global 6. Insufficient data to categorise
Service Access Point	The digital agriculture tools' access point. Where identified, the link to the access point was included in the inventory. Several identified digital agriculture tools have multiple access points (e.g., web, smartphone, and USSD); in some cases, only one out of multiple were identified.
Technology Focus	The digital agriculture tool uses digital technologies based on information in identified data, such as web-based and smartphone applications, IVR, USSD, or drones.
Thematic Focus and Functions	No pre-defined categories were used. Based on the identified data, the core thematic focus of the digital agriculture tools was documented. Identified digital agriculture tools were then categorised into twelve categories; 1. Advisory service, information service, decision support tool 2. Market price information, market linkages 3. Agro-input related functions 4. Agricultural financial services

	5. Farm - and/or Land Management and Land Use 6. Procurement, Business- and supply chain management 7. Pests and disease identification, mitigation, and response 8. Participatory development and/or research 9. Precision agriculture 10. Weather forecast information 11. Transparent value chains 12. Agricultural trade management and/or administration Categories are not mutually exclusive; one DA tool can be applied to several categories.
User Statistics, Impact and/or Results	Key statistics or data on the use, uptake, impact, and results were documented based on identified data (where available).
Access Costs	The digital agriculture tool's access costs are based on identified data and/or user testing. Costs were defined as direct fees and indirect costs related to specific devices, data, and other requirements to use various digital agriculture tools.
Implementing Partners	The implementing partners of the digital agriculture tool, based on the identified data.
Funders	The funders of the digital agriculture tool, based on the identified data.
Language(s)	The language(s) available to users of the digital agriculture tool are based on identified data and (where available) user testing.

Appendix 2: Summary of Reported Results from 41 Identified Digital Agriculture Tools in Tanzania

AfriScout	35000+ AfriScout registered users, 9000+ user submitted grazing alerts
Agripath Project (Farmbetter App)	30,000 farmer users (50% women)
Dairy Farmers Information System (DFIS)	Approximately 2000 dairy farmer users
Digital Inputs Financing Toolkit (DIFT)	10,929 farmers reached, 530 registered for a crop investment plan, 338 input packages sold, 406 farmers saved and paid on the service
Digital Mobile Africa	6688 farmers registered
AfriScout	35000+ AfriScout registered users, 9000+ user submitted grazing alerts
East Africa Fruits	10,000 registered farmers
E- License application for Exporters of Agri-products and Agricultural ERP	135 active users
eHakiki	35,000 farmer users
EMA-i	728 users
Esoko	1 million farmers reached in Africa, 32 million SMS and voice messages sent, 450 000 call services at call centres
GeoFarmer	A pilot in Tanzania registered 956 farmers for a demographic survey and geo-referenced 670 field observations
GreenFingers Mobile	12,000 farmers, 60,000 commercial transactions
iCow	1.6 farmers were reached in Kenya, but no available data for Tanzania. 4.6 million SMS sent.
Ilovu Sugar	8,000 outgrower farmers
Iringa – Mitigation, Adaptation, Productivity for Climate Smart Agriculture (IMAP4CSA)	10,119 plots were mapped, 22 952 digital messages were sent to 11,964 farmers, and 11,565 farmers were trained.
KilimoKlub	200,000 users
Kuza One	Network of 750,000 farmers, 5000+ youth agripreneurs
MAMIS (Mviwata Agriculture Market Information System)	51 893 messages were received and sent between September 2010 and April 2016. 1938 requests on market information in 2018.
Metajua	24,900 farmers in Tanzania connected
Mobile Agricultural Extension Tool	23 farmer facilitators trained and given smartphones
Mobile Application to Secure Tenure (MAST)	97,779 customary land documents provided, 74 villages set up land registrars, 69 land use plans (2021)
M-Kilimo	5,544,421 Household Heads had been registered on the M-Kilimo, a total of 17,906 consultations with farmers (total for all 5,544,421 registered farmers. (January 2022)
mFarming (mKilimo)	4 million farmer users across East Africa
mKulima	1.3 million users registered
Mkulima Hub	29,851 farmers digitally registered and linked to 31 input suppliers, 48 market off-takers and four financial institutions.
MyAgro	200,000 farmers served, \$252 increased annual income per farmer
MyPhoneExplorer	Bulk SMSs to 2500 farmers, quality of milk improved
Ninayo	Network of 40,000 farmers
Plantix	More than 15 million downloads (according to their website accessed 2022-02-24) globally
Plantvillage Nuru App	Downloaded more than 1000 times (2020)
SAGCOT Integrated Knowledge and Information for Agriculture (SIKIA)	Reached 125,000 farmers
SmartFarmer	15,000 active users and 300,000 registered users
Starfish Mobile	2 million subscribers (for all services, not only agriculture)
Tigo Kilimo	400,000 registered users in 2014 (10% estimated to be active)
Tigo Korosho	350,000 farmers registered for payments
Tumaini App	5000 downloads
Ubia Soko	10,000 farmers registered
UPTAKE (Upscaling Technologies in Agriculture through Knowledge Extension)	3.8 million SMS were distributed to 55,000 farmers.
Ushauri	300 users
Viamo Platform	12 million subscriber base. 35 million messages were sent in East Africa.
SAGCOT Integrated Knowledge and Information for Agriculture (SIKIA)	Reached 125,000 farmers
SmartFarmer	15,000 active users and 300,000 registered users
Starfish Mobile	2 million subscribers (for all services, not only agriculture)

WeFarm	The WeFarm SMS platform has had 2.4 million farmers registered and facilitated 37 million conversations between farmers.
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Appendix 3: Research Participants in Stakeholder Interviews

Code	Research participant (anonymised)
A1	Digital Innovation Consultant
A2	Research Director, Ministry of Agriculture
A3	Researchers, State University of Zanzibar/Tanzania Flying Labs
A4	Programme Manager, Sida/Embassy of Sweden
A5	Director, Viamo
A6	Board Member, BuniHub
A7	Director of Marketing, Ministry of Agriculture
A8	Regional Agricultural Officer, Ministry of Health, Tanga
A9	Ward Agricultural Extension Officer, Lushoto
A10	Ward Agricultural Extension Officer, Meru
A11	Programme Manager, Tanzania Horticulture Association (TAHA) Arusha
A12	Programme Manager, Anzia Sokoni
A13	Researcher, LandPKS
A14	Researcher, LandPKS
A15	Researcher, Tanzania Agricultural Research Institute (TARI) Mlangano
A16	Programme Manager, Tanzania Horticulture Association (TAHA) Zanzibar
A17	Director, IITA
A18	Extension officer, Ministry of Health Muheza
A19	Extension officer, Ministry of Health Muheza
A20	Extension officer, Ministry of Health Muheza
A21	Extension officer, Ministry of Health Lushoto

Appendix 4: Interview Themes & Guides

Visit 1: Interview Themes		
Farming methods and practices	Farm and household work	Material Assets
Farm type and size	Land ownership	Sources of Income
Crop types	Farming knowledge	Free time
Agricultural inputs	Animal husbandry	Personal Interests
Soil and land management	Family	Household composition

Visit 2: Interview Themes	
Moment of happiness & aspirations	Farmers Knowledge Systems
Exemplifying agricultural practices and challenges	Soil and Land Management
Creating, sharing, accessing and using agricultural knowledge and advice	Media Usage & Information and Communication Usage Charts (including use of ICTs)

Visit 3 Interview Themes		
Ownership of device	Agricultural use	Costs attached to use
Cost of device	Functions, applications and services	Current balance
Individual and shared use	Internet (non-)use	Current and average use of airtime and/or data bundle

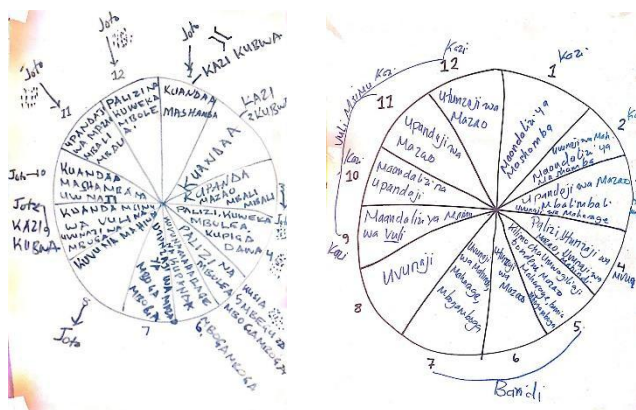
Appendix 5: Focus Group Discussions

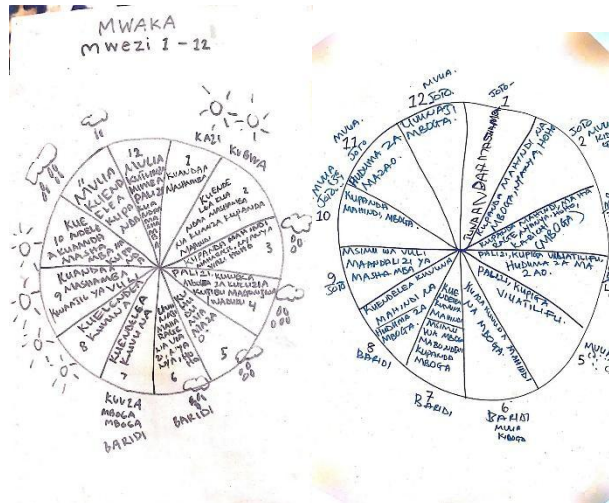
Focus Group Overview			
FGD	Theme(s)	Participants	Location
1-4	Community Defined Wealth Ranking, Crop Calendar, Community Mapping	Local leaders, ward extension officers, farmers	Ubiri Ward
5	Resource Portfolio Mapping	Young women	Ubiri Ward
6	Resource Portfolio Mapping	Men, mixed ages	Ubiri Ward
7	Community mapping, good farming	Young women	Ubiri Ward
8	Resource Portfolio Mapping	Young men	Ubiri Ward
9	Resource Portfolio Mapping	Women, mixed ages	Ubiri Ward
10	Mobile Phone Access and Use	Male youth, one older man and one middle-aged woman	Ubiri Ward
11	Mobile Phone Access and Use	Youth, mixed gender	Ubiri Ward
12	Soil and Land Mapping	Mixed ages and gender	Ubiri Ward
13	Community Defined Wealth Ranking, Crop Calendar, Community Mapping	Local leaders, ward extension officer, farmers	Kikwe Ward
14	Community Defined Wealth Ranking, Crop Calendar, Community Mapping	Local leaders	Kikwe Ward
15	Resource Portfolio Mapping	Women, mixed ages (savings group)	Kikwe Ward
16	Mobile Phone Access and Use	Women, mixed ages (savings group)	Kikwe Ward
17	Mobile Phone Access and Use	Young women	Kikwe Ward
18	Mobile Phone Access and Use	Mixed ages and gender	Kikwe Ward
19	Resource Portfolio Mapping	Men, mixed ages	Kikwe Ward
20	Mobile Phone Access and Use	Mixed ages and gender	Kikwe Ward
21	Soil and Land Mapping	Mixed ages and gender	Kikwe Ward
22	Soil and Land Mapping	Mixed ages and gender	Kikwe Ward

A community-defined wealth category exercise was conducted during six FGDs. Participants discussed and defined what four categories - *tajiri* (rich), *wastani* (average), *maskini* (poor) and *maskini sana* (very poor) - meant to them and in their specific context. The discussion was to be centred around the participants' village, and the goal was not that it would resonate with the whole ward, District, or Tanzania as a whole. Participants were encouraged to consider economic or material wealth factors as markers of wealth and leave the definition open to participants. Wealth categories are often three-fold, including *rich*, *average*, and *poor*. In this case, I included four categories by adding a category for the *very poor*. Distinguishing between poor and very poor contributed to a richer and more nuanced discussion, resulting in a better-refined sampling framework.

Crop Calendar

Each group participated in an exercise that mapped and discussed farming practices and methods, crop types, planting, harvesting, climate, and weather patterns. A simple visualisation of a year in the form of a circle with a section marked out for each month was used. Participants were given free hands to draw, write, and use post-its. The exercise was explained to the participants, and prompting questions were used if the conversation stalled. However, in all four cases, the discussions were vibrant and passionate and required little intervention from the researcher. The crop calendar exercise resulted in discussions around what farmers in that specific village grow, how the climate and weather usually affect farming during different times of the year, and when the year farmers do different types of tasks (planting, weeding, harvesting, selling) and if and when during the year farmers usually experience economic hardship.





Annual crop calendars created by participants during FGD 1-4, Ubiri Ward, January-February 2021.

Participatory Community Mapping

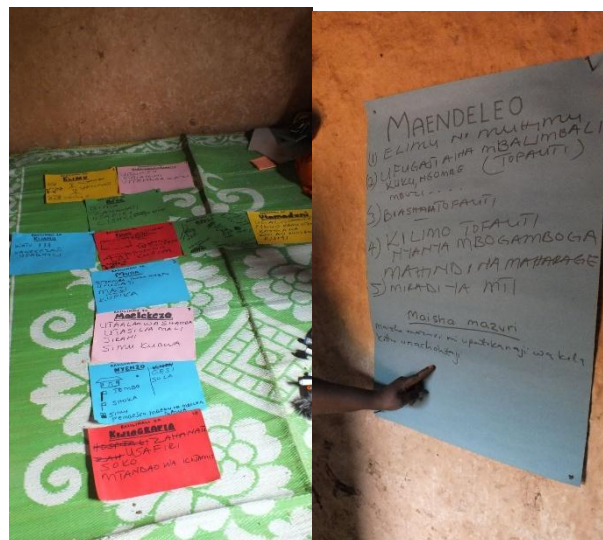
Participants were provided with large papers, and multicolored marker pens. After a short introduction that emphasised that the task was to draw one or several maps of their community, participants were free to organise themselves. Some groups decided to make one map together, while other groups divided themselves into smaller groups and produced up to three maps of the village. After the participants agreed that the maps were complete, the groups presented the maps and held a joint discussion around them. The participants were all given the maps after the FGDs, and several were hung in village offices or private homes. The exercise was participant-led, but prompting, clarifying, and follow-up questions were asked when needed. The participatory mapping exercise helped build an understanding of gendered structures, use of time and space, accessibility of services, farming practices, land management, and farmers' knowledge systems. The data gathered showed similarities and differences between the different villages in the ward and how different farmer groups interpreted and navigated these spaces.

been collected during other FGDs, interviews, participant observations, farm visits, and informal conversations.

Resource Portfolio Mapping

The FGDs had two distinct purposes. First, for participants to discuss and define what development means to them. The study strongly connects to the development concept and defines development based on Amartya Sen's (1999) capabilities approach (CA). This study aims to understand and use a farmer-centred definition of development, where "successful" digital agriculture is defined based on the ability to enable farmers to live lives they choose to value as per their definitions. Development is thereby understood as having both primary outcomes in the form of increased *choice*, and secondary outcomes, which each person defines based on what he or she values doing and being. During FGDs, the participants were given a large piece of paper and multi-coloured marker pens and asked to discuss, write, or draw what they considered to be development. When they finished that task, they were also asked to discuss what it means to have a good life.

Secondly, FGD participants defined, visualised, and mapped their resource portfolios, drawing on the Choice Framework (CF) (Kleine, 2013). The CF is a tool that can be used to develop a holistic - yet particular to that specific point in time - visualisation of a context framed around "the systematic relationship between agency, structure and choice" (Kleine 2019:4). The CF makes it possible to analyse which parts of a system that may need to change for positive development to occur. The CF breaks down the agency element of the framework into eleven resource categories; material, financial, natural, geographical, psychological, cultural, social, and educational resources, health, time and information resources.



Visuals created with young women during FGD on resource portfolio mapping which participants have ranked according to perceived importance and defining what development means, March 2021.



Examples of how participants visualised different resource categories (from the top left showing Education, Social Capital, Health, Economic, Material and Natural resources).

The CF sees agency and structure as constantly co-created. This FGD tool was designed with the purpose of understanding what different farmers' resource portfolios look like, and aimed to do so using a farmer-centred and farmer-led approach. However, as Kleine (2019) has pointed out, it can be challenging to apply the CF in a “concrete fieldwork context” (Kleine 2019:2). In her doctoral research with young girls in Nairobi, Kenya Ronda Zelezny-Green developed visualisations for each of the 11 resources. Accounting for the fact that interpretations of visuals are often not homogenous, but can vary depending on a person's culture, frame of reference and lived experiences, Zelezny-Green developed a card for each of the resources using input from both the girls and staff at their school, assuring that the were cultural and place specific visualisations of the resources. Zelezny-Green subsequently used the pictogram to discuss the girls' resource portfolios during FGDs (Kleine, 2019).

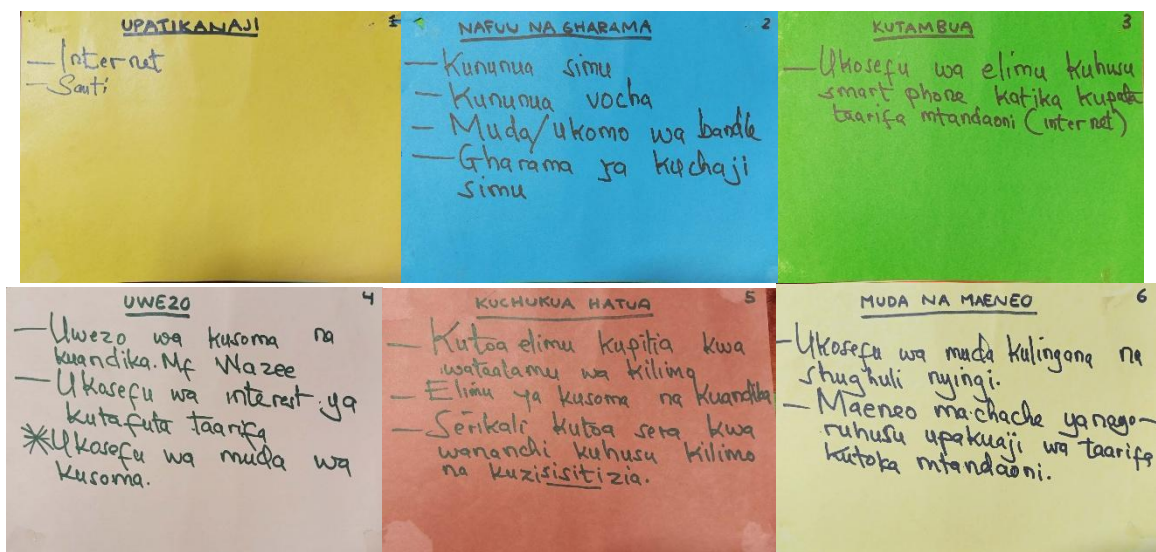
Zelezny-Green developed visualisations of resource categories prior to the FGD, and used the finalised visualisations as visual support tools during the FGDs. In this study, the process of developing the visualisations was instead placed at the centre of the methodology. Eleven papers had been prepared with the title of the resource category (in Swahili), and were presented to the FGD participants one at a time. For each of the resource categories the group discussed, defined and jointly decided what that specific resource category means to them in their context. A number of prompting questions had been prepared for each category in case the discussion stalled. When the same procedure had been repeated for all the eleven categories, participants were asked to rank the resource categories according to their importance, followed by a discussion around why they had ranked them in that particular way. While the final visualisations are useful data, so was the discussions and interactions involved in the process of making the visualisation. As the research was conducted with and about farmers, which is a wide category, the use of this method with groups representing different gender and age categories was a very useful approach to understanding the varying resource portfolios - and by extension agency - amongst different groups of farmers in the same community.

Mobile Phone Access Mapping

This method was used to explore and understand how the multifaceted and non-binary dimensions and nuances of *technology access and use* - specifically mobile phones and the internet - were manifested in a specific farming context. First, participants were asked to discuss if, how, and why mobile phones and the internet were important to them. A large paper and markers were provided to participants, and the discussion spanned using mobile phones for *personal*, *agricultural*, and *business* purposes. These three categories were selected based on data collected through interviews, farm visits, and participant observations, which indicated that these were the three main areas of mobile phones and the internet used by farmers.

The second part of the FGDs explored how different dimensions of *access and use of ICTs* were manifested within a specific context. The tool drew on several conceptualisations of the concept of technology access. Firstly, Gerster and Zimmermann (2003) understand technology access through three sub-categories: availability, affordability and capabilities. Secondly, Roberts and Hernandez (2019) frames and understands technology access using a framework of 5 A's - availability, affordability, awareness, abilities and agency. Third, Kleine (2009) emphasises the importance of acknowledging and understanding how gendered social norms and the use of time and space impacts technology access. Drawing on these conceptualisations, participants were asked to discuss the context-specific challenges to mobile phone and internet access and use based on six categories which were introduced to them one by one. The exercise was participant-led, but the facilitator introduced each category. An important part of the practical use of the tool was to let participants identify, define, and describe what each category meant in their context. Therefore, the introductions to each category were kept brief. Pre-defined prompting questions for each category were used in case the conversation stalled. The six categories that were discussed included:

1. *Upatikanaji* (Availability) - e.g., the availability of network connectivity, mobile and internet services, and content.
2. *Nafuu na Gharama* (Affordability) - e.g., affordability of owning and using different devices and services.
3. *Kutambua* (Awareness) - e.g., awareness of the different functions of a device, mobile, and internet services.
4. *Uwezo* (Abilities) - e.g., ability to use different devices and services.
5. *Kuchukua hatua* (Agency) - aspects related to e.g., age, gender, positionality, and education.
6. *Muda na Maeneo* (Time and Place) - considering social norms and gendered use of time and space.



Outputs from one of the FGDs on mobile phone and internet use and access, April 2021.

Appendix 6: Recent Mappings of Tanzanias Digital Landscape

Publication	Focus	Authors/ Publishers	Number of Identified tools	Comments	Year of Publication
Scaling up Farmer Financing through AgTechs in Sub-Saharan Africa	Mapping of AgTech related to farming financing in Côte d'Ivoire, Ghana, Kenya, Nigeria, Senegal, Tanzania, and Uganda.	IFC	217 tools accross the seven countries, 37 operational in Tanzania	Presents the results of the mapping, but does not share names, references, links or other details about the identified DA tools in Tanzania, beyond the five that have a head quarter in Tanzania (only the name of the tool is shared).	2024
The Digitisation of African Agriculture Report 2018 - 2019	Reports on the status of digitisation in agriculture in Africa	Tsan et al.	Identified 390 active digitisation in agriculture tools in Africa.	The report mentions several tools designed for and deployed in Tanzania.	2019
Digital agriculture country study Annex: Tanzania	Aims to map the digital agriculture ecosystem in Tanzania	CCARDESA, World Bank, IMC Worldwide	20 tools run by private sector).	Identified 27 active tools. Includes a table with the name, implementing partner, description and status. No links to references or websites for specific tools were provided, making it challenging to trace some of the mentioned DA tools.	2021/ 2022
Digital Agriculture Ecosystem Assessment: Tanzania	A digital agriculture ecosystem analysis	USAID, DAI, the AgTech Network	Mentions mapping 50 DA tools, mentions some of their names and provides links to 6 of them.	Developed with the aim to be a useful tool for DA practitioners and stakeholders. Developed a database with 50 identified DA tools. The data base is not linked or shared in the report, and I have not been able to find it online. Refers to the governments intentions to establish central coordination of the digital agriculture space. Does not share access point information (e.g., USSD code, smartphone app links)	2023
Status of digital agriculture in 47 sub-Saharan African countries	Presents conclusions for 47 sub-saharan African countries digital agriculture readiness.	FAO	Mentions six (unnamed) digital agriculture services identified by GSMAs mAgri tracker.	Highlights the need for a central database to unpack the DA landscape in Africa	2021
Aligning digitalization with agroecological principles to support a transformation agenda	Einstein Center Digital Future (ECDF)	A working paper using Tanzanias digital agriculture landscape as a case study	Drawing on preliminary results from my PhD research, the report mapped 94 DA tools	The presented DA tools all have links	2022
Digital Technology and Services for Sustainable Agriculture in Tanzania: A Literature Review	Thematic focus on sustainability	A literature review focused on digital agriculture in Tanzania	Identifies 8 DA tools	The literature review provides links to academic research papers where they were identified, but not to project websites or access points	2022

Mobile Landscape Analysis: Tanzania	CABI	An analysis of the	Identified 10 DA tools and implementing stakeholders in the DA landscape	The identified DA tools are mentioned by name but no direct linking to their access points or further information	2017
Digital Agriculture Maps 2020 State of the Sector in Low and Middle-Income Countries	GSMA	A mapping of the state of digital agriculture in LMICs	More than 700 active DA tools tracked accross Low and Middle Income Countries. Close to half of the tracked DA tools are available in 5 countries, of which Tanzania is one. 28 DA tools mapped in Tanzania.	The names of many identified DA tools are mentioned, but not in a organised manner or with attached links to access points, more information or documentation.	2020
GSMA Digital Agriculture Maps	GSMA	An online tracking tool for digital agriculture	Identified 28 DA tools in Tanzania. Users can select countries or regions to see specific statistics.	The number of services in the 2024 online digital map is identical with the 2020 published report, indicating that the tracking tool has not been updated the last four years and holds outdated information. No names or links to the DA tools in each country/region is available to users limiting the usefulness.	2024
Digitally Enabled Agriculture: A landscape study of digital advisory models for smallholder farmers in East Africa	A landscape analysis of digital agriculture in Kenya, Tanzania, Uganda and Rwanda	Gatsby Africa	146 DA tools in East Africa and 21.8 million users. 60 DA tools in Tanzania.	The DA tools were not named and linked.	2022
Digitalizing the African livestock sector:	GIZ	A landscaping report focusing on digitisation and livestock farming in Africa	Identified 20 DA tools that have a focus on livestock in Tanzania	Findings presented in the form of case studies, some with links to the implementors website	2024
Agricultural “plaforms” in a digital era	ISF, Feed the Future, MasterCard Foundation, Rural and Agricultural Finance Learning Lab	An analysis of the role of platforms in the DA landscape	2-5 digital agriculture platforms in Tanzania	The DA platforms are not named or linked	2021

Appendix 7: Tanzania's Digitisation in Agriculture Inventory Resource Bank

Full inventory available online:

<https://docs.google.com/spreadsheets/d/1CUe8uaMvxJTnnMsNx2Gh2hB9DxwtPxYqkbn64xEbW3U/edit?gid=1215030329#gid=1215030329>

1	AfriFARM	• https://globalcommunities.org/our-work/sustainable-development/resilience/food-security-agriculture/ • https://globalcommunities.org/annual_reports/annual-report-2019-global-stories-tanzania/ • https://kilimo.go.tz/highlights/view/afriFarm-waja-na-teknolojia-ya-kupambana-na-kiwawijeshi-vamizi • https://www.thecitizen.co.tz/tanzania/news/business/mobile-phone-applications-seek-to-revolutionize-tanzania-agriculture-2694070 • https://www.pciglobal.org/fall-armyworm/ • https://www.feedthefuture.gov/article/usaids-announces-winners-of-the-feed-the-future-fall-armyworm-tech-prize/ • https://foundationfar.org/programs/fall-armyworm-tech-prize/ • https://www.invasive-species.org/wp-content/uploads/sites/2/2019/02/FAW-Evidence-Note-October-2018.pdf
2	AfriScout	• https://www.pciglobal.org/afriScout/ • https://www.thecitizen.co.tz/tanzania/news/business/mobile-phone-applications-seek-to-revolutionize-tanzania-agriculture-2694070 • https://www.giz.de/de/downloads/giz2021-en-digitalizing-the-African-livestock-sector.pdf (p. 29)
3	Afya ya Mnyama Digital Limited	• www.amdl.co.tz • https://www.linkedin.com/in/afya-ya-mnyama-digital-2a40992a4/?originalSubdomain=tz
4	Agriculture Dashboard System/ Kilimo Dashboard	• https://www.kilimo.go.tz/stakeholders/view/kilimo-dashboard • http://kds.kilimo.go.tz/ (not functional) • https://iks.kilimo.go.tz/#/
5	Agriculture Trade Management Information System (ATMIS)	• https://atmis.kilimo.go.tz/atmis/tz/co/infowise/amis4t/home/homeuc.jsf • https://www.kilimo.go.tz/stakeholders/view/agriculture-trade-management-information-system-atmis • https://www.sciencedirect.com/science/article/pii/S277237552300206X
6	AgriManagr	• https://www.virtualcity.co.ke/our-products/agriManagr/ • https://www.f6s.com/agriManagr • https://measict.weebly.com/uploads/3/2/4/3/3243215/agriManagr_supply_chain_managment_tablet-smartphone.pdf • https://www.marketlinks.org/sites/default/files/resource/files/FACET ICT-enabled%20Outgrowing%20Operations %20Highlights%20from%20Africa.pdf • https://www.gsma.com/mobilefordevelopment/resources/bringing-efficiency-to-kenyas-dairy-value-chain-virtual-citys-agriManagr/ • https://www.slideshare.net/VirtualCityKe/agriManagr-39098395 • https://documents1.worldbank.org/curated/zh/167301467999716265/pdf/96226-REVISED-WP-PUBLIC-Box391469B-Mobile-Applications-for-ARD-v8S-Complete.pdf • https://nextbillion.net/news/acumen-fund-invests-in-virtual-city-to-automate-agricultural-supply-chains-in-east-africa-and/ • http://measict.weebly.com/uploads/3/2/4/3/3243215/agriManagr_supply_chain_managment_tablet-smartphone.pdf • http://webfoundation.org/docs/2016/12/WF-RN-Open-Data-and-Transparent-Value-Chains-in-Agri_Update.pdf

7	AgriPath Project (Farmbetter App)	• https://www.agripath.net/ • https://www.farmbetter.io/ • https://play.google.com/store/apps/details?id=io.farmbetter (link to application on main website - not functional) • https://play.google.com/store/search?q=farmbetter&c=apps&hl=en&gl=US (link to application in blogpost on website - functional) • giz2023-en-i4Ag-agripath.pdf • https://kilimotrust.org/agripath-project/#:~:text=Description%3A,Nepal%2C%20India%2C%20and%20Uganda. • https://www.globalresiliencepartnership.org/innovative-tools-for-smallholder-farmers-across-africa-and-asia/ • https://www.cde.unibe.ch/research/projects/agripath_sustainable_agriculture_through_effective_and_efficient_digital_pathways/index_eng.html • https://www.wocat.net/en/global-slm-database/ • https://foodtank.com/news/2023/04/agripath-working-to-benefit-women-and-youth-smallholders-in-sub-saharan-africa-and-asia/ • https://grameenfoundation.org/stories/press-releases/digital-advisory-services-for-smallholder-families-in-africa-and-asia • https://www.cgjar.org/news-events/news/just-launched-the-cgiar-user-research-toolkit/
8	AgriTechs	• http://www.agritechs.co.tz/ (does not work) • https://www.linkedin.com/company/agritechs/about/ • https://www.facebook.com/agritechstz/ • https://vc4a.com/ventures/agritechs-company-limited/ • https://www.instagram.com/agritechs/ • https://www.f6s.com/agritechs
9	Agricultural Innovation Pilot Project	• (CCARDESA, 2022:17) https://www.ccardesa.org/sites/default/files/knowledge-products/CCARDESA%20Digital%20Agriculture%20County%20Study%20-%20Tanzania.pdf
10	AgroBot	• https://www.f6s.com/agrobotz • www.agrobot.co.tz (inactive) • https://www.youtube.com/watch?v=8p6AeGz69WM • https://www.facebook.com/agrobotz • https://www.mwananchi.co.tz/mw/habari/kitaifa/tanzania-kutumia-tehama-kampuni-za-simu-kutoa-ushauri-wa-kilimo-2984634
11	Alternative Exchange (trading platform) in Eastern and Southern Africa	• (CCARDESA, 2022:17) https://www.ccardesa.org/sites/default/files/knowledge-products/CCARDESA%20Digital%20Agriculture%20County%20Study%20-%20Tanzania.pdf
12	Anzia Sokoni	• https://anzia-sokoni.koeeru.com/about/introduction • Stakeholder interview with representative from Anzia Sokoni • Stakeholder interview with extension worker that was trained to use Anzia Sokoni • https://www.jica.go.jp/Resource/tanzania/kiswahili/office/topics/press200909.html
13	Agricultural Routine Data System (ARDS)	• https://ards.kilimo.go.tz/dhis-web-commons/security/login.action • https://www.kilimo.go.tz/stakeholders/view/agricultural-routine-data-system-ards
14	Arifu	• https://www.arifu.com/ • https://www.cabi.org/Uploads/CABI/about-us/Scientists%20output/WP10_mobile_landscapes.pdf • https://www.mercycorps.org/en-gb/what-we-do/ventures/arifu • https://twitter.com/arifucompany?lang=en

15	COSITA/ FARM Africa	● https://www.cabi.org/Uploads/CABI/about-us/Scientists%20output/WP10_mobile_landscapes.pdf ● https://www.farmafrica.org/latest/news/post/809-tanzanian-sesame-farmers-trial-new-training-app-on-their-smartphones
16	Dairy Farmers Information System (DFIS)	● https://assets.publishing.service.gov.uk/media/57a08acbe5274a31e00007a0/Tanga-fresh-AECF-case-study.pdf
17	Digital Inputs Financing Toolkit (DIFT)	● https://agra.org/wp-content/uploads/2020/10/Layaway-for-Agricultural-Inputs-Tanzania.pdf ● https://grameenfoundation.org/stories/press-releases/digital-toolkit-to-give-tanzania-smallholder-farmers-access-to-finance-farm-supplies-and-training ● https://grameenfoundation.org/press-releases/digital-toolkit-give-tanzania-smallholder-farmers-access-finance-farm-supplies-and
18	Digital Mobile Africa	● https://www.uncdf.org/article/5934/uncdf-partners-with-a-digital-platform-to-link-farmers-to-financial-and-agricultural-products-and-services-in-tanzania ● https://www.microcapital.org/microcapital-brief-dma-uncdf-to-connect-farmers-in-tanzania-with-agricultural-inputs-buyers-digital-financial-services/ ● IFC (2024:) https://www.ifc.org/content/dam/ifc/doc/2024/scaling-up-farmer-financing-through-agtechs-in-sub-saharan-africa-ifc-2023.pdf ● https://www.expogr.com/tanzania/foodexpo/detail_news.php?newsid=6037&pageid=2 ● https://www.uncdf.org/article/5934/uncdf-partners-with-a-digital-platform-to-link-farmers-to-financial-and-agricultural-products-and-services-in-tanzania
19	Doctor Kilimo App	● https://apkcombo.com/doctor-kilimo/com.fahamutech.doctorkilimo/ ● https://play.google.com/store/apps/details?id=com.fahamutech.doctorkilimo&ref=apkcombo.com (does not work)
20	East Africa Fruits	● www.eafruits.com ● https://disrupt-africa.com/2020/06/12/how-tanzanian-agri-tech-startup-east-africa-fruits-plans-to-scale-after-3-1m-series-a-round/ (Accessed 06/05/2022) - no longer functioning link)
21	E- License application for Exporters of Agri- products and Agricultural ERP	● (CCARDESA, 2022:17) https://www.ccardesa.org/sites/default/files/knowledge-products/CCARDESA%20Digital%20Agriculture%20County%20Study%20-%20Tanzania.pdf
22	eHakiki	● https://www.ehakiki.com/ ● http://www.ttclhakiki.co.tz/ ● https://agrimark.co.tz/ ● https://www.linkedin.com/company/agrimark/about/ ● https://www.cabi.org/Uploads/CABI/about-us/Scientists%20output/WP10_mobile_landscapes.pdf
23	eKilimo Startup Acceleration Program	● https://ekilimo.saharaventures.com/ ● https://web.facebook.com/ekilimotz/?_rdc=1&_rdt ● https://www.youtube.com/playlist?list=PLhjH9RZ9ccf1vR4SGKLonekXx0HCIFlHK
24	EMA-i	● https://reliefweb.int/report/united-republic-tanzania/using-smartphones-fight-animal-diseases-united-republic-tanzania#:~:text=EMA%2Di%20roll%2Dout%20in,of%20EMA%2Di%20in%202017. ● https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7936506/ ● https://www.fao.org/3/ca7122en/ca7122en.pdf ● https://www.usaid.gov/sites/default/files/2023-05/FAO%20Factsheet%20May%20%202023.pdf ● https://bmcbvetres.biomedcentral.com/articles/10.1186/s12917-021-02789-x

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31	Food Processing Software	• (CCARDESA, 2022:) https://www.ccardesa.org/sites/default/files/knowledge-products/CCARDESA%20Digital%20Agriculture%20County%20Study%20-%20Tanzania.pdf p.18 • https://matrixsoftware.co.za/
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38	iProcure	● https://iprocure.re/ ● https://techfundingnews.com/kenyan-agtech-iprocure-raises-10-2m-to-expand-in-uganda-and-tanzania/ ● https://techfundingnews.com/kenyan-agtech-iprocure-raises-10-2m-to-expand-in-uganda-and-tanzania/ ● https://ftma.org/iprocure-expands-to-tanzania-partners-with-farm-to-market-alliance-to-reach-125k-farmers/ ● https://www.citizen.digital/tech/kenyan-agri-tech-start-up-iprocure-expands-to-tanzania-n320110 ● https://disruptafrica.com/2023/05/19/kenyan-agri-tech-startup-iprocure-expands-to-tanzania/?amp=1 ● https://www.bii.co.uk/en/our-impact/investment/fortem-holdings-limited-iprocure-investment-01/
39	Iringa – Mitigation, Adaptation, Productivity for Climate Smart Agriculture (IMAP4CSA)	● https://www.wehubit.be/en/node/167 ● https://www.wehubit.be/drupal_files/public/2022-08/KilimoTrust_Factsheet_0.pdf ● https://kilimotrust.org/iringa-mitigation-adaptation-productivity-for-climate-smart-agriculture-imap4csa/ ● https://riceforafrica.net/projects/iringa-mitigation-adaptation-productivity-for-climate-smart-agriculture-imap4csa/ ● https://www.facebook.com/KilimoTrust/posts/success-stories-from-beneficiaries-of-the-recently-ended-imap4csa-iringa-project/4002955356482275/
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41	Jembe	● https://jembe.co.tz/
42	JembeKilimo	● (CCARDESA, 2022:20) https://www.ccardesa.org/sites/default/files/knowledge-products/CCARDESA%20Digital%20Agriculture%20County%20Study%20-%20Tanzania.pdf ● https://www.builtinafrica.io/videos/jembe-tanzania-drone-iot ● https://www.facebook.com/agrinotfz/

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49	Kilimo Tanzania	• https://play.google.com/store/apps/details?id=com.xstudios.mjasiriamaliplusapp • https://kilimo-tanzania.en.softonic.com/android
50	Kilimo Guide	• http://kilimoguide.com/ (Not working) • https://www.f6s.com/kilimoguide
51	Kilimo Utabiri	• https://cms.nukta.co.tz/apps-10-za-kilimo-zinazoweza-kuwanufaisha-wakulima-tanzania/ • https://play.google.com/store/apps/details?id=com.cardeanutrition.kilimoutabiri&ref=apkcombo.com (Google Play link not working)
52	Kilimo Biashara	• https://www.kilimobiashara.org/ • https://play.google.com/store/apps/details?id=com.kilimo.mjasiriamali • https://www.facebook.com/www.kilimobiashara.org/ • https://appagg.com/android/education/kilimo-biashara-33599737.html?hl=en
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101	UZA EAC	• https://amea-global.com/wp-content/uploads/2022/04/kilimo-case-study-1-1.pdf • https://uza-eac.en.aptoide.com/app • https://kilimotrust.org/what-is-already-possible-to-enable-cross-border-trade-in-eac/https://kilimotrust.org/what-is-already-possible-to-enable-cross-border-trade-in-eac/
102	Viamo Platform	• https://viamo.io/services/viamo-platform/ • https://www.cabi.org/Uploads/CABI/about-us/Scientists%20output/WP10_mobile_landscapes.pdf
103	WeFarm	• https://about.wefarm.com/ • https://www.fastcompany.com/company/wefarm • https://www.gsma.com/r/wp-content/uploads/2020/10/GSMA-Agritech-Digital-Agriculture-Maps-2020-1.pdf (p.46) • https://dailynews.co.tz/news/2019-06-275d1482799d17f.aspx • https://about.wefarm.com/blog/news-release-11-million-to-expand-into-online • https://agrilinks.org/post/wefarm-connecting-small-scale-farmers-people-and-resources-they-need-be-more-successful
104	weightCAPTURE	• https://www.capturesolutions.com/site/weightcapture/index.html • https://www.ifc.org/content/dam/ifc/doc/2024/scaling-up-farmer-financing-through-agtechs-in-sub-saharan-africa-ifc-2023.pdf • https://www.gsma.com/r/wp-content/uploads/2020/09/Digital-Agriculture-Maps-Summary.pdf • GIZ (2021) Digitalizing the African livestock sector: Status quo and future trends for sustainable value chain development. Available online: https://www.giz.de/de/downloads/giz2021-en-digitalizing-the-African-livestock-sector.pdf (7/3/2024) • https://thedocs.worldbank.org/en/doc/414111556636984882-0090022019/original/CaptureSolutions.pdf • https://www.linkedin.com/posts/capture-solutions-limited_weightcapture-supplychaintransparency-ethicalfarming-activity-7037361590962155521-IIEx/
105	YaraConnect	• https://www.yara.co.tz/ (no information about YaraConnect) • https://play.google.com/store/apps/details?id=com.yara.connect.prod&hl=sw&gl=US (Android) • https://apps.apple.com/in/app/yaraconnect/id1531837503 (iOS) • https://actionafrica.zendesk.com/hc/en-us/articles/360015222340--KE-TZ-GUIDE-I-m-Kenyan-Tanzanian-retailer-what-do-i-have-to-do-to-get-Yara-points • https://web.facebook.com/permalink.php?story_fbid=1335116103580579&id=301435423615324&locale2=ms_MY&paipv=0&eav=AfZTcvUJ7tXl2s4LIBOdghqddsklxJqF8M6W7Nee2vZTB75iEx5vtu2AtRoInSUd2u4&_rdc=1&_rdr • https://web.facebook.com/watch/?v=512786370001722 • https://www.linkedin.com/posts/nikhilramlal_yaraconnect-tanzania-digitaltransformation-activity-6816273617593102337-t9uP/ • https://www.youtube.com/watch?v=aIwHFyDHLI4
106	Yara CheckIt	• https://www.yara.co.tz/crop-nutrition/farmers-toolbox/#:~:text=Yara%20CheckIT%20is%20an%20agricultural,identification%20of%20possible%20nutrient%20deficiencies • https://www.youtube.com/watch?v=-zUw-dAq3s • https://www.youtube.com/watch?v=BB2Rd1d_imw
107	Yara USSD Service	• https://www.cabi.org/Uploads/CABI/about-us/Scientists%20output/WP10_mobile_landscapes.pdf
108	Z Kilimo	• https://jiachie1.rssing.com/chan-7007640/article2101.html?zx=814 • https://www.vsointernational.org/sites/default/files/VSO%20Value%20Chain%20Analysis%20CASH.pdf

		● https://africanfarming.net/technology/infrastructure/tanzanian-farmers-enabled-to-access-agriculture-information ● https://www.facebook.com/ZantelTanzania/posts/the-z-kilimo-service-from-zantel-in-partnership-with-vso-under-umoja-wa-wakulima/760055974034512/?locale=hi_IN ● https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2015/02/GSMA_Case_Tigo_FinalProof02.pdf ● https://journals.sagepub.com/doi/10.1177/0340035220951828 ● https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2014/03/TIGO-Baseline-Report-final.pdf
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Appendix 8: Result Verification Workshop Themes

Agriculture and knowledge	
The village community is important for farmers to access and share agricultural knowledge.	Farmers learn a lot from farming with family and parents throughout their lives.
Neighbours, family, friends and people in the village are very important to farmers; they often meet and share advice and experience.	Farmers' lives are centred around agriculture, and life's agricultural and personal aspects are intertwined and not easily separated.
Farmers like to learn in practical ways. Farmers learn by doing and attribute much of their existing knowledge to years of experience, trial and error and innovation.	Savings, community, and agricultural groups are important in farmers' lives - especially for women.
Farmers have different views on sharing knowledge - some like to share knowledge and advice, and others do not.	People in the village have different types of access to extension officers. Some farmers often meet with the extension officer, while others never meet with the extension officer.
There are not many services available to farmers.	Farmers are very smart and have much farming knowledge, especially about farming in their local environment.
Farmers learn about agriculture in many different ways. Many farmers learn mainly on the farm, not in school.	Farmers think that advice is important. But farmers have many problems, and not all can be solved by getting advice and information only.
Many farmers think the affordability of inputs is a big challenge.	Farmers think that climate change is a big challenge.
Gender perspectives	
Cultural and social rules make women and men use time in different ways, do different work in the house and farm and do different types of business.	Women and men do different types of business.
Farmers, but especially women, do not have much time because they work in the house and on the farm and take care of the family.	Youth have different responsibilities at home and on the farm if they are a male or female.
Because women have a lot of work and not a lot of time, they have less time to use mobile phones.	
Mobile phones	
Mobile phones are very important to farmers.	Farmers think that the most important thing about mobile phones is to stay in contact and communicate with friends and family for personal and social reasons.

Many farmers use mobile phones.	Many farmers use basic mobile phones, and only very few have smartphones.
Most farmers use mobile phones for calling or messages only.	Some farmers with a smartphone or feature phone know how to use the internet, while others just know how to make calls and use it like a basic phone.
Many of the farmers with a smartphone do not like to bring it to the farm, and many have a second basic phone that they bring to the farm.	If a farmer cannot access a mobile phone, he can borrow from a neighbour or family to make a call.
Farmers share basic phones with other people, but smartphones are not shared as much because they are more private than basic phones.	Farmers think a “good phone” is not necessarily a smartphone. Many think “farm-friendly” devices like dust repellent, water resistant, strong flashlight, durable, long battery life are more important than the internet.
The use of new technology - like mobile phones - is not replacing farmers' use of other older technology like radio; farmers use both.	Farmers think mobile phones are important, and they use a lot of money to pay for vouchers, bundles, and charging.
Farmers experience many challenges using mobile phones. Farmers have challenges like the availability of networks, affordability of vouchers and charging, awareness and skills in using a phone, and other challenges.	Farmers use many smart ways to overcome these challenges, such as using multiple SIM cards, turning the phone off when not used, sharing phones, putting your SIM card in someone else's phone and knowing which parts of the village have a good network connection.
Digital agriculture	
Only very few farmers know about and use services for farmers on phones. In my research, I have found over sixty different services ¹ for farmers on small or big phones. But very few farmers know about them or use them.	The farmers who know about m-kilimo are those who have a good relationship with the extension officer. Other farmers do not know what it is or how to use it.
Farmers think that mobiles are very important for agriculture.	Farmers use their phones to communicate with other farmers, buyers, agents, people at the market, to organise transport for produce and many other things. The phone is good for getting advice, finding out market prices, the availability of agricultural inputs and other things.
Some farmers with smartphones or feature phones use social media like Facebook and WhatsApp.	Farmers use their phones in different ways during different seasons. For example during harvest season farmers use their phones a lot.
Development	
Farmers want development and a good life.	Farmers think that development is important, but there are many challenges.
Basic services like roads, electricity and clean water are very important resources.	Money and economy is important for development, but development includes many different parts. Farmers want and need many different resources to get development like health, environment, education, culture, religion, time, material resources, natural resources and many other things.
Agriculture, soil and land	

¹ At the time of the result verification workshops, I had “only” identified sixty digitisation in agriculture apps and services.

Soil and land is very important for farmers.	Farmers think that soil is an important part of their lives - it is the foundation of house building, pottery, agriculture and getting food.
Farmers hold generational knowledge about the soil and land in their areas, and have ways of categorising, caring for and strategically using different types of soil.	Many farmers experience challenges related to soil, and primarily identify industrial fertilisers with chemicals as the solution to the problem.

Appendix 9: Media Usage, Information & Communication Chart and Information and Communication Chart

Unatumia mara ngapi kwa haya matumizi ya kibinafsi na kilimo?

How often do you use these for personal and agriculture purposes?

	Zaidi ya mara moja kwa siku (<1/day)	Mara moja kwa siku (Once a day)	Mara mbili hadi tatu kwa wiki (2-3/week)	Mara moja kwa wiki (1/ week)	Mara mbili hadi tatu kwa mwezi (2-3/month)	Mara moja kwa mwezi (1/month)	Mara mbili hadi tatu kwa mwaka (2-11/year)	Mara moja kwa mwaka (1/year)	Kamwe (Never)
Radio (Radio)									
Ujumbe ya simu (SMS)									
Kupiga simu (Phonecall)									
Facebook (Facebook)									
WhatsApp (WhatsApp)									
Mtandao wa kijamii mingine (Other social media)									
Intaneti (internet)									
Kompyuta (Computer)									
Magazeti (Magazine)									

Mabango ya ushauri (Public notice board)									
Luninga (TV)									
Mpiga mbiu (Public announcement)									
	Zaidi ya mara moja kwa siku (<1/day)	Mara moja kwa siku (Once a day)	Mara mbili hadi tatu kwa wiki (2-3/week)	Mara moja kwa wiki (1/ week)	Mara mbili hadi tatu kwa mwezi (2-3/month)	Mara moja kwa mwezi (1/month)	Mara mbili hadi tatu kwa mwaka (2-11/year)	Mara moja kwa mwaka (1/year)	Kamwe (Never)

Ni mara ngapi unakutana na watu na mashirika yafuatayo kwa madhumuni ya kibinafsi na ya kilimo?

How often do you meet the following people, organisations and institutions for personal and agriculture purposes?

	Zaidi ya mara moja kwa siku (<1/day)	Mara moja kwa siku (Once a day)	Mara mbili hadi tatu kwa wiki (2-3/week)	Mara moja kwa wiki (1/ week)	Mara mbili hadi tatu kwa mwezi (2-3/month)	Mara moja kwa mwezi (1/month)	Mara mbili hadi tatu kwa mwaka (2-11/year)	Mara moja kwa mwaka (1/year)	Kamwe (Never)
Familia (Family)									
Majirani (Neighbours)									
Warafiki ambao ni wakulima (Friends who are farmers)									
Mkutano wa Jamii (Community meetings)									
Kikundi cha wakulima (Farmers group)									
Vikoba au Kikundi Kingine (savings group or other group)									
Maduka ya pembejeo (Agrodealer)									
Wanunuzi (Buyers)									

Wauzaji (Sellers)									
Mabwana Shamba au Afisa ya Ugani (Extension officer)									
Wakala (Agent)									
Kampuni za Vilimo (Agriculture company)									
Serekali za mitaa (Local government)									
Serekali ya taifaa (National government)									
Shirika lisilo la kiserikali (NGO)									
	Zaidi ya mara moja kwa siku (<1/day)	Mara moja kwa siku (Once a day)	Mara mbili hadi tatu kwa wiki (2-3/week)	Mara moja kwa wiki (1/ week)	Mara mbili hadi tatu kwa mwezi (2-3/month)	Mara moja kwa mwezi (1/month)	Mara mbili hadi tatu kwa mwaka (2-11/year)	Mara moja kwa mwaka (1/year)	Kamwe (Never)

Appendix 10: Coding Framework

Theme	Sub-Theme	Example Codes
Farmers' Knowledge Systems	Farming futures	Farming practices, farming priorities, farming aspirations, local definitions of development, visions of prosperity
	Decision-making processes	Risk management, farming priorities, and farming choices
	Farmers knowledge practices	Peer-to-peer advice, expert knowledge, farmers as experts, extension services, intergenerational knowledge practices, gendered knowledge practices
	Farming in practice	Embodied experiences of farming, seasonal farming cycles
Digital Technologies in Farmers' Lives	Roles of mobile phones	Market price information, personal communication, information sharing etc.
	Device use, ownership and preferences	Basic- and smartphone use and aspirations, perceptions of a "good phone"
	Sharing practices	Phone sharing within the household, gendered sharing practices, device sharing between households
Farmers' Digital Realities	Digital access	Availability, Affordability, Accessibility, Awareness, Agency, Gendered Access
	Informal digitisation in agriculture practices	Informal market price information, informal agricultural advice, informal knowledge sharing, other informal digitisation in agriculture practices
Digitisation in Agricultural Landscape	Development narratives (by digitisation in agriculture stakeholders)	Perceptions of agriculture, perceptions of farmers, perceptions of digital technology
	Tool-specific experiences	<i>Codes created for each digitisation in agriculture tool e.g. M-Kilimo, Ugunduzi, Fertilizer Optimizer App</i>
	Digital agriculture landscape	Interoperability, stakeholder collaboration, pilotitis, government ownership
Gender (stand-alone and cross-cutting)	Gendered farming	Gendered use of time and space, gendered farming practices, gendered farming priorities, gendered productive and reproductive responsibilities
	Gendered access to devices	Male vs female ownership, use and control of devices, Male vs female device types, Male vs female use and access of airtime/data

Theoretical lens: Script theory	Intended user script	Target user assumptions, digital reality assumptions, farming preference assumptions, digital literacy assumptions
	Scripted norms, values, narratives, discourses	Agricultural modernisation, market orientation, agroecology, organic agriculture, hybrid farming, industrial inputs
	Design-reality gaps	Practical examples of design-reality gaps from the data
Theoretical lens: Choice	Farmers choices	Existence of choice, sense of choice, use of choice, achievement of choice

Endnotes

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- ⁱ Similar debates have pointed out regarding the *for* in ICT4D (see Akbari & Masiero, 2024; Brown & Grant, 2010). ICT4D positions ICTs as a tool to attain a specific goal - development.
- ⁱⁱ In the Sustainable Development Goals, following the MDGs, the seventeenth goal recognises the private sector as an important partner for the sustainable development agenda.
<https://www.un.org/sustainabledevelopment/globalpartnerships/>
- ⁱⁱⁱ Principles for Digital Development. Website: <https://digitalprinciples.org/> (16 September 2023)
- ^{iv} M-Kilimo and the Fertilizer Optimizer App were tested on previous occasions. Ugunduzi is not (yet) available to the general public, and I only got access to the application in 2024 which is why it was not previously user tested.
- ^v Picture retrieved here: https://commons.wikimedia.org/wiki/File:Tanzania_map-en.svg
- ^{vi} <https://www.parliament.go.tz/polis/uploads/bills/acts/1565177092-The%20Union%20of%20Tanganyika%20and%20Zanzibar%20Act.%201964.pdf> (Accessed 8/2/2025)
- ^{vii} <https://www.gsma.com/r/digital-agriculture-maps/> (Accessed 8/2/2025).
- ^{viii} <https://bbtkilimo.co.tz/objectives/> (Accessed 8/2/2024)
- ^{ix} The mapping was officially closed on 17 March 2024 (no additional data added to the mapping after that date).
- ^x Data collected between October 2017 and April 2024.
- ^{xi} E.g. NGOs, cooperatives, organisations, private sector.
- ^{xii} This study has not analysed or coded sub-categories of mobile and web-based applications (see, e.g. Akour et al., 2016; Hamza & Hammad, 2020) as this goes beyond the scope and due to limited available data.
- ^{xiii} However, as I elaborate on in section 5.3., the compiled landscape mapping remains with data gaps due to a combination of missing data and the quality of available data.
- ^{xiv} They are subsequently excluded from Table 3. However, all identified details about all digitisation in agriculture tools are available in the complete inventory (see Appendix 7).
- ^{xv} Access IKS using this link: <https://iks.kilimo.go.tz/#/> (Accessed 18/3/2024).
- ^{xvi} <https://www.gsma.com/mobilefordevelopment/m4d-tracker/magri-deployment-tracker/> (Accessed 18/3/2024)
- ^{xvii} <https://medium.com/lwr-newswire/lwr-partner-launches-first-mobile-app-in-swahili-for-tanzanian-farmers-e2cf72a0101d> (Accessed 18/3/2024)
- ^{xviii} Note that the categories are non-exclusive as digitisation in agriculture tools may have available data in multiple sources.
- ^{xix} <https://www.farmbetter.io/> (Accessed 18/3/2024)
- ^{xx} <https://play.google.com/store/apps/details?id=io.farmbetter> (Accessed 18/3/2024)
- ^{xxi} https://play.google.com/store/apps/details?id=org.cabi.ofra&hl=en_GB (Accessed 18/3/2024)
- ^{xxii} E.g., <https://plantwiseplustoolkit.org/browse-tools/fertilizer-optimizer-tool/> (Accessed 18/3/2024)
- ^{xxiii} My supervisor Professor Dorothea Kleine was the one that coined the term *digitisation in agriculture zombies* during our many discussions about my thesis.
- ^{xxiv} Actors categories included in the mapping included family- and household members, neighbours and community members, friends and acquaintances outside of direct community, community meetings, savings groups, farmer groups, agricultural extension officers, agro-dealers, buyers, middle-men, agricultural companies, NGOs, local government and national government.
- ^{xxv} A commonly used type of fabric, available in various patterns and colours.
- ^{xxvi} Readers interested in the concept of savings groups may refer to e.g. Adegbite et al., 2022; Karlan et al., 2017.
- ^{xxvii} Tanzania and other countries in the region have experienced a growing problem with counterfeit agro-inputs over the last few years (see, e.g. Shao & Deo 2014), including the disguising and packaging of local varieties of seeds as

hybrid seeds. While counterfeit agro-inputs affect farmers globally, Tanzania stands out as a particularly challenging environment concerning counterfeit inputs. According to a report submitted by the Centre for Policy Research and Advocacy to the Agricultural Council of Tanzania in 2016, the Tanzanias agri-input market contains approximately 40% counterfeit products, which is a stark contrast to the estimated 5-7% in Europe and 15-20% average in Africa.

^{xxviii} Farmers' practical realities, existing knowledge, and local epistemologies heavily influence farmers' challenges, opportunities, choices, interests, and behavior in Kikwe and Ubiri.

^{xxix} I only encountered two farmers owning and using the third category of device during fieldwork.

^{xxx} Based on exchange rate on June 14th 2024 (www.xe.com) 1 TZS = 0.000383144 USD.

^{xxxi} <https://www.worldbank.org/en/news/feature/2021/03/16/a-roadmap-for-building-the-digital-future-of-food-and-agriculture>

^{xxxii} As highlighted throughout the thesis findings, farmers access to, ownership of and usage patterns are fluid and frequently changes. Therefore, it is important to acknowledge that the presented findings speak to a snapshot in time and space.

^{xxxiii} Exchange rate 13/6/2024 1 TZS = 0.000383112 USD (www.xe.com).

^{xxxiv} Readers interested in the concept of savings groups may refer to e.g. Adegbite et al., 2022; Karlan et al., 2017.

^{xxxv} Based on exchange rate 14 June 2024 (www.xe.com) 1 TZS = 0.000383182 USD.

^{xxxvi} Based on exchange rate 14 June 2024 (www.xe.com) 1 TZS = 0.000383182 USD.

^{xxxvii} As the data from this study is only collected from Ubiri and Kikwe, conclusions cannot be generalised to all of rural Tanzania. Yet, the data shows that the same inflated prices were present in both rural communities, indicating that similar practices likely occur in other rural locations.

^{xxxviii} Based on exchange rate 14 June 2025 (www.xe.com) 1 TZS = 0.000383021 USD.

^{xxxix} Result Verification Workshop 5, held in Ubiri.

^{xl} Result Verification Workshop 2, held in Ubiri.

^{xli} Focus Group Discussion 16, held in Kikwe.

^{xlii} These dimensions are further discussed in Chapter 9.

^{xliii} To beep someone, you leave a missed call to someone indicating that they want the person to call them back, a common frugal practice in Tanzania (and other similar contexts) used to be able to communicate despite not having any credit (see, e.g. Donner 2007). However, the method depends on whether the other person has airtime to call back, which was often not the case in Kikwe and Ubiri.

^{xliv} At the time of publishing this dissertation, the status of the service is unconfirmed, but no information is accessible on the organizations' website indicating that the service may have been discontinued.

^{xlvi} <https://wefarm.co.tz/> (Accessed 2022-08-22)

^{xlii} The three case studies have not been sampled to be representative of the diverse landscape of digital tools that has been designed in Tanzania's digitisation in agriculture ecosystem, but represents in-depth diversity across agricultural approaches and the digital technologies and functions used in the design. Refer to Chapter 3 for more details about the sampling of the case studies.

^{xlvii} Fieldwork was carried out in 2021-2022 and an informal revisit in Kikwe was conducted in 2023.

^{xlviii} <http://exts.kilimo.go.tz/> (Last checked April 30th 2024).

^{xlix} The authors have not time-stamped the data.

ⁱ In Ubiri and Kikwe, some extension workers were responsible for more than one ward (each ward typically has four villages).

ⁱⁱ Data collected from extension worker's M-Kilimo interface.

ⁱⁱⁱ Data collected from an extension officer in Meru.

ⁱⁱⁱⁱ WhatsApp conversation 7 February 2024.

^{lv} In reality, it is likely that some of these consultations may have been with the same individuals.

^{lv} USSD is short for Unstructured Supplementary Service Data and is a function that works on any mobile phone with a SIM card, to send and receive short text messages, typically starting with star and ending with hash (e.g. *100*01#).

^{lvi} Other research has similarly highlighted challenges related to bad eyesight and access and use of digital technologies among marginalised communities (Mills, 2016; Sherwin et al., 2008; Steinke et al., 2024).

^{lvii} This finding aligns with previous research that has pointed out that short time-out windows can be both a bottleneck and a source of frustration for users of USSD-based services (Erlich et al., 2018; Leung & Leung, 2016; Tafotie, 2020).

^{lviii} In Chapters 6 and 7 I share findings about farmers digital realities. The frequent changes of ownership and access of mobile devices among farmers illustrated in Chapter 6 was equally observed among extension officers.

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- ^{lix} I elaborate more on farmers knowledge systems in Chapter 7.
- ^{lx} WhatsApp conversation 7 February 2024.
- ^{lxi} 73,839 responses (Mushi et al., 2024).
- ^{lxii} <https://sautiyawakulima.net/bagamoyo/about.php?l=1> (Accessed 19 May 2024).
- ^{lxiii} I have co-authored a working paper with two researchers involved in the development of Ugunduzi (see Hilbeck et al., 2022).
- ^{lxiv} User manual available here in Swahili and English <https://sautiyawakulima.net/ugunduzi/download/index.html>.
- ^{lxv} https://sautiyawakulima.net/ugunduzi/download/ugunduzi_en.pdf (Accessed 19/5/2024).
- ^{lxvi} See <https://play.google.com/store/apps/details?id=org.cabi.ofra> and <https://bigdata.cgiar.org/digital-intervention/fertilizer-optimiation-tool-fot/>
- ^{lxvii} My empirical data only pertain to Tanzania.
- ^{lxviii} My empirical data only pertain to Tanzania.
- ^{lxix} The app requires Android 4.4 or higher to run, and the download size is eleven megabytes, which is considered lightweight.
- ^{lxx} Written brief by TARI Mlingano.
- ^{lxxi} <https://play.google.com/store/apps/details?id=org.cabi.ofra&hl=en&gl=US>
- ^{lxxii} <https://plantwiseplustoolkit.org/browse-tools/fertilizer-optimizer-tool/>.
- ^{lxxiii} www.agra.org
- ^{lxxiv} Drawing on conceptual work from Roberts & Hernandez (2019) and Kleine (2019).
- ^{lxxv} However, within a sector that remains diverse, commercial interest is only one example of the variety of interests that shape digitisation in agriculture.